User-Centred evaluation methods for Augmented and Mixed Reality

A working framework to inform and choose the best user evaluation methods based on multiple structured field surveys

Master Degree dissertation of Andrea Picardi.
Master of Science in Digital and Interaction Design.

POLITECNICO
MILANO 1863

User-Centred evaluation methods for Augmented and Mixed Reality

A working framework to inform and choose the best user evaluation methods based on multiple structured field surveys

Master's degree dissertation of **Andrea Picardi**
Student ID number: **915471**

Supervisor: **Giandomenico Caruso**

M.Sc. thesis submitted on July 2021
Academic Year 2020-2021

POLITECNICO MILANO 1863

Politecnico di Milano, School of Design
Master of Science in Digital and Interaction Design

Dedicate to all the people that helped me in my journey.

Acknowledgements

Guardarsi indietro alla fine di un lungo viaggio lascia sempre una sensazione di meraviglia mista a malinconia, il ricordare tutte le persone che abbiamo incontrato e con cui abbiamo condiviso risate, paure e successi è sempre un momento speciale.
Con questo lavoro si chiude un momento fondamentale della mia esperienza di vita e se ne apre un altro, ancora più vasto e importante. È quindi mio dovere ringraziare chi mi ha sostenuto e permesso di raggiungere questo importante obbiettivo.
In primis ringrazio il mio relatore di tesi, Giandomenico Caruso, che con la sua passione per l'argomento trattato e i suoi spunti di riflessione mi ha guidato nella relazione di questo elaborato.
Mi è d'obbligo dire grazie ai miei genitori, i quali non hanno mai smesso in tutti questi anni di sostenermi e spronarmi, e mi hanno supporto, non solo materialmente ma soprattutto moralmente.
Un grazie va a mio fratello per il tempo passato insieme e a nonna Nina, per il caffè e le partite a scala del sabato pomeriggio.
Grazie anche a zia Rosaria e zio Michele, per l'aiuto che mi hanno fornito nei primi tempi di permanenza a Milano.
Un ringraziamento va anche ai compagni di università che mi hanno accompagnato: a Nicolò per le notti insonni che mi ha fatto fare, per le discussioni e le parole di motivazione nei momenti difficili.
Ad Alessandro, Andrea, Beatrice, Claudia, Erica, Farnaz, Federico, Irina, Luca, Oriana, Pei, e Tao, per aver condiviso pranzi, fatiche e risate.
Infine, un grazie anche a tutti i colleghi e amici con cui ho spartito momenti spensierati.

Grazie a tutti voi per avermi sostenuto e incoraggiato fino a questo momento, così da aver reso possibile questo importante traguardo.

Andrea

Table of Contents

Acknowledgements III
List of abbreviations XI
Abstract ITA XII
Abstract ENG XIII
1. INTRODUCTION & BACKGROUND 1
1.1. Definition 2
1.2. Main events in the history of Augmented Reality 9
1.2.1. The history of AR 9
1.2.2. Future Trends 17
1.3. Principles and main components 19
1.3.1. Output devices 20
1.3.2. Tracking and sensing devices 23
1.3.3. Scene generators 27
1.3.4. Input devices 29
1.4. Uses & fields of applications 34
1.4.1. Military 34
1.4.2. Education & Training 35
1.4.3. Healthcare, medical and Emergency response 35
1.4.4. Architecture, Engineering and Design 36
1.4.5. Manufacturing, Logistic and maintenance 37
1.4.6. Vehicles & Machinery control 37
1.4.7. Arts & Culture 38
1.4.8. Commercial & Enterprise 39
1.4.9. Consumer Sector 39
1.5. Limitations and issues: 41
1.5.1. Technological problems: 41
1.5.2. User Issues: 42
1.6. Problem definition 44
2. LITERATURE REVIEW 45
2.1. Users Evaluations, what are and when employing them? 46
2.2. Traditional User evaluation methods 48
2.2.1. Analytic methods 48
2.2.2. Empiric methods 49
2.3. Limitations of current evaluation methods 53
2.4. Evaluation Approach commonly used 55
2.5. AR design Practices, Heuristics and Guidelines 58
2.6. Evaluation procedures 60
2.6.1. Usability engineering approach 60
2.6.2. Testbed evaluation approach 62
2.6.3. Sequential evaluation approach 64
2.6.4. User-based studies approach 66
2.7. User testing obstacles 68

2.7.1. Limitations related to the physical environment ____ 68
2.7.2. Difficulties in the setup of user testing ____ 68
2.7.3. Limitations related to the participants ____ 69
2.8. Field or Laboratory evaluation? ____ 71
3. RESEARCH METHODOLOGY ____ 73
3.1. Research Process and Questions ____ 74
3.1.1. Initial Process ____ 75
3.1.2. Studies Identification ____ 77
3.2. Identification of categorization parameters ____ 78
3.2.1. Technology used ____ 78
3.2.2. Domain/Field focus and Studies Design ____ 80
3.2.3. Evaluation methodologies and main investigated HCI aspects ____ 84
4. RESULTS & FRAMEWORK DEFINITION ____ 91
4.1. Studies sources and type ____ 92
4.2. Technology used ____ 93
4.2.1. Output technologies: ____ 93
4.2.2. Input technologies: ____ 97
4.2.3. Tracking technologies: ____ 101
4.3. Domains and fields of application ____ 105
4.4. Study design and characteristics ____ 108
4.4.1. Senses augmented ____ 108
4.4.2. Type of evaluations ____ 110
4.4.3. Evaluation setting ____ 112
4.4.4. Number of participants ____ 114
4.5. Evaluation methodologies employed and main HCI aspects investigated ____ 114
4.5.1. Methodologies ____ 114
4.5.2. HCI aspects ____ 119
4.6. Framework definition, description, and usage ____ 125
5. CASE STUDY ____ 129
5.1. First Case study ____ 130
5.2. Second Case study ____ 134
6. DISCUSSION & CONCLUSIONS ____ 137
1.0. Discussion ____ 137
6.1. Contribution to knowledge ____ 140
6.2. Open issues and future developments ____ 141
7. REFERENCES ____ 143
APPENDIX - A ____
Framework ____
APPENDIX - B ____
Table of papers analysis ____

Table of Figures

Figure 1-1 Virtuality Continuum (VC) schema (source: [9]) ____ 4
Figure 1-2 Benford et al shared spaces schema (source: [14]) ____ 5
Figure 1-3 Milgram and Kishin’s continuum (source: [15]) ____ 6
Figure 1-4 Stage setup for Pepper's Ghost, book illustration ____ 9
Figure 1-5 Picture of Sensorama by Morton Heilig (source: lausanne.inno-forum.org) ____ 10
Figure 1-6 Third Eye for Space Explorers (source: [29]) ____ 12
Figure 1-7 Sutherland’s The Sword of Damocles (source: Representation Degree Zero, A. Sdegno) ____ 12
Figure 1-8 (below left) Videoplace art installation by Kruegerg (source: Digital Art Museum) ____ 13
Figure 1-9 (below right) WearComp1 prototype concept (source: [29]) ____ 13
Figure 1-10 (below right) Sixth Sense by Steve Mann in its late revision (source: MIT Media Lab) ____ 14
Figure 1-11 (below left) MARS prototype by Steven Feinberg (source: [29]) ____ 14
Figure 1-12 (below left) First AR system on a consumer mobile phone i (source: [44]) ____ 15
Figure 1-13 (below right) LEGO DIGITAL BOX interactive totem (source: LEGO ____ 15
Figure 1-15 Magic Leap (source: Magic Leap) ____ 16
Figure 1-15 Microsoft HoloLens in its second revision (source: Microsoft) ____ 16
Figure 1-16 snapshot of Pokémon GO (source: Niantic) ____ 17
Figure 1-17 Garten Hype Cycle (source: [1]) ____ 18
Figure 1-18 Bimber and Raskar’s [57] visual output technologies classification ____ 20
Figure 1-19 Google Glass 2 (source Shutterstock.com) ____ 21
Figure 1-20 Daqri smart helmet (source: domusweb.it) ____ 21
Figure 1-21 IKEA Place smartphone app (source: IKEA) ____ 22
Figure 1-23 PHANTOM Omni haptic device (source: 3DSYSTEMS) ____ 22
Figure 1-24 CAVE system immersive technology ____ 22
Figure 1-25 HUD of a Boeing 787 (source: Pablo Andrés Ortega) ____ 22
Figure 1-26 A mechanical tracking device developed by Fake Space ____ 24
Figure 1-27 Marker-based tracking with a hand handed device (source: areteproject.eu) ____ 25
Figure 1-28 Feature tracking on a toy (source: wikitude) & SLAM tracking (source: Kade Barrancoe) 26
Figure 1-29 Outside-in, Inside-Out tracking differences (source: delight-vr.com) ____ 26
Figure 1-30 Nreal Smartglasses (source: Nreal) & HP Z VR backpack computer (source: HP) ____ 28
Figure 1-31 FinchRing tactile controller (source: Technologies Ltd) ____ 30
Figure 1-32 Cyber Glove II (source: CyberGlove Systems LLC) & Magic Leap (source: Magic Leap) ____ 30
Figure 1-33 SandScape, an example of tangible interface (source: Ars Electronica 2016) ____ 32
Figure 1-34 Concept of car manutention aid with an AR interface (source: zealAR) ____ 32
Figure 1-35 First Gen III F-35 Helmet (source: Rockwell Collins) ____ 34
Figure 1-36 AR utilization concept in education (source: Case Western Reserve University) ____ 35
Figure 1-37 AR utilization concept (source: Microsoft) & Mira headset (source: Mira Labs Inc) ____ 36
Figure 1-38 AR HUD by ASU (source: chinadaily.com.cn) & NO AD installation (source: L. Dormehl) ____ 37
Figure 1-39 Snapchat lens studio ADV experiments (source: Snap inc.) ____ 38

Figure 1-40 HoloLens AR game demo (source: Microsoft) ____ 39
Figure 2-1 Usability engineering approach by Hix et al. (source [103]) ____ 60
Figure 2-2 Testbed evaluation approach by Bowman and Hodges (source [146]) ____ 62
Figure 2-3 Sequential evaluation approach according to Gabbard, Hix & Swan (source [147]) ____ 64
Figure 2-4 User-based studies approach by Gabbard, Hix & Swan (source [148]) ____ 67
Figure 3-1 M. I. Zarour possible categorizations of User Experience and Usability (source: [170]) ____ 89
Figure 4-1 Domains and fields of application groups and quantity ____ 106
Figure 4-2 Framework sections preview ____ 126
Figure 4-3 Framework usage process steps ____ 128
Figure 5-1 iDrive simulator (source Dadhich et al. [178]) ____ 130
Figure 5-2 Case study Situation 1 & Situation 2 (source Dadhich et al. [180]) ____ 131
Figure 5-3 Screenshots of the virtual scenario Case Study (source Dadhich et al. [180]) ____ 131
Figure 5-4 1st case study – Section B and C, Corelation Chart and Method Used & Aspects Matrix ____ 132
Figure 5-5 Screenshots of the prototype build by Aleksy et al. (source Aleksy et al. [181]) ____ 135
Figure 5-6 2nd case study – Section B and C, Corelation Chart and Method Used & Aspects Matrix ____ 136

Table of Charts

Chart 4-1 Percentage of papers per source 92
Chart 4-2 Repartition of papers with different studies and pre-studies 92
Chart 4-3 Distribution of studies per number of output devices used. 94
Chart 4-4 Total number of outputs devices used 94
Chart 4-5 Corelation of output devices used between each other (total) 95
Chart 4-6 Corelation of output devices used (in studies with two devices used) 96
Chart 4-7 Corelation of output devices used (studies with at last three devices used) 96
Chart 4-8 Total number of Inputs devices used 98
Chart 4-9 Distribution of studies per number of input devices used. 98
Chart 4-10 Corelation of input devices used between each other (total) 99
Chart 4-11 Corelation of input devices used (in studies with two devices used) 100
Chart 4-12 Corelation of input devices used (studies with at last three devices used) 100
Chart 4-13 Distribution of studies per number of tracking devices used. 102
Chart 4-14 Total number of tracking devices used 102
Chart 4-15 Corelation of tracking devices used between each other (total) 103
Chart 4-16 Corelation of tracking devices used (in studies with two devices used) 104
Chart 4-17 Corelation of tracking devices used (studies with at last three devices used) 104
Chart 4-18 Diagram of Ven of senses augmented per studies 108
Chart 4-19 Distribution of senses used per domain 109
Chart 4-20 Evaluation types distribution (total) 110
Chart 4-21 Distribution of different Type of evaluations used per domain / field 111
Chart 4-22 Total proportion of evaluation settings 112
Chart 4-23 Distribution of senses used per domain / fields 113
Chart 4-24 Proportion of total evaluation methodologies used (2nd level) 114
Chart 4-25 count of studies per number of users involved during the evaluation. 115
Chart 4-26 Distribution of methods used per studies (3rd level) 116
Chart 4-27 Percentage of number of 2^{nd} level evaluation methodologies used inside a single study 119
Chart 4-28 Total proportion of investigated HCI aspects 120
Chart 4-29 Repartition of investigated HCI per Domain / Field 123

Table of Tables

Table 1 Kostaras and Xenos User evaluation methods 48
Table 2 List of surveys consider for the analysis 78
Table 3 Technology used classification 80
Table 4 Field / Domains description 81
Table 5 Type of Study Evaluation 83
Table 6 Evaluation Methodologies sublevel data structure and example schema 84
Table 7 Type of Study evaluation classification 87
Table 8 Hartson and Pyla subdivision of User Experience components 89
Table 9 Table of evaluations methods, 2nd, 3rd, and 4th level with percentage of total uses 117
Table 10 Table of HCI investigated aspects, with relative subgroups and percentage of total uses 121

List of abbreviations

AR:	Augmented Reality
GUI:	Graphical User Interface
NUI:	Natural User Interface
HCI:	Human-Computer Interaction
IMU:	Inertial Measurement Units
MAR:	Mobile Augmented Reality
MR:	Mixed Reality
SLAM:	Simultaneous Localization and Mapping
UI:	User Interface
UX:	User Experience
VE:	Virtual Environment
VR:	Virtual Reality
WIMP:	Windows Icons Mouse Pointer
WOz:	Wizard of Oz
XR:	Extended Reality

Abstract ITA

La realtà aumentata è uno dei paradigmi più promettenti nel campo del design dell'interazione, con più di quarant'anni di avanzamenti alle spalle, si trova adesso davanti a un momento cruciale del suo sviluppo.
Oggigiorno, le tecnologhe che possono permettere la sua piena fruizione hanno raggiunto possibilità tali da poter garantire un continuo arricchimento della realtà con informazioni puntuali e rilevanti, dovunque e sempre, risultati che solo pochi anni addietro rappresentavano problemi di difficile risoluzione.
Queste possibilità sono da altra parte oscurate dalla sempre più lunga lista di start up e aziende che, seppure pochi anni addietro promettessero nuove meraviglie tecnologie nel campo della realtà aumentata, sono costrette oggi a ridimensionare o addirittura abbandonare le proprie ambizioni.
Una delle motivazioni che sta limitando l'adozione di questa tecnologia è la scarsa attenzione all'utente finale, alle sue aspettative ed esigenze, che spesso vengono messo in secondo piano rispetto alla tecnologia stessa.
Il lavoro di questa tesi propone l'analisi e la classificazione dei metodi adottati fino a questo momento per la valutazione oggettiva e soggettiva di questa tecnologia.
Inoltre, è stato elaborato un framework per poter identificare le migliori tecniche di indagine.
Il framework ha il duplice scopo: illustrativo, per identificare metodi e tecniche impegnate in passato nel campo della valutazione utente con tecnologie AR, e operativo, per poter valutare quale metodologia e strumento siano i più adatti a una specifica situazione rispetto che un'altra.
All'interno di questo lavoro vengono anche proposti due casi studio per poter, da un lato, illustrare passo a passo l'utilizzo del framework, e dall'altro, per comprenderne i limiti e le potenzialità dello strumento sviluppato.
Entrambi i case study derivano da reali prototipi di sistemi AR, sui quali andremo a utilizzare il framework per decidere quali metodologie di valutazione siano le più opportune da utilizzare per ogni specifica situazione.
L'uso di questo framework potrà così favorire lo sviluppo e la validazione di nuove modalità di interazione sempre più incentrare sull'utente finale al fine di rendere la realtà aumenta alla portata di tutti e al di fuori dei centri di ricerca e sviluppo.

Parole chiave: Realtà Aumentata, Realtà Mista, Valutazione utente, metodi di valutazione, strumenti di valutazione, framework di valutazione, design centrato sullo utente, Esperanza utente, test con utenti, test di usabilità

Abstract ENG

Augmented reality is one of the most promising paradigms in the field of interaction design, with more than forty years of advancements behind it, right now is facing a crucial moment in its development.
Today we have the technology that can enable its full potential, allowing us to “augment” the world around us with timely and relevant information, everywhere and at any time, results that only a few years ago presented challenging problems.
However, these possibilities are obscured by the ever-growing list of start-ups and companies that, after long developments and promises of new tech marvels, are now forced to downsize, or even abandon their ambitions.
One of the reasons that are holding back the technology has been identified in the lack of study focused on the end-users, on their motivations and needs, often overshadowed by the technology itself.
In this regard, this thesis work aims to analyse and categorize the methods so far adopted to investigate the objective and suggestive spheres of this technology.
In addition, a framework has been developed to identify the best evaluation techniques to employ in the future.
Thus, this framework has two goals: an illustrative one, to inform which fields and which techniques have been used in the past regarding the user evaluation with AR technologies, and an operational one, to evaluate which methodology and tool are the best suited to a specific situation over the other.
Inside this work, we also propose two case studies to illustrated step by step the use of the framework, and to understand what the limitations and potentials of this tool are.
Both case studies derive from real AR prototypes, and on these we will use the framework to decide which evaluation methodologies are the most appropriate to use for each specific situation.
This framework would thus be able to guarantee faster development iterations, keeping the end-user always at the centre of the development, and bringing this new revolutionary technology in the hands of people outside the research and development centres.

Keywords: Augmented Reality, Mixed Reality, user evaluation, evaluation methods, evaluations tools, evaluation framework, User Centered Design, user experience, user testing, usability testing

1. INTRODUCTION & BACKGROUND

Augmented Reality (and to an extent Mixed Reality) is one of the most promising technology right now in the field of interaction design, it has the potential to change irremediably the way we act, see, and experience the world around us.
With a long history of advancements in the last century, in the next years is expected to reach wider and wider adaptation **[1]** bringing us what is considered the “next-generation interface **[2] [3]**, a new interaction paradigm without borders between the real world and the information accessed, where the world is itself become the interaction medium, the next leap in Human-Computer Interaction after the Graphical User Interface **[4]**.
But exactly what are we talking about? In the next section, we will lay down the bases to understand this new interaction paradigm, define exactly what is, where came from, and what is the main application that these new technologies could bring us in the future.
We will also see the main problems and issues that afflict Augmented Reality right now and define exactly what is imitating the integration and adoption of this technology, as well as what could stem these problems.

1.1. Definition

The term Augmented Reality was originally coined by Caudell and Mizell **[5]** in the early 1990s, two Boing engineers that at the time were developing an innovative system to help workers visualize the complex aircraft schematics directly on the body of the plane on the factory floor (through the utilization of a headset).
Although the term was created at the end of the XX century, the concept of Augmented Reality is at least one hundred years old, as we will see in the next chapter.
As often happens with new paradigms and technology that challenge how we define and behave with the world (as well as our relationship with the technology itself), giving a brief and concise definition is quite difficult, and the borders of this definition can only be blurry and undefended.
Therefore, to better understand what we are dealing with, we had to define not only what is Augmented Reality (hereinafter abbreviated as AR), but also what are Mixed (MR), Virtual (VR) and Extended Reality (XR).
We will start with the definition of Augmented Reality to better understand the definition problem.
Springer's Encyclopaedia of Multimedia define Augmented Reality as:

> “ *Augmented reality is a system that enhances the real world by superimposing computer-generated information on top of it [6]* ”

that is not dissimilar to the Cambridge Dictionary definition:

> “ *Images produced by a computer and used together with a view of the real world [7]* ”

At first glance, these definitions could appear complete and comprehensive, but paint only a small part of the complex and variegated definition that AR has.
To start, these definitions seem to indicate that the term is restricted only to the sense of view (pictures and images, that the most used media by our society to share information), but during the years the AR term was commonly used also to “augment” other senses, such as auditory, kinaesthetic, olfaction and so on, without limiting it only to one sense that would be too restrictive.
The second insight, these definitions offer, is that AR can be only generated by a computer, and, in the past, there have been debates about the topic of “exclusivity” of computer to be the device that can augment the real world, or if also an analogue device (such as, an analogic radar screen reflected inside a cockpit) can be considered AR.

This is a complex taxonomy topic and for the purpose of this work it could be neglected and both cases can be considered AR.
This statement is originated from the consideration of the current state of our technology, where thanks to the unprecedented computational power of today devices often in small form factors, and the infinite potential that they can have in generating an AR context, the subgroup of analogue AR devices, which has always been small and confined to the first searches of the field, will be less and less relevant in the future, if not completely inexistent.
Returning to the main topic, another more comprehensive definition is the one from the Interaction Design Foundation that says:

> “ *Augmented reality is an experience where designers enhance parts of users' physical world with computer-generated input. Designers create inputs (ranging from sound to video, to graphics to GPS overlays and more) in digital content which responds in real-time to changes in the user's environment, typically movement [8]* ”

It states that the real world can be enhanced not only by images but also by something more (like data, sound and so on), this definition is better than the previous one, but is still lacking.
It does not say how much an experience can be enhanced, and if we start to consider other types of technologies that also can enhance an experience the boulders of AR start to become too fuzzy and undefined: are the graphics superimposed on the sports channel on the T.V. (like the world record position in a swimming competition) in the same category of a VR game or exhibition?
Both of them are enhancing the user physical world after all, one in an informative way, the other for entertainment and cultural purpose, we need something more to define AR.
To cope with this differentiation problem, we need to introduce a framework where both AR and VR can be better defined: the reality-virtuality continuum by Milgram and Kishino **[9]**.
They created this concept in 1994 to better define the various typologies of visual display available back then for AR and VR, and since then, the reality-virtuality continuum has been the standard framework to distinguish these terms and technologies.
This continuum relates to the different types of objects and environments that can be presented in any display situation (both immersive and not).
It could be viewed as a spectrum, where on one end lies any environment composed only of real objects, including whatever might be seen in the real-world scene, either directly in person or through some kind of (video) display (either see through that not).
On the other end of the spectrum lies instead every environment that consists only of virtual objects (such as conventional computer graphic simulations), either monitor-based or immersive.
The authors then introduced the Mixed Reality (MR) concept, defined it as any environment in which both real and virtual world objects are presented together within a single display, and can be,

according to the degree of what is displayed, anywhere on the continuum **[Figure 1-1]**.

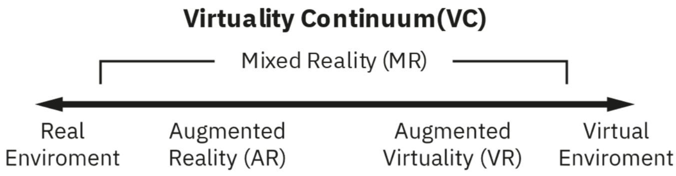


Figure 1-1
Virtuality Continuum (VC) schema *(source: [9])*

Milgram also individuates on the continuum the interesting concept of Augmented Virtuality (AV).
It consists of “Augment” the virtual world with something from the real one, we can see this special type of augmentation in action in the special effects industry for live TV broadcasts, where thanks to special techniques they can represent people in a totally fake and constructed (virtual) sets.
Now, looking at the Virtual Continuum schema, we can easily differentiate Augmented Reality from Virtual Reality (that in the original virtual continuum schema was called Virtual Environment and is position on its far-right side), VR, on the contrary of AR, completely substitute the real world with the virtual, instead to enhance it.
With this concept in mind, Milgram and Kishino define Augmented Reality as:

> “ *Augmenting natural feedback to the operator with simulated cues [10]* ”

This board definition simplifies the differentiation between AR, VR and MR, but is too vast, are the images virtually enhanced of films (like Jurassic Park, where the T. rex was layered on the top of real images in a later production stage) the same of the information displayed in real-time on a HUD of an aircraft? We are missing one dimension here, time.
On this matter various researchers tried in the past to define better the specially and intractability of AR: around the year 2000, Azuma has investigated the best visual trade-off used in AR application of the time, and further reduced the broad definition of Milgram **[11][12]** including these assumptions:

1. AR combines real and virtual world (according to the Virtual Continuum concept),

2. AR is Interactive in real-time,

3. AR is registered in 3D (it matches the viewer position with the world position).

According to Azuma, these principles narrow the field of possible applications that can be considered AR, without narrowing too much the possible technologies that can be used for achieving AR.
We can borrow them to define better our definition, they imply the necessity of AR applications to work in real time and match the real-world input.
Finally, we can combine what we have discussed until now in this definition:

Augmented Reality is the augmentation of the natural feedback that one person has of his or her surroundings employing various devices, it is interactive in real-time, and combine the real (what is augmented) and virtual world (that is the augmentation) in a seamless way according to the virtual continuum.

This is only one definition, and it is a highly technical one (it is originated for the need of Milgram, Kishino and Azuma to differentiate the various types of video display used in the virtual continuum to find the best tread off for the best AR visualization), but it can be used right away and is not too difficult to grasp.
However, there is no common agreement on the right definition of AR, and different definition and taxonomy exists (Normand and Moreau even classified them in four different groups before trying to create their own taxonomy of AR **[13]**)
Other researchers tried to improve the definition and they expand the Virtual Continuum to better define their research fields.
To study the concepts of shared spaces, collaboration and interaction within Virtual and Augmented Realities, Benford et al. **[14]** in 1998 expanded this definition by taking the Virtual Continuum as a starting point.
Together with the real/virtual axes, they introduced another dimension parallel to the first one, called "Dimension of Transportation". On this new axis, they collocated at one extreme all the situation where people share the same physical space (local), and on the other side the situation where the users were far apart (remote), this created a new 2D space on which concepts as Telepresence (TP) and Physical Reality (PR) could find place **[Figure 1-2]**.

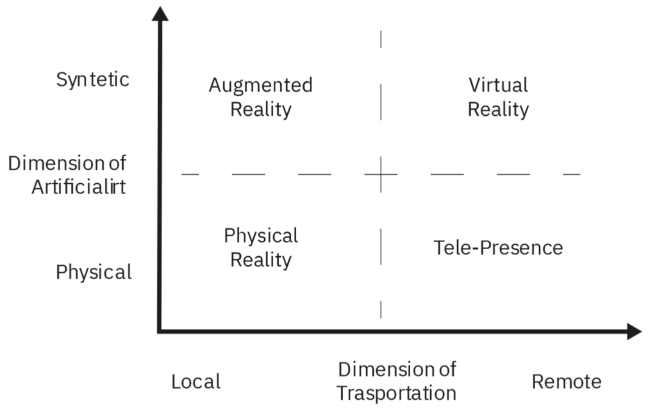
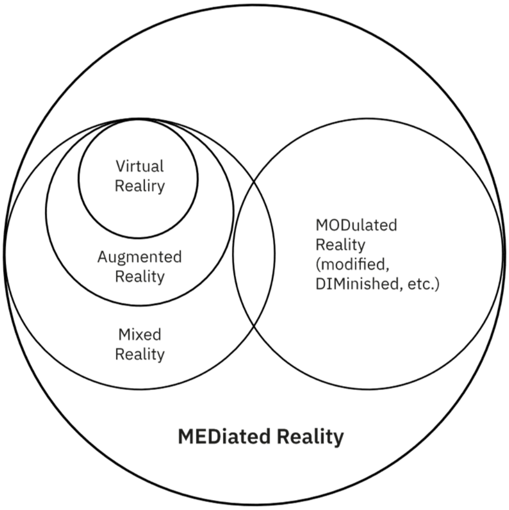


Figure 1-3
Benford et al shared spaces schema *(source: [14])*

Another work that expanded the Milgram and Kishino continuum was made by Steve Mann, that in 1994 introduced the concept of Mediated Reality **[15]**.
In his interpretation, the continuum is not limited to mixing real and virtual objects, but it can also modify and filter the users' view of the real-world (e.g., substitute unwanted advertising on a public billboard with something else, like the user personal email client) **[Figure 1-3]**.

Figure 1-4
Milgram and Kishin's continuum
(source: [15])



Mann introduced another dimension to the Virtual Continuum, the amount of mediation (or filtering) that is performed in the users' perception of the real (or virtual) environment.
The author also introduced the concept of MODulated (or DIMinished) Reality, that contrary to what happens with AR, which should enhance the users' world perception, reduce what the user is experiencing, like in the case of unwanted advertising on public billboards. It is an intriguing use case that these technologies could bring.
A fascinating definition based on a completely different point of view is the one from Olivier Hugues, Philippe Fuchs, and Olivier Nannipieri **[16]**.
Starting not from the technologies that enable AR but from the definition of AR itself, they tried to understand its potentials, functionalities, and purposes, they asked to themselves:

> “ *What is augmented in augmented reality?*
> *If reality is by definition everything that exists,*
> *then strictly speaking reality cannot be augmented since*
> *it is already everything. So, what is augmented? [...]*
> *The answer seems obvious: it is not reality, but the perception*
> *of reality which is augmented.* ”

This shift of perspective from reality to perception (they also coined the term “Augmented Perception”) opening the door to a different type of consideration about AR; a pragmatic one.
They continued considering Bergson’s definition of perception **[17]**: He said that for human beings, any perception and any knowledge have only one final aim: action.
We do not perceive and do not attempt to familiarize ourselves to know, but rather to act, indeed perception is never disinterested, knowledge is only ever a means to acting better in the real world: surviving for wild animals or being happier for humans **[18]**.
This concept is further altered by the ability of humans to use the things we build (i.e., technology) to interact with the real world: using any technical device modifies our relationship with the environment, and so it modifies our perception **[19]**.
Therefore, we cannot “only” endeavour to perceive better (augment our perception) since perception is not a final aim, but a means of achieving an aim (surviving or being happier), thus, AR technologies may satisfy two objectives for humans:

1. Enhance the understanding and mastery of the real world and so, an augmented perception of reality.

2. Propose a new environment whose aim does not appear to obey either requirements in terms of knowledge or practical requirements **[**16**]**.

This shifting of the definition problem from the technological one to a pragmatic one, allow us to better think about the aim of this technology, its limits, possibilities, and meanings for us as humans without being imitated to the practical and technical aspect of it.
Finally, I want to clarify some acronyms that lately are being used by the specialized press (mainly in the marketing and tech world), which are different from the classical academic definition we found and discussed in this chapter.
After Google launched its Google Glass project back in 2012 **[20]**, Oculus its first prototype in 2012 **[21]** and Microsoft its HoloLens project in 2016 **[22]**, terms like VR, MR, AR, entered the common jargon, but thanks to the marketing push of this, and other big tech companies that join the market, a different definition for AR and MR was adopted.

The main differentiating factors of this definition are the degree of interaction between the virtual objects and the real world, and how these elements are represented in respect to each other, which is instead the key differentiating characteristic of the Milgram's Virtual Continuum:

→ AR is often described as superficially interact with the environment, with no occlusion between the virtual and real environment. The user cannot interact directly with the virtual objects, and sometimes they are not even matched in the real 3D world **[23]**.

→ MR on the other way, (also referred to as Mediated **[24]** or Hybrid **[25]** reality by some company) is the complete merge of the virtual and real world. In this definition virtual objects can interact with the real world (and often also the other way around), there is real-time occlusion between them, and sometimes they can react to the lighting changes of the environment to better camouflages themselves with the environment.

Occasionally also the term Extended Reality (XR) can be found online, it is an umbrella term that encompass AR, MR, and VR, and it is in some way similar to the Virtual Continuum.
For the purpose of this work, I will use the terms used in the academic literature, thus the term Augmented Reality will be refired to the definition we found in this chapter, and the terms Mixed Reality, Virtual Reality and Augmented Virtuality as the ones defined by Milgram and Kishino.

1.2. Main events in the history of Augmented Reality

Although the technology that enables AR made great strides in the last decade, the first idea and the initial implementation are not recent.
With at least one hundred years of advancements since the first concept, through the first research imitated to the military and aeronautical fields, the opening to other sectors in the 80s and 90s, and finally arriving at the commoditization and the entrance of the term in the lives of common people in the last decade.
In this chapter, we will retrace the main events in the history of AR to better understand what has been done, where the concepts came from, and where we are headed.

1.2.1. The history of AR

The ancestor of AR can be traced back to the so-called Pepper's ghost illusion by the English scientist's John Henry Pepper **[26]** during the mid-19th century.
The illusion, even in use today inside amusement parks and in some AR systems, use a clever system of light, mirrors, and optical elements to give the impression that the reflected objects share the same space of the real objects that the user is looking at.
[Figure 1-4]

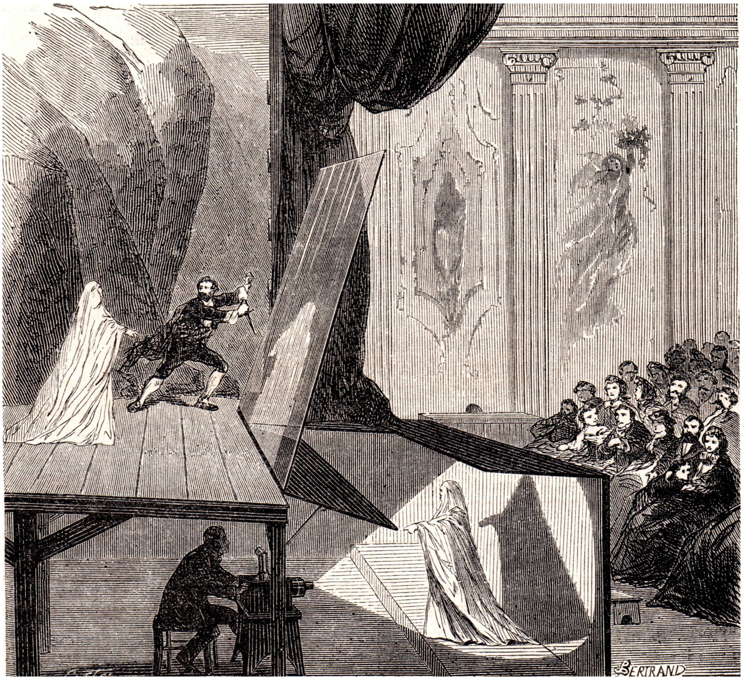


Figure 1-6 - Stage setup for Pepper's Ghost, book illustration of the IX century *(source: Le Monde Illustré)*

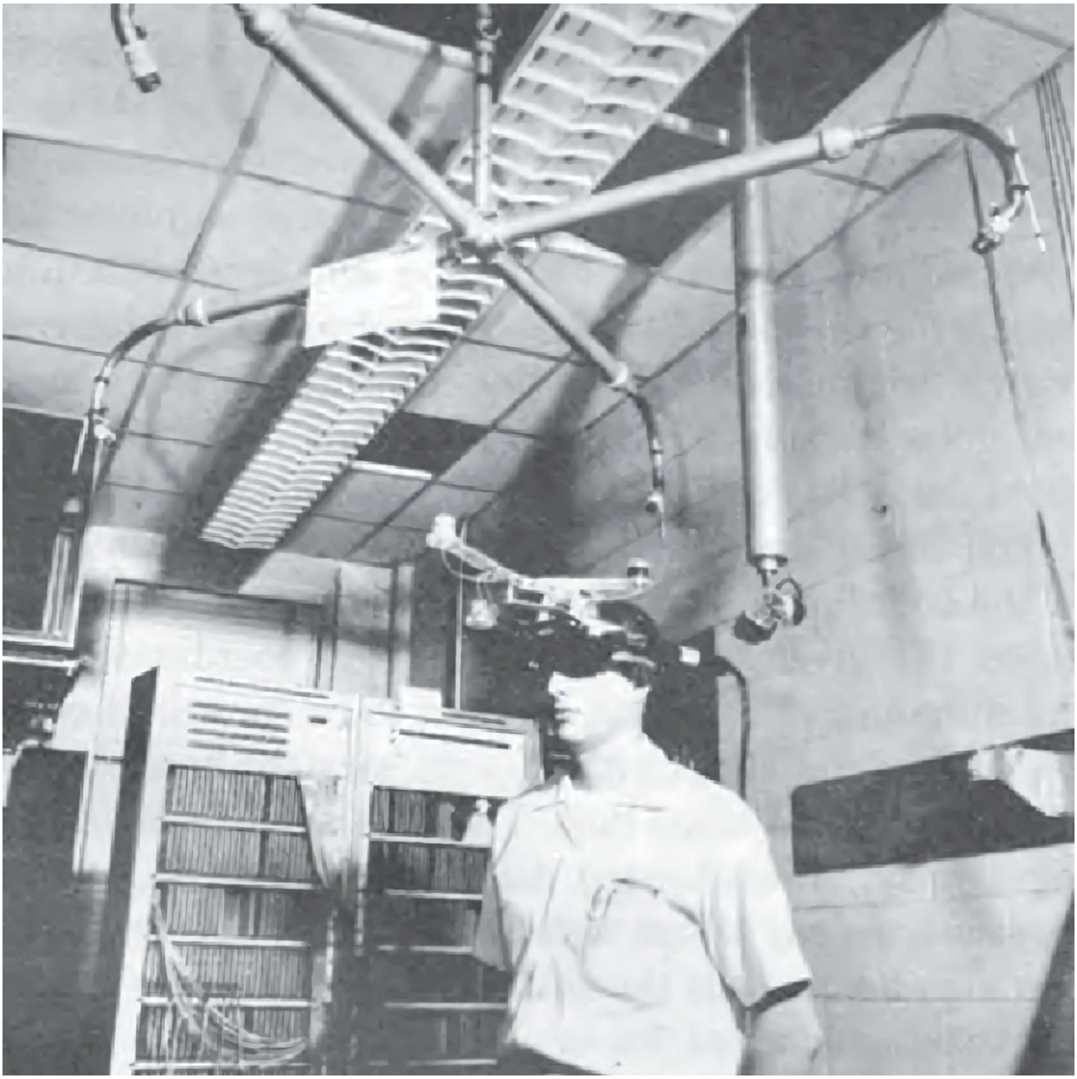
We can also find a similar concept inside the 1901 novel *Master Key: An Electrical Fairy Tale* **[27]** novel is published by L. Frank Baum's (author also of The Wonderful Wizard of Oz).
In this book there is one of the first mentions of an augmented reality-like device, the so-called "character marker" glasses.
This pair of spectacles could reveal to the persons wearing them the hidden personality traits of the characters surrounding him, though a letter that will appear on the person's forehead.
But we had to wait until the 1942, In the context of the Second World War, to see the first proper experiment inside the field of AR, and more specifically inside the context of the Telecommunications Research Establishment in England.
They were experimenting with the combination of images from the radar system and the gunsight system of the Havilland Mosquito night fighter, where the resulting image were projected on the windscreen of the cockpit **[28]**.
Similar research was then conducted ten years later inside the United States ANIP program, were the first prototype of synthetic vision for aircraft system **[29]**, a special type of instrumentation that collected the flight data from the aeroplane and provided them to the pilot to improve the operation of the aircraft in all-weather conditions, were develop.
Interesting was also in 1957 the works conducted by the Cinematographer Morton Heilig, he built the first immersive multi-sensory experience prototype called Sensorama **[30]**, initially described in his 1955 essay "The Cinema of the Future" **[31]**.
This prototype consisted of a new theatrical experience, where the viewer could experience a film not only with his or her eyes and ears, but also with the other senses in an effective manner. Today this experiment is considered an ancestor of modern-day VR and AR experiences **[Figure 1-5]**.

Figure 1-7
Picture of Sensorama
by Morton Heilig
(source: lausanne.inno-forum.org)

We need anyway wain until the earl 60s of the last century to see the first prototypes of wearable headsets, with Philco and Hughes Aircraft and theirs Headsight and Electrocular **[32] [33]**, two head-mounted systems designed to improve remote operation and jet fighter pilots' performance.
In the same years, Bell Helicopter Company started experimenting with a servo-controlled infrared camera, controlled by a remote viewing device on a headset, the aim of this prototype was provide to helicopter pilots with an augmented remote view of the ground linked with their head movements **[Figure 1-7]**.
However, only in the years between the 1965 and 1968 the AR research field really begins to flourish, mainly with the developments of Ivan Sutherland, associate professor at Harvard University (and the creator of the SketchPad project at MIT three years prior **[34]**).
Interesting is his essay "The Ultimate Display" **[35]**, published in these years, where he conceptualizes a room where a computer could control everything, even down to the existence of the matter, this prompted him to say:

> " *With appropriate programming, such a display could literally be the Wonderland into which Alice walked* "

A clear vision that will constitute the aim of his work, and of this field as well.
Indeed, three years later, Sutherland and his students visited Bell Laboratories, and deeply impressed and inspired by their remote viewing prototype, they begin to build their version in the same year: "*The Sword of Damocles*", a headset system with head-tracking capabilities enhanced by computer-generated images **[36]**.
This head-mounted display consisted of two CRTs (one for each eye) suspended from the ceiling (due to his weight, and thus the origin of the name), the unit was partially see-through and used a special purpose computer to generate a single cube with some lettering on the sides.
This prototype is often cited as a precursor to AR and VR technologies, and credit as the first of its kind, allowing 3D head tracking in space with the ability to display both the virtual and real environment, it permitted Sutherland's team to conduct various experiments within this new and unexplored "virtual world" in the following years **[Figure 1-6]**.
Of course, seen with today eyes, this prototype seems cumbersome and of difficult use, however if we consider that in those years, even the simplest computer had the dimensions of entire rooms, we can well see how this prototype was revolutionary at the times, and how it shaped the history of this field.



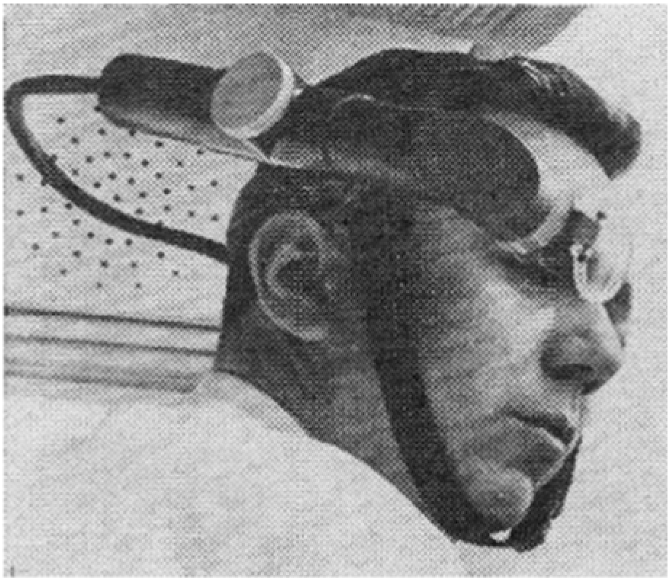


Figure 1-10 (above)
Sutherland’s The Sword of Damocles headset
(source: Il grado zero della rappresentazione / Representation Degree Zero, A. Sdegno)

Figure 1-9 (left)
Third Eye for Space Explorers
(source: [29])

At the end of the decade, Myron Krueger developed a series of interactive computer artworks which he named “artificial reality” **[37]**.
These works consisted of interactive computer-generated environments that could connect far away people (even miles apart) in a responsive and playful way, today this artwork is considered the forerunner of telepresence.
A series of projects (Glowflow, Metaplay, and Psychic Space) followed during the years, culminated in 1975 with Videoplace, an Art installation and interactive environment where visitors could control the surrounding space through their movements and actions without the use of goggles or gloves **[Figure 1-8]**, applications that are very close to the spatial AR systems that will be thoriate only twenty years later.
In the eighties, Steve Mann (who later in 2000 received the title “Father of Wearable Computing” by the IEEE for his inventions and contributions to the field **[38]**) created the WearComp1, a concept prototype for a wearable AR headset computing device, the first of his kind, he also continued, over the span of three decades, to iterate this concept in what we know today as Eyetap **[Figure 1-9]**.
In 1985, Jaron Lanier (former Atari developer, who later will coin the term “virtual reality”) and his fellow co-worker Thomas G. Zimmerman founded VPL Research.
This company will later develop the Data Glove (a device that allowed people to use their hands to interact with a virtual environment) and the EyePhone, (a head-mounted display), the first devices of their kind available to the public.
In 1990, the term “Augmented Reality” is finally conceived by Thomas P. Caudell, and David Mizell two Boeing researchers **[5]**.

Figure 1-11 (below left)
Videoplace art installation
by Kruegerg
(source: Digital Art Museum)

Figure 1-12 (below right)
WearComp1 prototype concept
(source: [29])

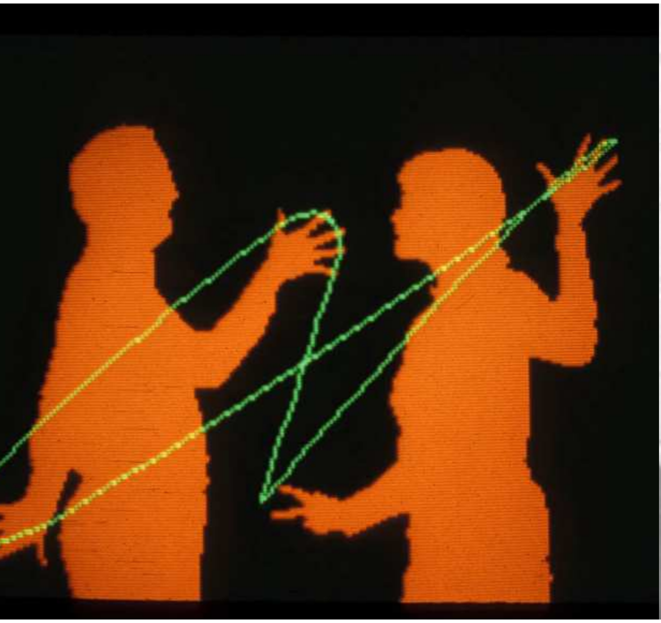
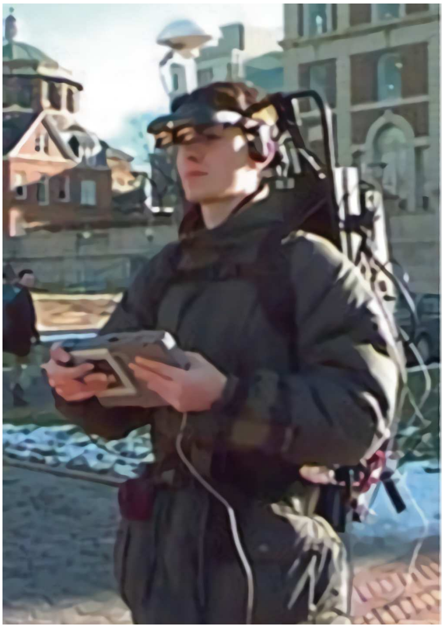
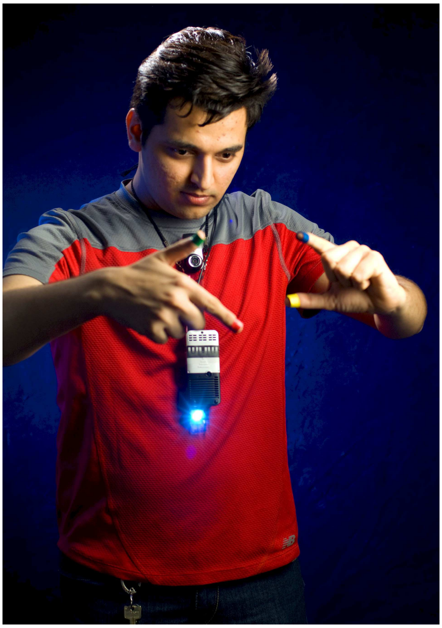


Figure 1-13 (below right)
Sixth Sense by Steve Mann in its late revision *(source: MIT Media Lab)*

Figure 1-14 (below left)
MARS prototype by Steven Feinberg *(source: [29])*

The scope of their research was to simplify the process of conveying wiring instructions for aircraft assembly to the factory floor workers. They proposed a headset that overlaid computer represented material on top of the real world (their research was later published in 1992 in a paper).
In the second part of this decade, Steve Mann develops the first version of Sixth Sense within the context of MIT Media Lab **[39]**, a gesture-based wearable computer system.
This prototype will undergo a series of iteration: In 1997 he will become a head-worn item, in 1998 a neck worn device and finally in 2009 a projected AR tool with internet connectivity **[40]** (thanks also to the work of Pranav Mistry) **[Figure 1-10]**.
In 1996, Steven Feinberg (professor of computer science at Columbia University) created the first outdoor mobile augmented reality system using a see-through display.
This project will develop some years later in MARS (Mobile Augmented Reality System) and The Touring Machine **[41]**.
The AR system was composed of a head-mounted display, a handheld tablet display for interaction, a backpack with a computer, GPS, and internet connection through digital radio for wireless web access **[Figure 1-11]**.
The system was still cumbersome and uncomfortable, anyway it allowed users to see combined overlaid 3D graphics elements with the untethered freedom of mobile computing, proving support for everyday interactions with the world, thus making a substantial contribution to the field of mobile AR.
In the same year, Sony released the Glasstron, a head-mounted display that included two LCD screens and two earphones for video and audio respectively, it could also become a see-through display

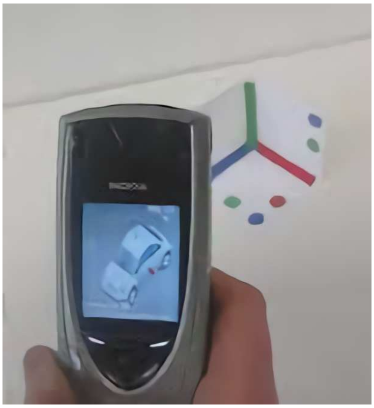




in its late revisions, this device will be later used in many AR studies due to its versatility.
Here, in the late nighties, the new-born Augmented Reality field started to become a distinct field of research, with several interactional conferences, workshop and symposium on the topic of AR and MR, became possible to rapidly build AR prototypes thanks to open toolkits like the ARToolKit and survey on the state of the technology become available **[**12**]**.
Always in these years the concept of spatial augmented reality (SAR) is introduced at the University of North Carolina, where virtual objects are rendered directly within, or on, the user's physical space without a headset **[42]**.
At the turn of the millennia ARQuake, one of the first outdoor AR game experiences, was developed by Wearable Computer Lab University of South Australia, using a head-mounted display, a mobile computer, a head tracker, and a GPS system to control the game player **[43]**.
Four years later, the first augmented reality system on a consumer mobile phone was accomplished by Mathias Möhring, Christian Lessig, and Oliver Bimber at the Bauhaus University **[44]**, making prototyping for mobile AR technologies more accessible **[Figure 1-12]**.
In 2007, Sony released for the gaming console PlayStation 3 the game *The Eye of Judgement*, introducing to the gamers audience the concept of AR, it was a card-based battle game where players used their physical cards, recognized by the PS3 camera, to control the game. The game sold over 300,000 copies, making it the most widely used AR experience at the time **[45]**.
But only two years later, in 2009, the general public will have they first experience with the world of AR, with
Indeed, this year represented a turning point for AR: LEGO launch DIGITAL BOX in its stores **[46] [Figure 1-13]**, where customers could see a preview of the products on dedicate AR totems, and Esquire Magazine publish its special on AR **[47]**, including AR markers that the reader can use to experience extra the content in real-time with the help of their smartphones, the general public interest in AR field start to raise.

Figure 1-15 (below left) First AR system on a consumer mobile phone implemented by Bauhaus University (source: [44])

Figure 1-16 (below right) LEGO DIGITAL BOX interactive totem *(source: LEGO*



Always in 2009, Projects such as *Vuforia* and *nyARToolKit* are launched, simplifying the development of AR for the web, and further simplifying the creation of AR applications.
The next decade will see Microsoft launching project *Baraboo* (relying on its experience with the *Kinect technology*), to develop mixed reality smart-glasses, it will become *Microsoft HoloLens* in 2016 with its first developer's edition at the market price of $3000 (they will launch the second version in 2019, this time aimed more towards the Enterprises field). **[Figure 1-15]**
In 2011, instead Magic Leap began to raise investments, the first round of $50 million, which will become $1.4 billion in 2014, the largest public investment in the AR field so far **[48]**.
They will launch their first retail version in 2018 for $2300, and in 2020 declared they would focus on the enterprise sector, meanwhile cutting half of their staff **[49] [Figure 1-16]**.
In 2012 Google publicly announced the Google Glass project, developed by Google X, their technological advancements division, and one year later, the Explorer Edition was made available to Google I/O developers in the United States for $1500, they discontinued the consumer edition in 2015, in 2017 they relaunch them aimed at the enterprise sector and in 2019 unveil their second edition **[50]**.
Meta company is founded by Meron Gribetz with the aim to produce an interactive real 3D headset for desktop use, the company will close six years later in 2019, and declare itself insolvent **[51]**.

Figure 1-21
Magic Leap
(*source*: Magic Leap)

Figure 1-21
Microsoft HoloLens
in its second revision
(*source*: Microsoft)

In 2016, Nintendo and Niantic released Pokémon GO **[Figure 1-16]**, an Android and iOS games that utilize the player GPS position and camera to allow an immersive and delocalized gameplay, its success allowed more and more people to learn about the concept of AR **[52]**.
Two years later, in 2018, IKEA lanced the Android and iOS application IKEA places, it allowed users to use their phone camera to preview the Swedish company catalogue directly in the real world and helped the term AR to become commonly used even outside certain fields of application, marking the definitive popularization of the term.

Figure 1-22
snapshot of Pokémon GO
(source: Niantic)

1.2.2. Future Trends

Right now, the public opinion for AR technologies is in decline **[53]**, this is expected as Augmented Reality is entering the so-called Trough of disillusionment of the Gartner hype cycle model **[54]**.
This model created by the American research firm Gartner uses a graphical presentation used to represent the maturity, adoption, and social application of specific technologies, subdivide into five phases:

1. Technology Trigger: A potential technology breakthrough kicks things off. Early proof-of-concept stories and media interest trigger significant publicity,

2. Peak of Inflated Expectations: Early publicity produces several success stories - often accompanied by scores of failures,

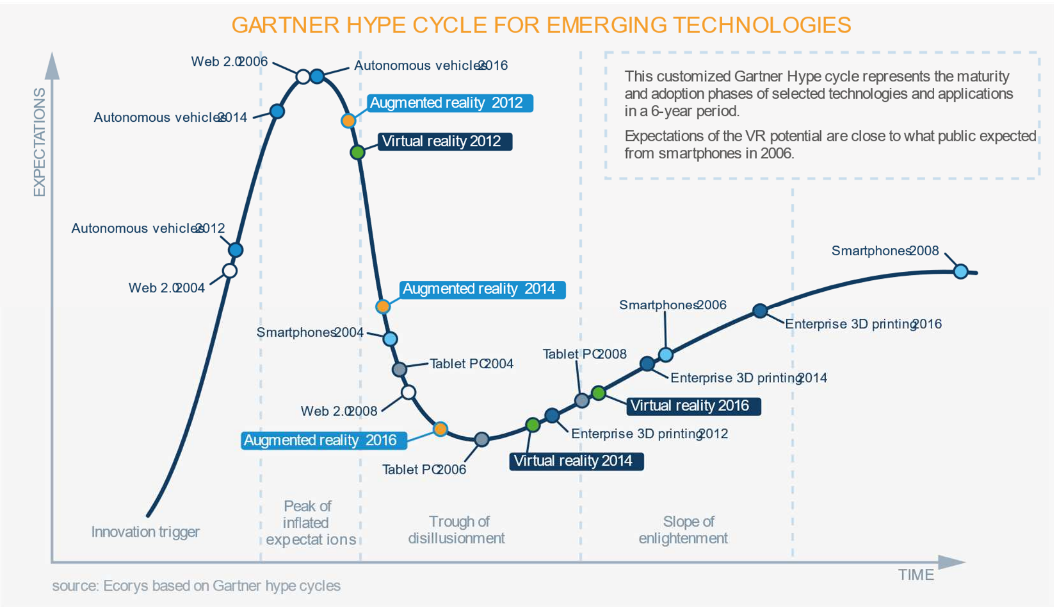
3. Trough of Disillusionment: Interest wanes as experiments and implementations fail to deliver.

4. Slope of Enlightenment: More instances of how the technology can benefit the enterprises start to crystallize and become more widely understood,

5. Plateau of Productivity: Mainstream adoption starts to take off. Criteria for assessing provider viability are more clearly defined, the technology gains market applicability and relevance.

Figure 1-23
Garten Hype Cycle
(source: [1])

If we take VR technology as a reference point, which is years ahead of AR regarding market and user adaptation and is entering the slope of Enlightenment, we can expect that AR will follow a similar pattern in the next years, with some estimation that forecasts an adoption of AR by the market in 10 years **[1]**.



1.3. Principles and main components

As we have seen until now, AR has a long history of advancements a large variety of technologies have been utilized to realize different AR experiences. In this chapter, we will provide an overview of the major techniques and technologies that today are (and were) in use in the research, industrial and cultural fields, we will also briefly indicate some of the taxonomies that are in used to differentiate these types of technologies.

This section will not represent a comprehensive list of all the possible techniques and taxonomies that could be used, but anyway, it could be useful to understand the possibilities and shortcomings of AR.

As we will see, a lot of these classifications refer to AR that is achieved using some types of display, thus utilizing the sense of vision as the main medium to enrich the user perception.

This is a clear indicator that the AR research field is focused on the visual spectrum of sense, as natural results of its roots in the information technology and Human-computer Interactions (HCI), fields that have always related heavily on visual clues and inputs to communicate with the users, just think of the first command line and then later the graphical user interfaces (UI) that characterized the first HCI.

Due to this unbalance, some of the following classifications will deal mainly with the augmentation of the visual sense.

If we should describe a barebone AR system, it will have at least these three main components **[55]**:

1. A tracking and sensing device for recording the user position in 3D space,

2. An output device for enriching the user,

3. A scene generator (as a visualization software running on a computer device) for collecting the tracking data, generate the virtual elements and finally match them together to enhance the user perception.

4. And finally (depending on the type of augmentation) the system could also include an input device for user control.

In the next sections, we will look more in detail at these components, and we will outline the common sequence on how an AR system work.

1.3.1. Output devices

An output device is defined as any tool that allows the user to enhance their perception with virtual elements, once they have been matched with the real world according to the data collected by the tracking sensors,

Considering that AR is not limited to any particular sense, this means that also the output technology cannot be limited to only a class of devices, this creates a very vast field of technologies that can augment reality, for example some of these could be: common smartphone displays, see-through monitors (both head-mounted and fixed), projectors, contact lenses screens, aural headphones, special smells dispensers, or even tongue electrodes (like in the case of BrainPort **[56]**, an aid device for blind people, where video information are converted to an electric signal transmitted on the user's tongue).

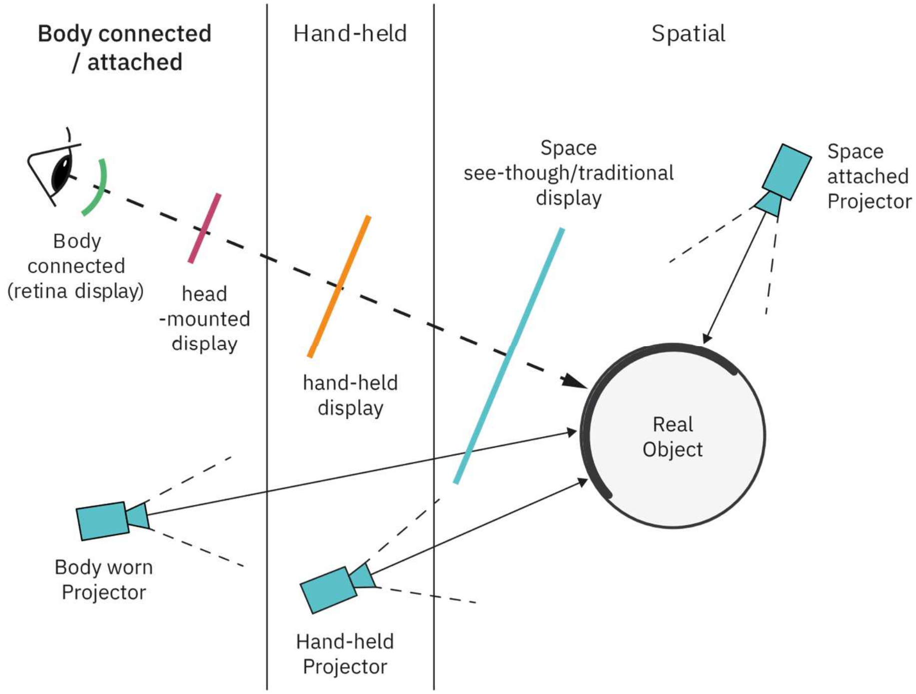
With such a broad spectrum of possible devices, a taxonomy that defines how exactly we can enhance the end-user perception become a necessity.

As we have seen in chapter 1.1, there are a lot of taxonomies that tried to cluster all the different types of devices used in AR.

One the most used is the one by Bimber and Raskar **[57]**, this classification is imitated mainly to the visual sense of AR but can be adapted also to other types of senses with some work.

They decided to divide the output devices into three main categories, depending on the distance of the output device from the users.

Figure 1-24
Bimber and Raskar's [57]
visual output
technologies classification



→ Wearable: On the closest position relative to the user, we have all those devices that are worn or are directly in contact with the user, both see-through and monitor based. They can be further dived in:

- Helmets: devices that incorporate completely the user head, such as the Daqri Smart Helmet **[58]**.

- Headsets, divided in integrated (that comes all in one form factor, like the HoloLens) and add-on (that instead are added later, like in the case of the Google Glass)

- And finally, in direct contact with the user (such as smart contact lenses, like the Mojo Vision **[59]**, bone conduction audio speakers and so on).

- Head handle: That are all the devices that the uses can hold in their hands (like a smartphone, tablet PDA and so on), or are attached to the device that the user Is holding (like in TrakingPoint **[60]**, a special optical sight used on hunting weapons where the user aim is enhanced with computer-generated aids), usually all the main AR components (Input, scene generator and output devices, that we will discuss in the next chapter) are integrated.

- On borderline between this category and the successive, we find all the devices that are not fixed to some surface, but the user had to physically touch in order to work (like in the case of the PHANTOM Omni **[61]** or the haptic canvas **[62]**)

Figure 1-25 (right)
Google Glass 2
(source Shutterstock.com)

Figure 1-26 (left)
Daqri smart helmet
(source: *domusweb.it*)

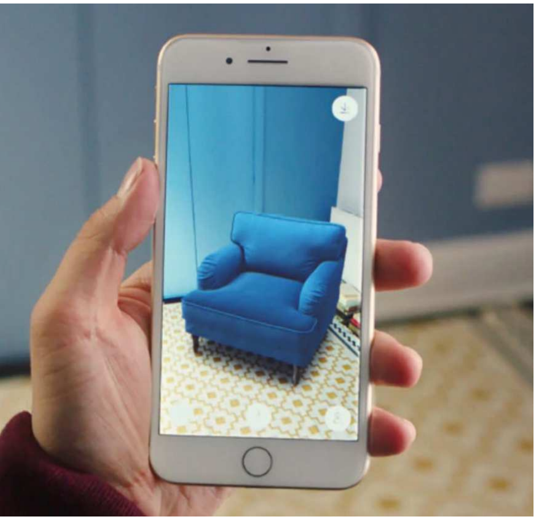


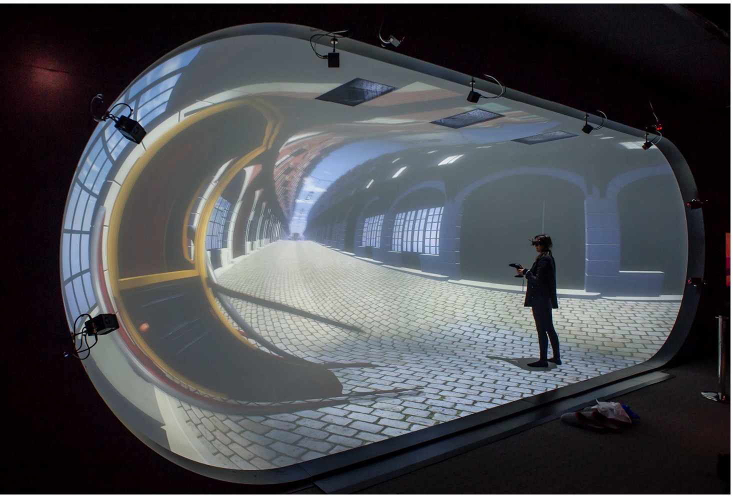
Figure 1-27 & Figure 1-28
(above left) IKEA Place smartphone app (source: IKEA)

(above right) Precision Guided Firearm from TrackingPoint (source: defense-update.com)

Figure 1-29 (left)
PHANTOM Omni haptic device (source: 3DSYSTEMS)

Figure 1-30 & Figure 1-31
(below rleft) CAVE system immersive technology (source: ST Engineering Antycip)

(below right) HUD of a Boeing 787 (source: Pablo Andrés Ortega)



- Spatial: Are all the output device that is “far away” from the user, and they could be fixed to the real world, or enhance it directly (like in the case of SAR), in this group we can find:

  - Heads-Up Displays (HUD), both factory-installed and retrofitted.

  - Stationary devices, such as a fixed display (like in the case of see-trough screen, like the LG Transparent OLED Signage **[63]**, or video-based like a normal TV monitor with an “augmented” live video feed), as well as stationary speakers, and smell dispensers.

  - Projected, both with a normal projector (like in the case of a CAVE system **[64]**) or with a retro-reflective system (such as the CastAR **[65]**), as well the on that use make use of projectors that are worn or are attached to the user (like in the case of the Six Sense device **[40]**)

Each of these groups includes completely different types of technologies and technical principles that can be used to deliver an AR experience, everyone with different pros and cons, as well different unique problems and, a clear statement of the vastness of this field and its applications.

1.3.2. Tracking and sensing devices

On the contrary of what happens with VR, where the tacking sensor could produce a less accurate position in the virtual environment, in AR their precision and readability are fundamental (with, of course, some difference according to the application), however some VR tracking methods, with the right adjustments, are used in AR as well.
The techniques that are used to track the user are various, and all of them have different pros and cons depending on the final AR system task and requirements.
We can group them in these macro-categories based on the technology that is usually employed **[66]**:

Mechanical
It relies on a physical structure that is attached to some fixed reference point, this structure is then composed of a series of linkages that connect the fixed point to the tracked object **[67]**.
Those linkages have sensors at each of the joints (usually a variable resistor, e.g., a potentiometer) that register the angle between them, thus the position is determined by calculating all of these measurements.

Figure 1-32
A mechanical tracking device developed by Fake Space

This method is quite old (Sutherland used this in the Sword of Damocles prototype) and was often used only inside research labs due to its strong limitations.

Electromagnetic tracking
Also known as Magnetic sensing, works measuring the intensity of inhomogeneous magnetic fields with electromagnetic sensors. A base station, often referred to as the system's field generator, generates an alternating or a static electromagnetic field that is piked and measured by the receiver on the tracked object **[68]**.
The need for s fixed station paired with the imitated range of operation do not provide high freedom of moments, this could be an imitating factor for outside applications.

Wireless tracking
Uses a set of anchors that are placed in fixed spaces and one or more tags attached to the tracked object. These anchors broadcast a signal that is received by the tags and then triangulate to know their 3D position **[69]**, the specifics of these wireless systems are varied and depend on the type of application, the desired range and precision (e.g., some system could use a Wi-Fi signal or localization beacon, as well the GPS signal if the precision is not required and the application is outside).

Ultrasonic or Acoustic tracking
Use various techniques similar to those found naturally in animals (i.e., echolocation), they utilized a set of at least three ultrasonic sensors and at least three ultrasonic transmitters on the devices to calculate the position and orientation of the object.
Again, this method required a fixed transmitter and has an imitated range, so may not be suitable for external application.

Inertia tracking
It uses data from accelerometers (that measure linear acceleration) and gyroscopes (measure angular velocity) that can be integrated to find the position and orientation relative to some initial value (the origin point) **[70]**.
Modern Inertial Measurement Units systems (IMU) are based on MEMS technology and allows to track the orientation (roll, pitch, yaw) in space with high update rates and minimal latency.
Usually. dead reckoning techniques and prediction algorithm are used to track positional data, hover due to the intrinsic characteristic of dead reckoning that leads to drift, this type of tracking method is unreliable if used for a long span of times without recalibration.

Optics:
It uses cameras to determine position and orientation based on computer vision algorithms, it’s also one of the most promising tracking methods for AR **[71]** as well as one of the most used and researched, it can be father divided **[72]** in: Marker-based or marker-less: Optical tracking can be done either with or without markers, tracking with markers involves some types of targets (such as a known pattern) to serve as a reference point, this target is constantly sought by the image recognition algorithm in camera feed, once this is found, other algorithms are used to extract and match the position of the object.

Markers can be visible, such as printed QR codes, barcodes or fiduciaries markers, or can be optical, such as infrared light LEDs embedded directly in the tracked objects or reflected back to a tracking station.

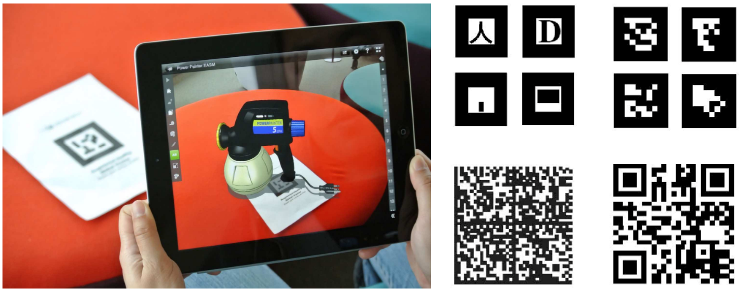
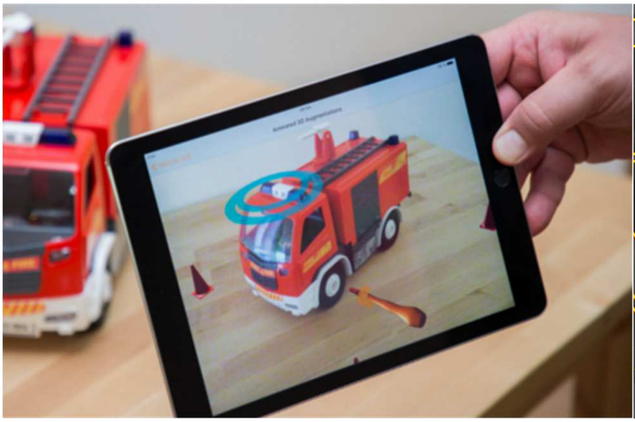


Figure 1-33

(left) example of a Marker-based tracking with a hand handed device
(source: areteproject.eu)

(right) Examples of Markers commonly used in marker-based tracking
(source: ARTag, a fiducial marker system by M. Fiala)

On the other end, marker-less tracking does not require any pre-placed targets but instead uses special algorithms (usually built with the help of machine learning procedures) of features recognition to track a desiderated object.
The type of features that are actively sought can be natural elements of the environment (such as the edges of a structure, the ground plane, a surface topology), or can be object-based (a predefined object, human traits like faces or hands, body positions and so on).



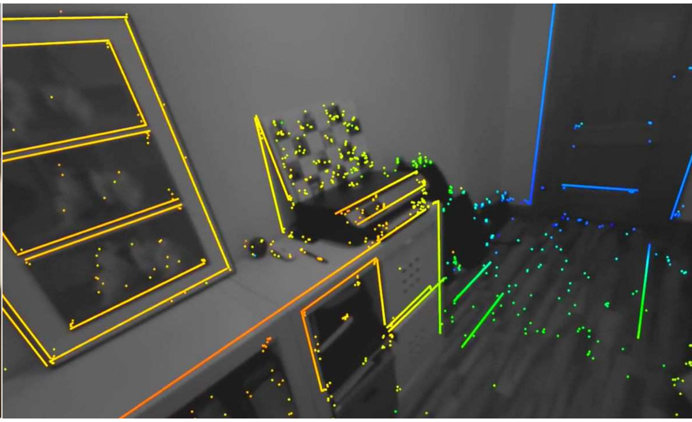
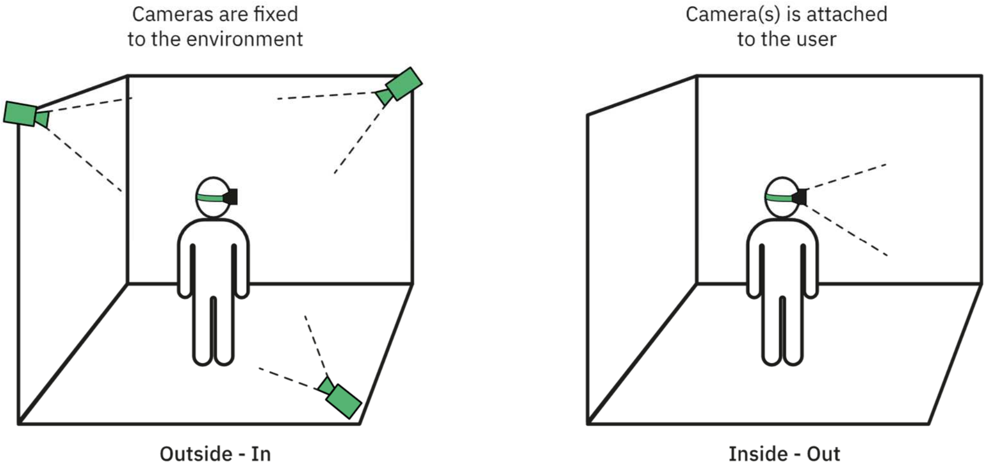


Figure 1-34 (above left) example of feature tracking on a toy (source: wikitude)

(above right) SLAM tracking with border recognition (source: Kade Barrancoe)

Figure 1-35 (below) Outside-in, Inside-Out tracking differences (source: delight-vr.com)

The second fundamental differentiation for the visual tracking is the Outside-in / Inside-out configuration; In the Outside-in configuration, the cameras are placed in stationary locations around a pre-defined environment, those cameras constantly survey the area in search of the known references points (both marker-based and not), and carry all the limitations that space-imitated tracking has.
In the Inside-out methods instead, the cameras are attached to the tracked object and thus look outward to determine its location in the environment.
This method can work with or without markers, but lately advanced marker-less techniques are used, one of those is SLAM (Simultaneous Localization And Mapping) **[73]**.
It uses advanced feature detection and reconstruction processes to create a 3D map of the surrounding in real-time, then machine learning algorithms are deployed to determine the position and orientation of the tracked object within the 3D map.



The SLAM method is quite performance heavy and is usually employed by high-end headsets like the Microsoft HoloLens or the Magic Leap, anyway, this technology allows these devices to be self-contained and highly versatile at the same time.
Usually, more than one method is used to collect data, then through several sensor fusions algorithms (that match the data together), the results are processed to get a more precise and reliable position. Using more than one sensor is also useful for compensating the shortfalls of each sensor, for example, an optics sensor can be paired with an inertia one, this is beneficial because they synergise well together: inertial sensors are optimal for tracking fast movements but accumulate errors quickly (i.e., sensor drift), the optical one can help to provide an absolute reference point.
On the other way around, inertial tracking can help exceed some shortfalls of optical tracking (like reference points occlusion) providing an estimation of the position until the reference point is visible to the optical sensor again.

1.3.3. Scene generators

Also called processors, are the components with the task to create the virtual elements, collect the data originated from the tracking and sensing devices, modelling the real environment on the base of these data, and finally match the rendered virtual elements with the tracked real world in order to enrich the user perception.
Nowadays this job is usually carried out by some software running on a computer (that can be dedicated or specific) that, generally speaking, execute four distinct tasks to achieve its task, here there is a brief description of these **[74]**:

1. Screen capture: the system processes a single frame, namely the single "snapshot" that the sensors communicate to the computing device, (e.g., s single frame if the sensor is a camera),

2. Scene identification: is the key process that differentiates AR from VR, this step varies widely depending on the type of sensors, and the tracking technique used,

3. Scene processing: After the scene is captured and identified, the virtual elements are created and then mixed with the captured scene, essentially any type of virtual information (i.e., audio and video) is matched with the real scene,

4. Visualization: When the process is completed, the results are outputted to the users (e.g., if the output is an image, this is displayed on the screen).

These processes can be quite complex depending on the type of sensor and the quality and quantity of the data collected, not to mention the direct access to the gathering hardware.
On this complex matter, today there are available SDK and third-party tools that are built to simplify this process and communicate directly with the underlying hardware (some examples are: Unity 3D game engine **[75]**, Vuforia **[76]**, ARCore **[77]** and so on).
According to the resolution and type of virtual elements rendered, the load on the computing machine could range from trivial (in the case of wireframe and simple graphical elements and sounds) to really heavy (in the case of complex 3D elements with photorealistic shaders, or if is processing and modelling a lot of data coming from the sensors).
Devices that can run these processes in the last two decades are become quite available and can range from common smartphones (for small to medium loads) to systems that employ a laptop in a backpack configuration (like the HP Z VR **[78]**), reaching also stationary systems like traditional workstation with powerful graphics card or dedicated servers, that then deliver the data through the network to the output device.
In some case they can also run-on custom build hardware that is designed specifically for this type of operations and can be light and mobile (like the HoloLens, the Nreal Smartglasses **[79]** or the Magic Leap).

Figure 1-36
(below left)
Nreal Smartglasses and its external computing unit
(source: Nreal)

(below right)
HP Z VR backpack computer
(source:: HP

1.3.4. Input devices

As we have seen until now in this chapter, the domain of possible technologies and solutions that AR can use is really large, and this is also true on what concern the possible types of interaction techniques used by users to interact in this new and unique space.
Here in this chapter, we will touch and illustrate only some of them, again, this will be by no means a complete collection of input

modalities that can be used in AR, but it could be a good starting point to understand what has been done, and where the research is aiming.
Before we start to describe them, we had to discuss some aspects that these new interfaces must have to create intuitive and direct interactions between the user and the virtual content of AR. According to Julie Carmigniani and Borko Furht **[72]**, there are three non-exclusive possibilities for such interfaces:

- → *collaborative AR interfaces*, which includes the use of different technologies to support remote and co-located activities such as remote sharing of collaborative workspaces and telepresence.

- → *hybrid interfaces*, then combine an assortment of different, but complementary interaction methods as well as the possibility to interact through a wide range of devices.

- → And finally, *multimodal AR interfaces*, which combine real objects input with naturally occurring forms of language and behaviours such as speech, touch, natural hand gestures, gaze or bio-signals.

This last type of interface is also often called *Natural User Interface* (NUI) and is a recurrent theme in AR interfaces since the 90s when Steve Mann began to use in his works on AR terms such as "natural user interfaces", "Direct User Interfaces", and "metaphor-free computing"**80**, It is also one of the most discussed **[81]**.
Right now, there is no standard defined for interfaces in AR due to the vastness of this field, it is also unlikely that only one type of these interfaces will be adopted over the other, being the use of AR at the moment task centred, and one solution could never fit all the possible use cases that this paradigm cover.
Here are some of the most used input categories in the past and now:

Direct interaction with the AR device
It is one of the simplest ways of interaction and consists of controlling the virtual element directly on the AR device itself (like tapping on the side of google glasses or using the touchscreen of a smartphone), according to the type of AR system it could be the most straightforward way of interaction.

Figure 1-37
(above left)
FinchRing tactile
controller
(source: Technologies Ltd)

(above right)
Leap Motion Controller
(source: Ultraleap)

Figure 1-38
(below left)
Cyber Glove II
(source: CyberGlove
Systems LLC)

(below right)
Magic Leap One Controller
(source: Magic Leap Inc)

External Physical devices (i.e., hand controllers)
It consists of using external physical devices that are not physically connected with the AR output device, such as hand controllers, remotes, wands, wireless special keyboards, gyroscopic mice (like in the MARS prototype **[82]**) and so on.

Gestures recognition and hand tracking
Where, as the name imply, directly uses the users' hands to interact with the AR application, this is an attractive alternative to other cumbersome devices (such as those described above), hand gestures can help in achieving ease and naturalness that NUIs process. There are a lot of prototypes and commercial devices that can be used to perform gesture and hands resonation, the most commonly used are: *special gloves* (called also data gloves, wired glove or cybergloves, and were one of the first types of device used to get data from the users' hands position), *waves or eco-localization* (that determinate the distance of the hands from the wave or sound source), and lately *IR* or *normal cameras* (that paired with special recognition software can track the hands in 3D space).

Voice recognition
also called speech recognition, is an input technology that has a long history In the HCI field.
From the 50s, it has undergone a series of iterations and only in the last decade has reached the common consumer.
With this input device, the users directly communicate to the device with their voice, and according to the complexity of the system, these commands could range from really simple to syntactically complex, and these could be useful to achieve a similar human to human interaction with the devices.
In the context of AR it could be really useful in situations where the user could not use their hands, (like in the case of assisted maintenance), anyway, its strong limitations and issues in both in the practical and social domains, make the uses of this input really imitated and task-specific.

Eye-tracking
Eye-tracking consists of measuring the point of gaze (where one is looking) or the motion of an eye relative to the head, and today is primarily used for behavioural studies in real-world environments and ophthalmology studies, but also as an interface for disabled people (like people affected by Tetraplegia).
Eye-tracking in the context of AR can be used as an attention and context selector paired with other input devices, but right now its limitations, like the physical integration in the devices, the lack of common user interaction paradigms, the calibration required to filter involuntary eye movements and errors correction (that are unique to each person **[83]**), makes its adoption challenging.

Tangible interfaces
In this type of interfaces, users interact with the digital information directly through the physical environment, in this way, real-world objects become the input device themselves, allowing unprecedented simplicity and intuitiveness to the interaction **[Figure 1-34]**.

In the context of AR its possibilities are endless, for example, consider this user scenario: Marco is repairing his car in the garage, he is wearing an AR headset like the Magic Leap, and his visual perception is enhanced by task-specific information like the user manual presented directly on his field of view.
These instructions then could be different if he decides to pick up a wrench or a screwdriver, the physical tool in this context is used as an input device for the virtual elements **[Figure 1-33]**.

But tangible interfaces are not imitated only to single objects, they could be referred also to entire environments: in our previous example, let's imagine that Marco went to the kitchen to take a glass of water, the information visualized has changed, and now are showing what is in the fridge and that he needs to go out to buy some milk.
In this context, changing the room means that the purpose of the space has changed, thus also the interface and information visualized had adopted accordantly.

Figure 1-39

SandScape,
an example of
tangible interface
(source: Ars Electronica 2016)

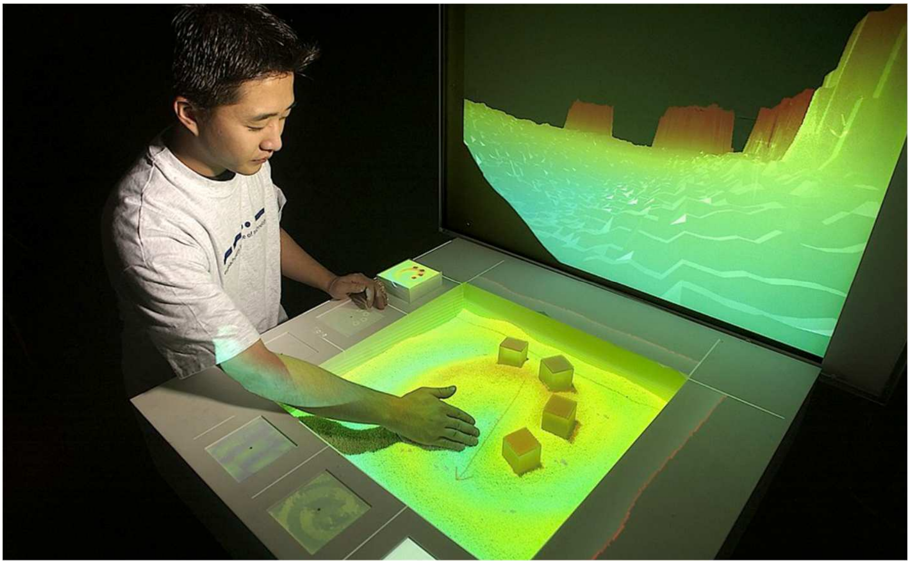
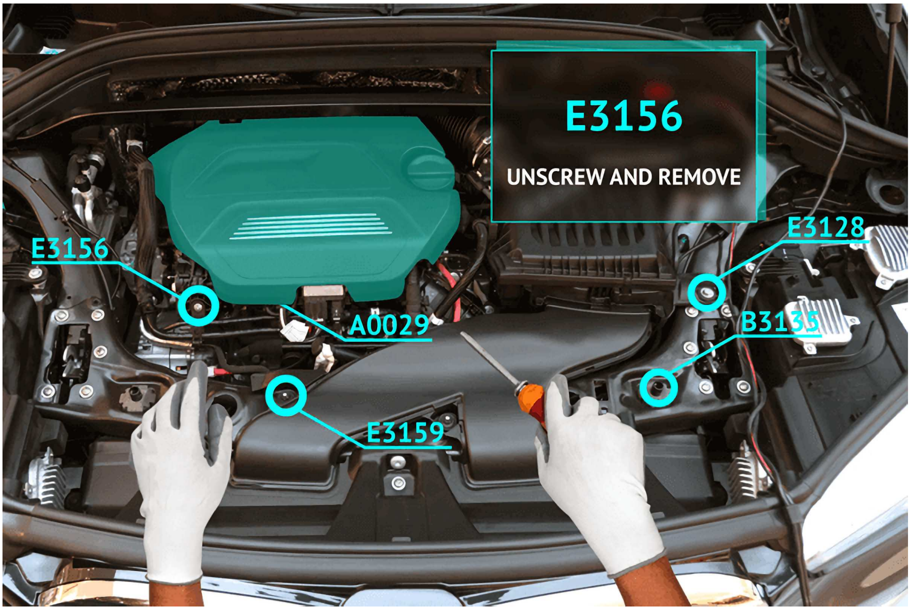


Figure 1-40

Concept of car manutention
aid with an AR interface
(source: zealAR)



1.4. Uses & fields of applications

As we have seen in the previous chapters, with a so broad spectrum of radically different type of technologies and possibilities, also the spectrum of possible application it can only be large as well. As we have already discussed in chapter 1.2, the first applications for AR were related to the military field, and only at the beginning of the 90s, they entered the civil field, and specifically in the guided maintenance and assembly research fields (with Feiner **[84]**, Caudell and Mizell **[**5**]**).

Anyway, over the years researchers and developers found more and more areas that could benefit from augmentation, expanding more and more the possible field of applications, and today it is difficult to think of one sector that could not be helped by some form of AR.

Now we will see a quick and not comprehensive overview of the major field that have been explored or hypothesized to benefits from AR in one way or the other, briefly discussing the main solution and possibilities adopted.

This chapter is divided into several fields coming from both public and private sectors, they are presented without following a specific order, and a lot of the solutions presented are transversal to more fields.

This set should not be taken as an inclusive taxonomy of applications (that is beyond the scope of this work), but more as an overview aiming at better understand the possible application and possibilities of this new paradigm.

1.4.1. Military

This field could be considered the father of wearable augmented reality, and one of the first heavily researched in the domain of AR (think at the first research in the field of the 40s and 60s). Some technologies are already in use by fighter jet and helicopters pilots (think to cockpit HUDs, HMS and recent “smart” helmets, like the F-35 pilot helmet **[85]**) to visualize the fight data directly in front of them and minimize distraction and reactions times, lately, these helmets are being deployed also in heavy vehicles, like tanks **[86]**.

But AR could also be used directly on the battlefield, traditional information systems required the soldiers to look down on maps or mobile devices to access tactical information, and thus to direct their attention away from what is happening in front of them, AR could instead allow soldiers to acquire time-critical data on the environment around them directly in front of them, this has experimented extensively with the BARS **[**Errore. Il segnalibro non è definito.**]** prototype, but only in the last years these types of devices are being considerate usable by the US Army **[87]**.

Figure 1-41

(above left)
First Gen III F-35 Helmet
(source: Rockwell Collins)

(above right)
IVAS CS 3 Military Form
Factor Prototype
(source: Courtney Bacon)

1.4.2. Education & Training

Education and Training are one hot topic for AR (and also VR technologies), they could complement or enhance a standard curriculum by imposing a graphic, video or text, and audio into a student's textbook or practical exercise in real-time, facilitating the learning process through experiences, and the so-called learning by doing.
This holds true also in the field of training, where learning by doing is often the norm like in medical and first aid training, here students and medical professionals need more situational experiences, especially for the sake of patient safety, but not only, in the context of medical training **[88]**, AR as proved itself to provide a rich contextual experience to help practitioners to achieve core competencies, such as decision-making and teamwork, these could be also expected in other fields.

1.4.3. Healthcare, medical and Emergency response

The medical field has a long story of using imagining technologies for tasks such as pre-operative imaging studies of the patient, that provide the surgeon with the necessary view of the internal anatomy, and image-guided surgery, that help the surgeon perform the operation.
With technologies like these used in the field, is not surprising that this domain is viewed as one of the more promising for augmented reality systems.
Using AR systems would give doctors "X-ray vision" inside the patients, this would be very useful during minimally invasive surgery **[89]**, which reduces the trauma of an operation by using small incisions or no incisions at all.

But the benefits could not be only for surgeons, also roaming nurses and doctors could benefit from important information being delivered directly to them when they needed, like manage patients' medical history or visualize pertinent information during an emergency, like a stroke.
Another subfield of research in the medical AR field is the therapeutic one, some examples are post-stroke hand rehabilitation training **[90]**, phobias and psychological disorders treatment **[91]**, and help patients to cope with an illness or condition **[92]**.
Another prolific branch of research is the use of AR technology to assist the impaired, such as supporting the visually impaired through augmented navigation, communicate using the eyes (using devices such as eye-speak **[93]**) or help navigation in complex environments.
Concepts are also being envisioned to help first responders **[94]**, not only in the training phase (like we saw), but also on the field, providing a hand-free real-time link of position and point-of-view display between the responders and the situation manager, improving coordination and analysis of the situation, as well as collecting detailed and accurate information about the environment and the situation.

1.4.4. Architecture, Engineering and Design

Computer-Aided Design is a group of software made for Industrial designers, mechanical engineers, architects, interior decorators and so on, that in the last 40 years have the way these professions create and envision new things, environments and realities.
This revolution is destined to repeat with the advent of AR and its possibilities, leading us to spectacular insights in these fields, enabling large and complex 3D CAD data to use for direct visualization and comparison with real-world conditions, as well as modelled and simulated.

Figure 1-42

(above left)
AR utilization concept in education
(source: Case Western Reserve University)

(above right)
AR utilization concept in surgery
(source: Microsoft and Philips)

AR could be also paired with telepresence; clients or experts could literally "walk-around" the virtual model inspecting it in order to generate useful insights, even in the earlier stage of the design process, even before a proper prototype is built, speeding up and making the whole process more efficient.

1.4.5. Manufacturing, Logistic and maintenance

As already mentioned, one of the first use for AR in the public sector was on the assembling line of a factory, and to communicate maintenance instructions, undoubtedly these sectors could benefit from the adoption of this technology, allowing the operator to increase their productivity, both during training and on the job. AR could support manufacturing, logistic and maintenance tasks by acting as an "x-ray" like visor, by providing information from sensors directly to the user or providing technical documentation superimposed directly "onto" their field of view.
Even more, like what we have seen in the previous section, telepresence could immensely help the AR worker in case of troubleshooting and repair procedure of complex machinery, where an expert could guide the action of the operator on the field to accomplish the task in the best way possible.

1.4.6. Vehicles & Machinery control

Assistance in flying aircraft is one of the pillars of AR, with its roots going back during World War II (as seen in chapter 1.2), and made its way also in the commercial field, and today is present in some form or another (the most common as a HUD that overlays flight information on what the pilot can see on the windscreen) and is even becoming of common use in commercial drone field, where drone pilots use HMD to proper flight their devices.

Figure 1-43

(below left)
AR utilization concept
(source: Microsoft)

(below right)
Mira headset use
in logistics
(source: *Mira Labs Inc*)

Today these HUD are being used more and more also in non-flighting vehicles, like cars and trucks, and consist of small screens that project on the windscreen the most important information for the driver, like vehicles speed, direction, the location of lane markings, how close the car in front of you is, nearby points of interest (such as gas stations or parking lots) and sign recognition in the most advanced model.

1.4.7. Arts & Culture

One of the first use of AR principles could be traced back to the mid-IX century with Pepper's ghost illusion, used to enhance theatrical plays all around the world as a special effect.
Art galleries and museum exhibits have been experimenting with this technology since the early 2010s to better enrich the visitors' experience, offering also supplemental “backstories” to pictures along with some history of the personalities involved.
One interesting application of augmented reality in the museum context is the “museum or Stolen Art” (MOSA) **[95]** in Hertogenbosch, southern Netherlands. It is an art initiative to let people enjoy art that they could only see in a virtual way because it is stolen or destroyed.
Another interesting application in the art field was made in 2015 by a group of New York students, called NO AD **[96]**.
In this AR project, the New York subway movie posters and product adverts were virtually replaced with works of art curated by RJ Rushmore of Vandalog.
It consisted of 39 GIF artworks by 13 artists and collectives that commuter could access through the use of an AR mobile app.
Another use of AR in spectacles and performance art and exhibition could be found also in the art form of projection mapping **[97]**, where entire buildings or environments are enhanced by projecting an image 3D mapped on the real space in order to create various illusions, effects and display certain information.

Figure 1-44

(below left)
AR head-up display by ASU
(source: chinadaily.com.cn)

(below right)
NO AD installation
(source: Luke Dormehl)

1.4.8. Commercial & Enterprise

Some application already disused could eventually be used also in the enterprise sector, mainly in the collaboration field such as conferences and telepresence devices, anyway in the last year a lot of attention has been reposted in the commercial and marketing sectors.

Starting from interactive product packaging and passing through print ads and billboards, Augmented marketing" have opened a new range of communication opportunities to enhancing brand image and utility, with the objective to increase consumers conversations and brand recognition.

These first experiments were introduced in the early 2010s with various advertising campaigns made with the help of QR codes and special AR mobile apps, one example overall is the 2014 charisms campaign made by the Coca-Cola company **[98]**: In this promotion, users could interact with some brand icons, such as their bottles and trucks, using the Magic App, an application that the customers could download on their smartphone in that period.

Another large branch in the commercial AR sector is the virtual "visualize before you buy", where products are shown to the consumer in a virtual way before they purchase the goods, this is achieved through various methods, such as: *special totem* inside Brick and mortar shops (like the LEGO digital boxes in their stores or the Magic Mirror prototype **[99]**), in *virtual e-shop websites*, using a webcam (as in the case of the Ray-Ban store), or with the use of an *AR application for smartphone*, like IKEA Place (where users can visualize in real-time and with the right dimension the company's furniture catalogue before the purchase, eliminating the issues of measuring and imagine the product in the real environment).

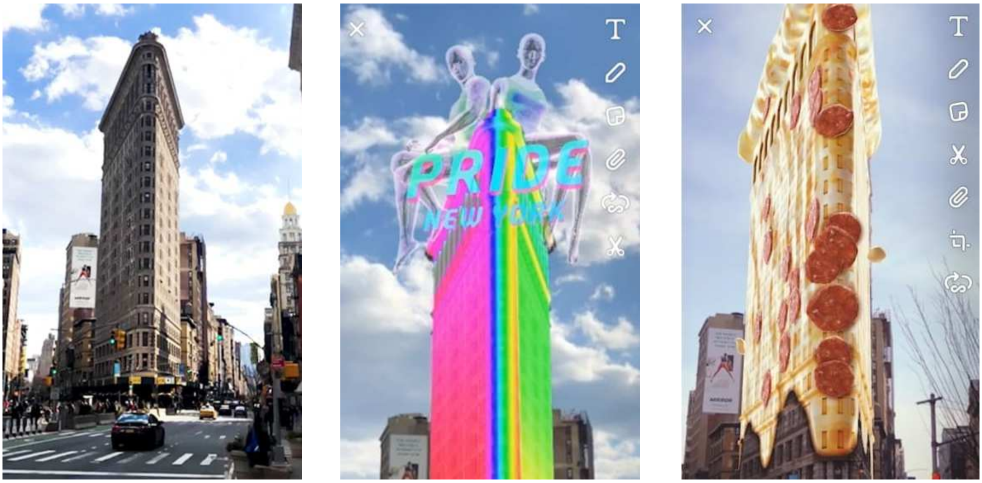


Figure 1-45
Snapchat lens studio ADV experiments (source: Snap inc.)

1.4.9. Consumer Sector

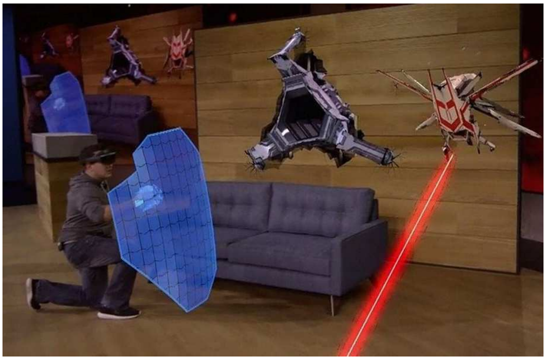
The needs and usage of commercial and enterprise AR are dramatically different from consumers, whereas commercial and enterprise users are more concerned with functionality and return on investment and reliability of the solution, the consumer sector would be most interested in appearance and price.
AR for the consumer sector is here today, but it is still in its infancy and not ready for wide adaptation (similar situation of the smartphones in the mid-2000s), someone speculates that its evolution will take years, but at the same time has a lot of potential **[93]**, anyway
There are a lot of problems that must be addressed before AR could enter this market (such as social acceptance, battery, data connection...) but we will see these in the next chapter, right now let us focus on what fields, unique to the consumer sector are the most interesting for AR.
Right now, one of the most used applications for AR in the consumer space is probably the features Lens by the social network Snapchat **[100]**, it consists of special AR filters that are applied directly on the camera field of the smartphone to enhance the picture with various effects, and currently this is mainly used for sharing contents on the social network, but could be also expanded to other fields, like fashion and makeup industries, where not only the users could previsualize before purchase product (like we have seen in the previous chapter) but also purchase virtual and unique items that only them could use **[93]**.

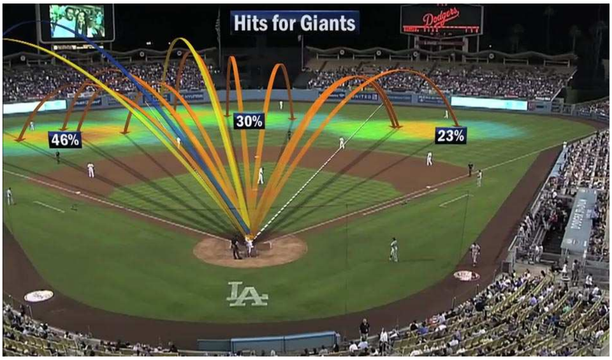
Figure 1-46:
(top – left)
HoloLens AR game demo
(source: Microsoft)

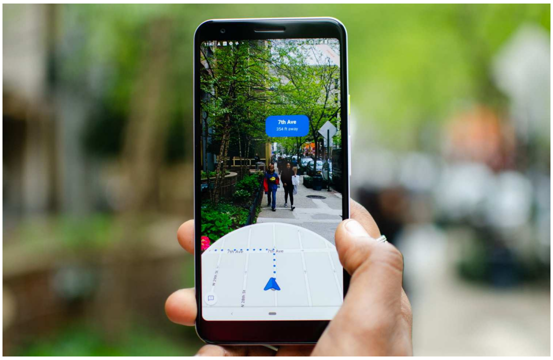
(top – right)
Sport vision technology used in a baseball match
(source: Piero Augmented Reality)

(bottom – left)
Recon-Zeal Transcend smart ski googles
(source: Recon-Zeal)

(bottom – right)
Google Maps AR walking directions
(source: Digital Trends)







It’s also used by business to reach wider and wider users, through tailor-made marketing campaigns (as we have already seen in the previous chapter).
One of the most anticipated filed of adaptation is the entertainment one, and specifically the game sector, with advancements and prototypes carried out as early as the 1990s within institutions like MIT and the University of South Australia.
Initially, the solutions were cumbersome, like in the case of AR Quake in 2000, where the players in order to “play” needed a computer backpack, gyroscopes and head-mounted display, this allowed them to control the game with their current physical location. Later with the advancements of devices and software, other alternatives come out, like augmented reality Tennis for the Symbian platform (develop by the NVIS Linköping University **[101]**).
On the end of the 2000s, always more player started to approach to AR gaming thanks to the games like “The Eye of Judgment **[**45**]**” for the gaming console PS3, that used a camera as the main input control (see chapter 1.2 for more info).
During the 2010s always more game-integrated the use of AR as a feature, but no other game did more to introduce the concept of augmented reality to the public than Nintendo’s Pokémon GO. It was a free-to-play, location-based augmented reality game published for iOS and Android platforms and quickly became a global phenomenon with downloads exceeding 75 million in the first year. Pokémon GO has been credited with making augmented reality understandable and more accessible to millions of people who never interacted with an augmented reality game or device before, but also attracted a lot of critics, about the user data and physically safety (countless were the cases of injury on the player due to lack of attention or starlight up attacks by malicious people), turning on a spotlight on AR issues that until that moment were only hypnotizes or just unknown.
In the customer sector we also have the use of AR in sports, both to enhance the viewer experience during broadcasts, such as the Sport vision technology that highlight some aspect of the game invisible to the spectator (like the trajectory of a ball, the touchline in a football match, the disk in hockey games and so on...) or in devices aimed to improve the perceptions of who is practising sport, like in the case of the Recon-Zeal Transcend **[102]**, an augmented reality goggles targeted at skiers and snowboarders, that using a micro LCD display is able to show all the important information the user needs at the moment.
Finally, in the last years we have seen also the use of AR to help customers access tailor-made information (and Ads) directly in the real world, such as in the case of Yelp Monocle and later inside some Google products (such as Maps and Translate) that have some AR capabilities. These features and applications, usually really on the phone camera to add 3D layers of information on the real world to help the users, and can range from place reviews around them, wayfinding, object, and products through trough AI, on the moment translations of texts and audio and so on, features that undoubtedly will change the way people relate to the world around them.

1.5. Limitations and issues:

With a so broad range of technical solutions and fields of application, as many different and unique problems can only rise, in this chapter I will try to illustrate the main problems that both academia and the industry have been trying to address in the last three decades, please note that, again, these will not be compressive list and each of them is a topic that will require a book to fully understand and discuss.
These problems could be specific to one form of AR and completely irrelevant to another (e.g., smart glasses must be discrete and follow precise ergonomic criteria, but this is not true for special augmented reality, which instead faces a completely different type of problems).
We will split this chapter into two macro-categories, the technological problems, and the user issues to better understand and illustrate the problems.

1.5.1. Technological problems:

In this group we can find all the issues that are created by the hardware itself, they are specific for each component of the system defined in chapter 1.3 and vary widely according to the devices.
Output devices have unique issues according to the type of application: Visual components like Optical see-through and video-see-through displays have their own peculiarities such as deficiencies in resolution, field of view, brightness and contrast (especially if the system should be used in an outside settings), optical problems such as stereo vision (for example, no interpupillary distance or vergence adjustment), focus adjustment and deep perception are the most common ones for head-mounted devices.
Audio output is usually trouble-free, but according to the situation could be difficult to integrate or unappropriated, like in the case of wearable technology or spatial AR, instead, other devices, like the olfactory one, are not suitable for mobile AR and are imitated in their application (like when applied inside stores or exhibitions), and have issues related to the “persistence” of the smell, that usually is difficult to clear in large spaces **[103]**, taste (gustation) and vestibular senses are still in the prototype phase and hepatic display depending on the application could be difficult or impossible to integrate.
For what concerns tracking devices, according to the technology chosen, the range, accuracy, robustness, latency, ergonomic comfort, and user-friendly calibration vary immensely **[104]**,
this dictates that, while certain systems have achieved good performance in one or some of these characteristics, it often comes at the expense of another (for instance, high accuracy can be achieved over a short-range, or low-accuracy over larger spaces), this might work for some application classes (for example, AR over a desktop area versus AR in a room) but clearly there is work to do.

Usually, more than one tracking methods is used to balance all the advantages and disadvantages of each component, but these could add complexity and points of failure to the system.
Tracking in unprepared environments, such as in outdoor situations, remain challenging, problems like noise and orientation errors when tracking distant objects, recognition of boundaries between physical and the virtual world, environmental factors such as lighting, weather and bad lighting conditions constitute difficulties that still need to be resolved **[105]**.
Related to the scene generation, nowadays the computational power required to run an AR application is quite available and distribute, even in consumer products (like a common smartphone) **[103]**, this of course could vary widely depending on the specifics and the task that the system had to perform, for instance matching some data form the sensor to get the device position is less intensive than traying to modelling and blending all the virtual elements with the real environment.
With this in mind, the main issues derived from the trade-offs that are made when choosing the most suited solution for the AR system; these include decisions such as portability vs power, portability vs network access, or cross-platform performance vs the need for network access.
Generally speaking, one of the most adopted solution, when portability is needed, is a standalone application on a handheld device (like a smartphone or smart tablet), However, if the application requires more computation or memory than the device supports, the trade-off should be done between a larger system (like a laptop in a backpack) or to connect the portable device to a remote server via a network, these anyway open a lot of problems on the network availability and reliability of the system.
In general, for AR in mobile settings, the hardware used should be small, light, easily portable and fast enough to display graphics, all this then should be powered by a battery with enough capacity to allow a good time span of usage, but without weighing down and waste space on the device **[105]**.

1.5.2. User Issues:

Moving away from the world of technology, also from the final users' viewpoint there are a lot of topics unresolved, these are usually related to the ergonomic world, both physical, like the weight and comfort, but also in the cognitive space, such as usability, interaction and satisfaction of using AR applications and usefulness perceived by the end user **[**105**]**.
Indeed, all the interaction methods described previously have their problems, that depending on the situation can range from small discomforts to completely inappropriate.
Also, well-established User Interfaces paradigms such as the traditional WIMP (Windows, Icons, Menus, and Pointing) have issues, and in some situation could not be the best interaction methods for AR, this has led some researchers to argue that they should be

rethought, favouring multimodal interfaces that simplify the communication with the users **[106]**, without overload them with information while also preventing them to overly rely on the AR system. This anyway create a new set of unique problems, such as the lack of standards, both in the interfaces themselves, but also in the evaluation methodologies used to created and tests these interfaces, the next sections will be totally dedicated to these issues.
Another big problem that an AR will face, mostly in the consumer mobile AR domain, is the social acceptance by the users themselves and the people around them, both in terms of natural interaction and fashion **[107]**.
Let us consider, for example, a smartphone notification system that procures a distraction to the user, these distractions are mostly considered to be socially unacceptable if the owner of the devices is distracted from having a conversation with someone or if this disturbs also other persons present in the same ambient (of course this change according to the culture and the customs of the place). This is another hot topic for AR researchers and has been found that interaction with an Augmented Reality system implemented in mobile applications needs to be subtle, discrete, and unobtrusive, thus do not disrupt the user and the people around the users and be considered socially acceptable **[108**].
Another important factor to socially acceptable devices is that the user has to be able to interact with the device in a natural way. If the interaction between the user and the device is unnatural, it will appear awkward to use in public places, for instance, using hands gesture in mid-air to control an AR mobile system in the middle of a crowded bus could be considered not acceptable by today standards.
Any mobile system will also face fashion issues as a user usually will not want to wear a bulky HMD or other visible devices. As a result, developers of mobile systems should take this into account as well as fashion trends, this right now is a big obstacle to overcome, considering that common fashion items could not have the space to accommodate all the technical device required to provide properly AR.
Finally, personal mobile AR systems should also consider the privacy issue **[109]**, meaning that the accessed information should only be viewed by the device user, and not others, systems like the MIT six senses that project directly the information onto the ambient has exactly this kind of problem,
On the other end, sometimes is useful or necessary to share the information that the user is viewing, thus these systems should also have the ability to share this information if the user desires to.
In addition, AR mobile systems need to be careful not to violate the user (and also other users') privacy, indeed, information that are available and not considered private on social networks can be considered private in everyday life, as a result, technologies that make use of online available information might face privacy issues due to the way, and witch settings, the information are being disclosed.

1.6. Problem definition

As we have discussed in this brief introduction on the background, possibilities, and issues that Augmented Reality has, we saw that in the last 40 years the research has advanced considerably, but still a lot of problems needs to be resolved, both in the technical field and in the user side.

Indeed, most of the research conducted up to this point focused mainly on how to overcome hard and software issues, with only a little part devoted to the user-centric side of this field **[110]**.

With different groups involved in the AR research process with a strong technology centre, it is not surprising that the results that emerge are new technologies and prototypes that do not fully address any specific user problem.

This process unquestionably drives technological advancement, but on the other hand often forgets the end-users, that often find themselves without a useful and usable implementation.

This is expected, as in most emerging technological fields the initial effort is spent on the technical issues, however, as the field matures and more applications are developed, the users must acquire more and more importance, both in the design of the solution, as well as in its evaluation.

This has been individuated as an important step to bring the technology out of the research labs and into people's everyday lives, that paired with well-designed user experiences will declare the success of Augmented Reality technologies **[111]**.

On this matter, a survey conducted by Swan and Gabbard on AR-related publications in specialized journals found that only 14% of those addressed some aspect of HCI, while just 8% had any formal user-based experiments **[112]**, they concluded that the absence of formal user evaluations was due to the research's lack of knowledge on what tools use for their specific situation.

The amount of user-centred researched, user-driven design and former evaluation with actual users have slightly raised in the following decade **[113] [114]**, thanks to the definition of some guidelines and heuristics principles, anyway there is still a need for more human-centred research in the field of Augmented Reality to generate reliable evaluation methods and guidelines.

An effort is also needed in the direction of rearranging and then re-evaluate what has been done until now, to create on the existent state of the art a solid foundation for the future user evaluations of AR systems, always keeping in mind the importance of the end-users, their needs, emotional aspects and desirers (often dismissed in the technology-driven development of this field), that in the end will play a fundamental role in the effectiveness of an AR product and consequently in its use **[115]**.

2. LITERATURE REVIEW

To catalogue and evaluate the various tools and methods that have been (and are) used in the Augmented Reality field, first we will discuss the definition of “user evaluation”, then we will identify the interaction issues of Augmented Reality systems and how they can be addressed; finally, previous categorization modalities will be presented and discussed.

2.1. Users Evaluations, what are and when employing them?

Evaluation is an integral part of any design process and involves collecting and analysing data about users' (or possible users) experiences while they are interacting with a specific designed artefact (or system).
The final aim of these evaluations is to found potential problems that may arise, for later addressing them on successive iterations or during the development phase **[116]**.
User Evaluation are also sometimes called 'Usability tests', however this term can create some confusion being the two similar, does not help the fact that they are often even used interchangeably.
Usability testing revolves around defining a representative group of tasks against a set of various attributes (Nielsen individuated five: Learnability, Efficiency, Memorability, Errors, and Satisfaction, but there are also many other models in use, as seen in **[117]**), that are later menstruated and confronted with the help of real users.
Its final aim is always to collect the necessary data in order to fix the problems found during the test, but they focus only on the property of the system of being usable (with the definition of "usable" changing according to the model used **[117]**), but this might not always be the case. For instance, user evaluations can be used to compare a new interaction technique regarding user efficiency or accuracy, study user behaviour and interaction with a new prototype, or study how a new system supports collaboration and so on.
Different evaluation techniques are in use at various points in the development cycle, from the very beginning (like in the ideation phase), where methodologies such as Heuristic evaluation and Wizard of Oz techniques are adopted **[118] [129]**, to the final prototype, where test with the physical prototype and the real users are conducted.
Anyway, a test run with the final prototype, or using evaluations methods developed for usability testing does not always mean that a usability test is being performed, therefore it is essential to clarify the purpose of every evaluation study **[119]**.
What is the best moment for conducting an evaluation?
This depends on a lot of factors: the type of development processes that someone is following, if the concept is new, if the technologies used are already available and well spread, if there are already studies that slightly address the problem on hand and so on.
This means that evaluations cover a broad part of the processes, from the early stages of the prototype development to the tweaking and perfecting phase of a nearly finished design.
Small informal tests can also be conducted throughout the project, and they are a very valuable way to quickly uncover usability and design problems, allowing for rapid iterative advancements of the design, and ensure that the development is on track.

However, they do not provide reliable results that can be generalized, and, if they are not followed by formal evaluation confirming the results, they can be also harmful.
Indeed, Greenberg and Buxton **[120]** on this matter argued that: although evaluation is a valuable tool, it can become dangerous if used inappropriately or with the wrong settings.
User evaluation nowadays has become a key concept in Human-Computer studies, both in the Academia and Industry fields, but it can produce terrible results if done by naively following the rules rather than the critical thought.
In some situations, user studies could give meaningless or trivial results, in others, they could even misdirect or suppress future design directions, "it is not a universal panacea that guarantees user-centred design when ap-plied in a project", the authors warn.
Validating a prototype does not necessarily tell us how it is going to be used in everyday life, there are myriads of other factors that should be considered when analysing a user evaluation, components like the underlying social context, the usefulness of the system itself and the perceived ease of use, just to name a few.
They conclude affirming that the choice of an evaluation methodology, if any, must arise from and be appropriate for the actual problem or research question under consideration.
In the end, user evaluation is a powerful tool in the research process, but it should be only used if employed in the correct way, it can add value to the project only if it is rigorously designed, carried out, analysed, and if it helps to answer a meaningful research question.

2.2. Traditional User evaluation methods

There are several methods that can be used for the evaluation of an AR system, but to understand the main approaches that are available right now, we need to take a brief overview of the traditional methods used in common interfaces.
In the research literature we can find various classifications of evaluation techniques (for example the one from Bowman et al.**[121]**, Mahrin et al. **[122]** or Ledo et al. **[123]**) anyway we will discuss the one from Kostaras and Xenos **[124]** that is simple enough to pick up, sufficient flexible to accommodate a lot of the techniques commonly used and was created with the context of AR.
They decided to divide the evaluation methods into two basic categories on the base of Nielsen **[125]** work; *Analytic* and *Empiric* evaluations, that then could be divided again in four subcategories as we can see in the following schema in **[Table 1]**.

Table 1
Kostaras and Xenos
User evaluation methods

do not need users evolvement	**Analytic Methods**	Inspection methodologies	→ Heuristic Evaluations → Cognitive Walkthroughs → Pluralistic Walkthroughs → (...)
		Theoretically based models	→ Fitts's Law → GOMS → (...)
need users evolvement	**Empiric Methods**	Experimental methodologies	→ User observation → Thinking aloud protocol → Co-discovery → (...)
		Inquiry methodologies	→ User questionnaires → User interviews → Focus groups → (...)

Before we start to discuss more specifically this classification, we need to introduce an important notion, the difference between Qualitative and Quantitative data.
Evaluation methods consist of a collection of data, later organized and analysed to prove or reject specific hypotheses.
These data can be divided into two main categories: *Qualitative data*, information that consists of some metrics (task completion time, number of errors, heart rate, etc.) and *Qualitative data*, information that derives from observational finding, and are not related

to any direct measurable metric, (usefulness of a feature, emotions felt, interaction behaviour, etc.) **[126]**.

Sometimes, qualitative data can be transformed into Quantitative, for instance, the usefulness of a feature can be addressed with a questionnaire where the users must rate on a numeric scale what they think of the feature under analysis.

In the following, a brief overview of common evaluation methods is provided. It is worth noting that this overview includes evaluation methods not used for AR. These anyway can be categorized again within this categorization that will come handy in the next chapters when we discuss specifically the evaluation methods used in AR systems.

2.2.1. Analytic methods

Analytic methods include all the theoretical models, rules or standards that simulate the user's behaviour, and thus the presence of users during the evaluation process is not needed.

They could be used in the first part of the development process during the requirement analysis or even before the development of the prototype, and usually, they are less time-consuming than other categories.

We can further divide them into two methods: Inspection and Theoretically based models.

Inspections methodology

The most used procedures inside the inspection methodologies are Heuristic Evaluations, Cognitive Walkthrough and Pluralistic Walkthroughs **[122]**.

Heuristic Evaluations employs experts to identify any interaction problems with the system, this is usually achieved according to common pre-established assumptions called heuristics.

They are a set of principles and rules which use common sense knowledge, usability guidelines and standards that have been proven valuable and true in the past.

Cognitive Walkthrough employ experts "walking" through several scenarios composed by various tasks inherent to the system and involve simulating how users would approach the application in terms of problem-solving at each task.

In *Pluralistic Walkthroughs* a group of experts analyses the system and writes down the action they will take to accomplish the specified goal.

Once each inspector has written their own response, one of the inspectors (the administrator) reveals their answer for the task, then the inspectors will debate their response as well as any possible usability problems.

Theoretically based models
The theoretically based models, instead, are used for comparing the efficacy of different interfaces of the same system, and the optimal arrangement and location of the features of these interfaces **[116**]. They make use of formulas (the most famous and influential is Fitts's Law), and predictive modelling to derive various measures of user performance and estimates the efficiency of different systems for various kinds of tasks.

2.2.2. Empiric methods

If in the analytic evaluation cluster, users do not need to be present during the evaluation phase, on the contrary, the Empiric methods depend on the implementation, the evaluation, and the rating of the system by a representative sample of end-users (with or without the help of several experienced evaluators).
This category can be further divided into *Experimental* and *Inquiry* methodologies.

Experimental methodology
The range of tests that can be conducted with the Experimental methodology is considerable, from true classic experiments with large sample sizes and complex test designs, to informal qualitative studies with a single participant, depending on the objectives and time and resource requirements available.
Usually, Experimental evaluations are suitable at later stages of system design to check for consistency of the system's response to the user and to evaluate the extent to which the evaluated system meets specific criteria previously selected.
According to the complexity of the experimental evaluation performed, different type of choices about the study design had to be made, such as the sitting of the experiment, the group of users employed, the types of variables present in the system and the kind of tasks performed.
Experimental evaluations can be conducted in two different settings: in a laboratory environment or on the field, each with its pros and cons, as we will see in a few chapters.
If more than one system, interface or tasks had to be evaluated in one experiment, usually two different study design are used **[127]**:

→ Between-subjects (or groups) study design: Where different users test each condition of the system, so that each person is only exposed to one.

→ Within-subjects (or repeated-measures) study design: where the same person tests all the conditions.

Each type of experimental design has its own series of benefits and drawbacks: within-subjects designs require fewer participants and

increase the likelihood of discovering a true difference between your conditions, instead, between-subjects designs minimize the learning effects across conditions, lead to shorter sessions, and may be easier to set up and analyse.
If more group of users are involved in an evaluation (indifferently if they study design is Between-subjects, Within-subjects or both) or more system designs are addressed, evaluators must also determinate which variables of the experiment are Independent (the ones that can be directly manipulated by the researchers, for instance the age of the participants) and Dependent (the ones that are mensurates and are expected to vary as a result of the independent-variable manipulation, for example the accuracy of the task assisted), this is important because different variables lead to different study design (i.e., the choosing of Between- or Within-subjects methodologies).

Evaluators should also decide what type of task are asked to the users to perform inside the system, these can be:

→ Structured: the tasks are structured in a way that the experimenter creates a step-by-step to-do list which the users perform to complete the task, these types of tasks can be written down in a very detailed manner, like providing a realistic scenario explaining what the user needs to do.

→ Unstructured: tasks are written down on an abstract level, so the users have full control of the steps needed to complete the given task.

Experimental evaluations involve a wide array of techniques, one of the most used is the *user observation*, where the actions (and sometimes also the performances) of the users are observed and recorded during their interaction with the system.
Different type of methods can be used to observe the user, such as note-taking, voice recording, video recording, eye tracking, system logging (i.e., screen recording, keystrokes, mouse movements, etc.), user biofeedback recording (i.e., galvanic skin response, Heart Rate, Electroencephalography, etc.) and so on. The results of this techniques are aggregate data that are then father analysed.
These data can be both quantitative, like in the case the evaluation observed the user's performance with measurements on their time and accuracy with the system) and qualitative (if the observation produced consideration about how the user behaved in the evaluation scenario).
Another important and commonly used experimental qualitative technique that can be integrated is the *Thinking Aloud Protocol* **[128]**.
According to this method, used to estimate the effectiveness of a system and the user's satisfaction, a small number of users interact with the system while they state aloud their thoughts, opinions, emotions, and sentiments.

Two alternatives of this method are the Co-discovery and the Questions-Answers Protocol: In the first a group of users attempt to perform tasks together while being observed, simulating a typical work process (where most people have someone else available for help), instead of the second method the evaluator provokes the user to express thoughts and feelings while interacting with the system by asking specific questions.
A widespread technique commonly used is also the so-called Wizard of Oz approach **[129]**, often used in rapid prototyping at the early stages of the design process, when it is not clear what the underlying technology would be. In this approach, a “wizard” (an evaluator) simulates either some part of the model (the unbuilt system components) or the complete envisioned system with the users, that would test all the simulated (and real), features of the system. Even though the evaluation is carried out in a quasi-realistic environment, the user awareness of the “mock-up” parts of the systems, or the incorrect system behaviours (i.e., the simulated system is overperforming or underperforming) can corrupt an evaluation and compromise the results, however, its flexibility at the early phases of the development process is remarkable, making it a valuable tool at the evaluators disposal.

Inquiry methodology
Inquiry methods focus on the examination of the quality characteristics of the system by measuring users’ opinion and usually are less time consuming than the other categories **[128]**.
They can be used alone or paired with other types of evaluations, such as the user observations of the experimental methodology, and can be used at every step of the design process, even before a proper prototype is built. Consequently, they could be used not to evaluate something, but to collect more insight about the users’ needs and wishes.
The most popular of these methods are *User questionnaires, User interviews* and *Focus groups*.
With the use of questionnaires, users are requested to express their opinions about the system addressed by completing a structured questionnaire usually consisting of multiple-choice questions.
User interviews, on the other hand, form a structured method of evaluating a system where the researcher is in direct contact with the user.
The questions of the interview follow a hierarchical structure, through which the general opinion of the product is first formed after which more specific matters of the system characteristics are considered.
Finally, focus groups are a variation of the User interviews, where a group up to 10 participants is formed under the supervision of a coordinator (also called facilitator) in charge of the topics of conversation, at the end of this conversation, the coordinator gathers their conclusions on the assessed system features.

2.3. Limitations of current evaluation methods

As described in the previous section, many techniques and methods are used in the assessment of traditional systems, anyway, in the case of AR implementations the use of these approaches cannot always be achieved.
Common evaluations techniques are developed specifically for traditional interfaces, so rely heavily on the WIMP (window, icon, menu, pointing device) metaphor used in common Graphical User Interfaces (GUIs), differently, AR (and VR) environments allows new and unique multimodal interfaces which are rather different from the standard ones.
Indeed, AR systems implementations could be very different from each other: they could work on different senses (sight, hearing, touch, etc.), could be contained in a single device or in whole environments, could be used in outdoor or indoor conditions, be realized with different types of input and output technologies which allow a variety of interaction techniques and so on.
This disparity causes that, although traditional methods may be able to detect some problems with new interfaces, none of the existing ones really addresses fully the unique needs of these **[130]** but must be adapted case by case.
The novelty of AR interfaces also creates another issue, the lack of design guidelines that can be used both in the development and in the evaluation phases.
Indeed, WIMP inspired heuristics do not always fit the design needs of AR systems and common and settled design guidelines used in the creation of traditional GUI interfaces had to be used wisely. The well-known ten usability heuristics of Nielsen **[131]**, for example, do not cover issues related to radically different input and output modalities of AR interfaces, as well as 3D space interaction.
This means that part of the Analytic methods used in traditional evaluation cannot be used in AR without modification, as there are no experts or agreed guidelines on the use of the technology yet (anyway, as we will see in the next chapter, in the last ten years some generic guidelines have been developed).
Moreover, the limitations of WIMP-based evaluations methods in Virtual and Augmented Environment does not stop at the effectiveness and efficiency of the evaluation method itself, but according to Stanney et al. **[132]** also concern their intrinsic aspects, such as:

→ Multimodal system output (visual, auditory, haptic) is not comprehensively addressed by used methods.

→ Assessing presence, immersion, system comfort, sickness and after-effects are not covered by traditional evaluations.

- → Traditional performance measures (time, accuracy) do not always comprehensively characterize Virtual Environments (VE) & AR system interaction.

- → Lack of methods to assess collaboration in the same environment.

- → Multidimensional object selection and manipulation of objects in 3D space are not touched directly by traditional interfaces.

Another challenge that complicates the evaluation of AR is that, often, evaluators draft and create a single prototype as a proof of concept, test it, and then move on to the next issue, leaving behind a wide range of fascinating ideas and prototypes that do not necessarily share many common features, exacerbating the problem of finding common guidelines for design and evaluations of the next AR systems **[118]**.
The variety of AR applications also create problems when we need to define a single category of users on which focus: the users may be novices, experts, casual users, frequent users, children, adults, elderly, and so on, all categories that affect radically the ways in which interaction is designed and evaluated.
Without a clear idea about the final users of the system, we cannot design effective systems and then evaluate them to get representative and meaningful results.
Traditional interfaces do not have these issues; they share many characteristics between each other, such as the input methods that are quite standard, and they are the result of an incremental development instead of a radical innovation, as in the case of AR.
Moreover, traditional GUI/WIMP evaluation frequently focuses on different issues than AR interfaces, in AR systems increasing the user's effectiveness and efficiency are not always the primary goals as it happens in WIMP based systems, where the focus is usually to support users in accomplishing specific tasks (office work, word processing, etc.).
While some AR systems pursue similar goals (e.g., AR systems for engineering), most evaluations focus more on providing a novel user experience that requires different evaluation techniques **[118]**.
All these problems made the development of a general evaluation framework for AR systems rather challenging. Dünser and Billinghurst on this matter has proposed two solutions to overcome this generalization problem: Creating a general framework for AR systems, finding an acceptable level of abstraction necessary to allow the creation of practical guidelines and for accommodating a large part of solutions.
Narrowing down the field of interest to an extent that it permits the definition of common sets of guidelines for different kinds of systems sharing certain characteristics, for instance, creating guidelines for mobile phone AR systems, head-mounted AR, spatial AR, and so forth.

2.4. Evaluation Approach commonly used

Although evaluation methods used in traditional interfaces are not build for AR system, various researchers have tried to use and categorize the available methods and tools that have been used during the years in different AR studies.
One of the first research to study this issue and to propose some methods, which could be used for the evaluation of Mixed Reality systems, were Bach and Scapin **[133]**.
They found that the available knowledge at that time was relatively limited, with a lot of technical problems that needed to be solved compared to the number of issues that need to be tackled in such complex environments.
They mentioned three categories of methods that they considered general enough to be used in Mixed Reality settings: questionnaires/ interviews, inspection methods and user testing.

→ According to the authors, questionnaire and Interviews allowed the gathering of subjective data, important to evaluate visual appeal, preferences, aesthetics, missing functionalities, and very useful to compare or cross-reference performance data, providing specific lead questions for interviews and questionnaire items that could be tailored and validated for such environments.

- The second good candidates they found was the group of Inspection methods, which has been proven valuable during the history of Human-Computer Interaction in the fields of GUIs, the web and VR applications. The main problem they reported was the need for more data on how to evaluate MR systems on Issues regarding recommendations identification and structuring these into dimensions (such as guidelines).

- Finally, they propose user testing as a valuable method of evaluation, as it has been the major assessment methodology in the past, and they predicted that it would equally be important for MR Systems. However, they stated that, to successfully apply that method, several methodological problems have to be tackled first (we will see a selection of these problems in the next section).

They concluded with two recommendations: the first of “not re-invent the wheel”, as MR systems are composed of “mixed” components, therefore new knowledge needs to be gained only for the novel issues specific of the system, and not on its non-specific elements (e.g., real objects, 2D displays, etc.).
The second suggestion was to incorporate evaluations with the systems early in the development process with user testing.

Another pair of researchers that analysed different evaluation methods used in the literature on the application of the evaluation methods in the assessment of AR systems, as well as the potential problems and difficulties were Kostaras and Xenos **[124] [134]**.
They found no evaluation methodology specifically designed for the assessment of AR user interfaces, although some traditional methods used in HCI could be applicable to AR systems if the system requirements and the objectives of the assessment are the same or similar to those of traditional "standard" interfaces.
The authors continued expanding the methodologies previous found by Bach and Scapin **[135]**.
They found that Inquiry methods such as the use of Questionnaires and Interviews are suitable and very useful in AR systems assessment, thanks to their easy implementation, which does not need specialized hardware and software equipment to be performed, and versatility in collecting subjective data, such as users' opinions and preferences on ease of use, understandability, efficiency, and aesthetics of a system.
Analytic methods, instead, have limited application in the assessment of AR systems at the time, due to the lack of knowledge on ergonomic issues as well as concrete design guidelines and standards.
Experimental methods were employed in most cases and provided very useful data, however, for better results in user testing, new methods and techniques had to be tailored for AR technologies.
In the end, they suggested that to better trickle the problem of evaluations in AR, a combination of methods from the three main categories found could bring the best results.
Starting with the application of heuristic evaluation, using a set of application-specific heuristic rules, then employing inquiry and experimental methods would be useful to reveal new problems that arise during user interaction with AR systems, for them collecting users' opinions regarding the system and the degree of their satisfaction during the interaction.
Finally, Dünser, Grasset and Billinghurst in their surveys on the state of the AR research **[110]** categorized the evaluation methods used in the AR field.
This classification did not follow any other methodology categorizations and was mainly inspired by the authors' experience.
Its goal was to get an overview of the research approaches and methods that have been applied in the field, as well as provide a guideline and resource to the AR community, several publications since then have referred to this one to categorize and illustrate the various methods used in their AR research **[136] [137]**:

1. Objective measurements: All methods that produce a reliable and repeatable assignment of numbers to quantitative observations. They can be taken automatically or by an experimenter, and typical measures include times (e.g., task completion times), accuracy (e.g., error rates), user or object position, or test scores, etc.

2. Subjective measurements: These rely on the subjective judgment of people and include questionnaires, ratings, rankings, or judgments.

3. Qualitative analysis: The data is gathered through structured formal user observations (direct observation, video analysis), classification or coding of user behaviour (e.g., speech or gesture coding) or formal interviews (structured, unstructured).

4. Non-User Based Usability evaluation techniques: This includes evaluations techniques such as cognitive walkthroughs, heuristic evaluations, task analysis or Wizard of OZ, as well as techniques that involve people who are not end-users (e.g., expert-based usability evaluations, think-aloud method, etc.).

5. Informal testing: studies that report informal user observations or informal collection of user feedback (e.g., gathered during demonstrations). They were surprised that a reporting method with such limited capability was so common and accepted in AR contexts, above all when compared with traditional CHI publications, where informal evaluations were almost disappeared.

2.5. AR design Practices, Heuristics and Guidelines

A reason for the lack of inspection methods used in AR evaluation is linked with the limited knowledge in the AR field and the very few design guidelines developed during the years **[111]**.
Most guidelines are rather specific findings by researchers, and there is right now a generalization problem in AR, that is the direct reflection of some problems already discussed, such as the different Input and Output devices that can be used in the AR domain, that has not yet defined specific interaction techniques and interfaces (and somebody asks also if this field would ever find standardize interfaces for all its applications **[111]**).
While "traditional" interfaces, such as Web or desktop applications, share common design guidelines and tools, the same cannot be directly applied for AR applications.
This absence has led some researcher to hypnotize that, without established design and interface methodology like the ones that emerged for the 2D desktop environment over the last 30 years, we would be still limited to an exploratory, trial-and-error-style approach to 3D interface and interaction design **[138]**.
This, together with the relatively fast changes in hardware capabilities, device availability and their associated costs, has been

individuated as the main cause that hindered the development of AR until now **[111]**.

Some attempts have been made to develop guidelines and heuristics in the past, drawing on the ones developed for Virtual Environments: Sutcliffe and Gault **[139]** created a very concise list of 12 heuristics, which could be adapted to the AR field, Stanney et al. **[132]** have created a computerized system to assist in the evaluation of virtual environments called MAUVE (Multi-criteria Assessment of Usability for Virtual Environments), Sutcliffe and Kaur **[130]** present a walkthrough method for VE user interfaces.

One of the few efforts to define design and evaluation guidelines for AR systems was presented by Gabbard **[140]**, he started collecting information from many different sources including AR specific research and more general VE based research, this led to an extensive list of 69 statements and guidelines in several categories. Again, the size of this list shows the challenge of creating a concise list of AR design guidelines that could be easily applied by practitioners and researchers.

Dunser et al. **[111]** investigated how general HCI guidelines may relate to the domain of AR application design, to do so, they combined some known user-centred design guidelines with the aim to identify issues that should be considered by AR interface researchers. According to the authors, this work was an initial attempt to fill the gap that existed in the area and the presented design guidelines were just a small overview and the guidelines given were rather general and had to be further refined.

Ko et al. **[141]** proposed the creation of usability guidelines for the development and evaluation of smartphone applications using AR technology.

The authors developed these guidelines by analysing existing research about heuristic evaluation methods, design guidelines for AR systems, guidelines for handheld mobile device interfaces, and usability guidelines for tangible user interfaces.

Kourouthanassis et al. **[142]** proposed a set of interaction design guidelines for the development of Mobile Augmented Reality (MAR) applications.

According to the authors, the design recommendations adopt a user-centred perspective and thus, they focus on the necessary actions to ensure high-quality MAR user experiences.

Vi et al. **[143]** proposed 11 guidelines for User Experience (UX) in HMD after an analysis of different resources both from the industry and the academic field, anyway these are suggestions for the designers building an AR application, rather than elements for a complete and correct evaluation.

Finally, Endsley et al. **[144]** developed 9 general AR heuristics starting from a set of 11 general and specific guidelines and HCI principles, that were refined using affinity diagrams, expert evaluations, feedback from active AR designers, and statistical analyses.

We can conclude that current principles and heuristics, not always completely validated, often focus on specific applications and technologies for AR or are too general to provide some valuable insight into distinct aspects of AR design evaluation **[144]**.

2.6. Evaluation procedures

Until now, we discussed only the evaluations methods and tools used in AR systems themselves, without touching the procedures that could be employed in the development of new AR interfaces.
Hix et al. **[145]** were the first to adapt an evaluation procedure to support the development of AR, the following two, from Bowman and Hodges **[146]**, and Gabbard et al. **[147]**, were created for Virtual Reality applications, though, they have been individuated as usable for the development of AR systems if accordantly adapted **[115]**.
Finally, the approach from Swan et al. **[148]**, which is based on the Gabbard's one **[147]**, tries to mitigate some of its shortfalls when applied in the AR field.

2.6.1. Usability engineering approach

One of the first evaluation procedure specifically developed and applied in the field of AR was the one from Hix et al. **[145]**, and specifically implemented for the usability testing on their Battlefield Augmented Reality System (BARS) prototype.
This procedure, also called Usability engineering by the authors, was a structured, iterative user-centred process, applied during all phases of the development life cycle, and included both design and evaluations with users.
The procedure could be divided into five main phases linked to each other through an iterative approach (one step inspire the following and the one that preceded – **[Figure 2-2]**), resembling closely the waterfall development process of common software development **[149]**.

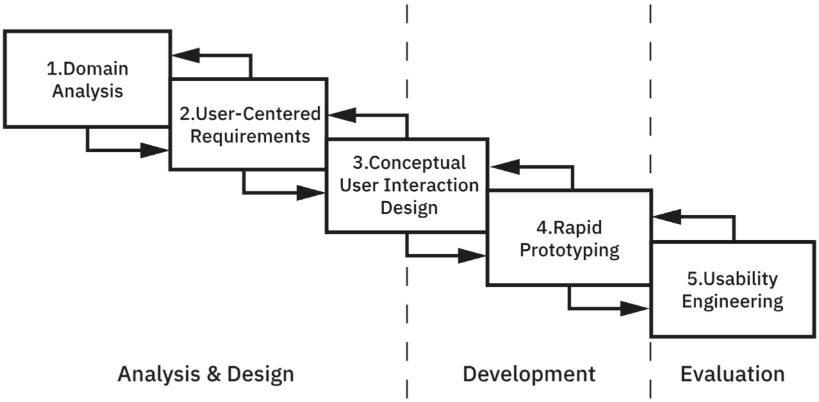


Figure 2-1
Usability engineering approach by Hix et al. (source [103])

The main phases of this approach are:

1. Domain Analysis: this is the activity in which two critical questions are answered: Who are the users? And what tasks will they perform? This is not only useful as reveal the methods users would employ to complete the tasks at hand but, more importantly, allows gathering information about the user's point of view.

2. User-centred Requirements and Metrics: they are quantitative ways of respectively specifying and measuring user interaction and user performance within the system. User-centred requirements ensure that requirements definition efforts reflect user goals (and likely user activities), user-centred metrics instead are based on measures related to the task domain and allows us to assess the usability of the system.

3. Conceptual and Detailed User Interaction Design: these are activities that encompass the design of a particular set of user interactions, based on tasks and users who would perform them.
   This activity could range from conceptual, where large-scale usage and equipment requirements are discussed, to detailed, where specific user interactions are developed.

4. Rapid Prototyping: It is a quick and temporary way of implementing detailed user interaction for the system, and in this methodology is necessary before those designs can be evaluated.
   In this phase, the initial versions of these designs must be implemented rapidly and cheaply, considering that they are certain to change after the usability evaluation. Because of this, a series of techniques are used, such as the Wizard of Oz approach, to create the prototype in the fastest possible way, without the need of writing any line of code.

5. Usability Evaluation: it is the activity of assessing and measuring the usability of a user interaction design. The purpose of this evaluation is to drive successive iterations of user interaction design by pointing out interaction design flaws, as well as missed task and system requirements.

2.6.2. Testbed evaluation approach

The procedure by Bowman and Hodges called *Testbed evaluation approach* has the aim of empirically evaluating low-level interaction techniques outside the context of applications (i.e., within a generic context, rather than within a specific application). In addition, it adds the support of a framework for design and evaluation.
This approach is divided into eight steps as follow:

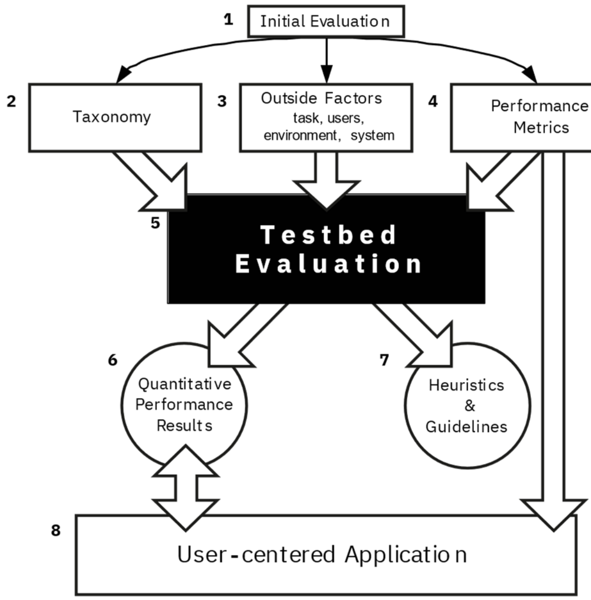


Figure 2-2
Testbed evaluation approach by Bowman and Hodges
(source [146])

1. Initial Evaluation: the first step consists of gain an intuitive understanding of the generic interaction tasks in which is interested, and current techniques available for the tasks. This is accomplished through experience using interaction techniques and through observation and evaluation of groups of users.

2. Taxonomy: the next step is to establish a taxonomy of interaction techniques for the task being evaluated, partitioning the task into separable subtasks, which represent a decision that must be made by the designer of the interaction. Once the task has been decomposed into a sufficiently fine-grained level, the taxonomy is completed by listing possible technique components for accomplishing each of the lowest-level subtasks. Ideally, the taxonomies established by this approach need to be correct, complete, and general, any interaction techniques that can be conceived for the task should fit

within the taxonomy, thus, subtasks will necessarily be abstract.

3. Outside Factors: interaction techniques cannot be evaluated in a vacuum, a user's performance on an interaction task may depend on a variety of factors that had to be accommodate for.
   The authors identified four categories of outside factors: task characteristics (attributes of the task itself), environment characteristics, user characteristics, and system characteristics, each of these must be considerate and studied.

4. Performance Metrics: aspects that the evaluation would investigate, are then selected, usually these are speed and accuracy, as they are easy to measure and quantify, but also other performance metrics had to be considered, such as perceived ease of use, ease of learning, user comfort, sense of presence (inside Virtual Environments in particular) and so on.

5. Testbed Experiments: this is the final stage of the evaluation of interaction tasks, and it is an experiment that uses a formal, factorial, experimental design, with the tasks that involve all important aspects previously individuated. This evaluation tests each component of a technique, considering outside influences (previously defined) on performance, and that have multiple performance measures (as defined). Normally, it requires many subjects, and the number of trials per subject can become overly large, so interaction techniques are usually a between-subjects variable (each subject uses only a single interaction techniques), while other factors are within-subjects variables.

6. Qualitative Performance Results: Testbed experiment produces a set of results or models that characterize the usability of the interaction techniques for the specified task at hand. Usability is given in terms of multiple performance metrics, with respect to various levels of outside factors, these results become part of a performance database for the interaction task, with more information being added to the database each time a new technique is run through the testbed.

7. Heuristics & Guidelines: These results can also be generalized into heuristics and guidelines, that can easily be evaluated and applied later in similar new systems design.

8. User-centred Applications: The last step is to apply the performance results to other applications of the system, with the

goal of making them more useful and usable. To choose the most appropriate interaction for the task, the evaluators must understand the interaction requirements of the application, as there is no single “best” technique due to their uniqueness (what is best for one application would surely not be optimal for another application with different requirements).

Once the requirements are in place, the performance results from the testbed evaluation can be used to recommend the interaction techniques that meet those requirements.

2.6.3. Sequential evaluation approach

The Sequential evaluation framework by Gabbard, Hix & Swan **[147]** is an approach based on usability engineering and addresses both design and evaluation of novel user interfaces in a sequential manner.
While some of its components are well-suited for the evaluation of generic interaction techniques, the complete sequential evaluation approach employs application-specific guidelines, domain-specific representative users, and application-specific user tasks to produce a usable and useful interface for a particular application.
These factors make the results of this approach applicable to other similar applications and, but only in some isolated cases to generic systems.

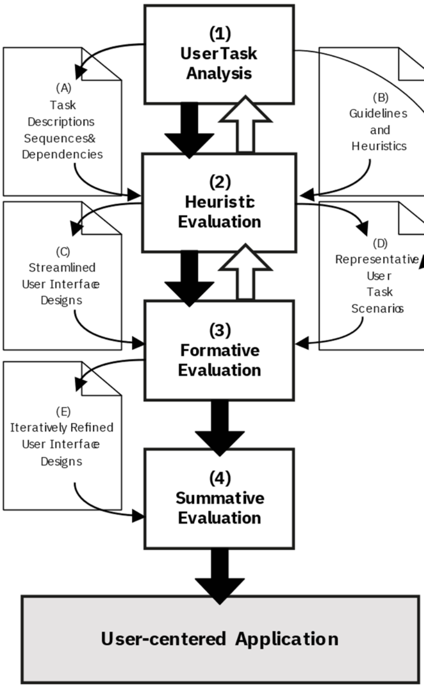


Figure 2-3
Sequential evaluation approach according to Gabbard, Hix & Swan (source [147])

This approach involves a sequential evaluation that evolved iteratively at each step, leveraging the results of each individual method by systematically defining and refining the Virtual Environment user interface in a cost-effective progression.
Depending upon the nature of the application, this sequential approach may be applied in a strictly serial manner or be iteratively applied many times, depending on the application's complexity and maturity.

1. User Task Analysis: It provides the basis for design in terms of what users need to be able to do within the application. This step usually produces a list of detailed task descriptions, sequences and dependencies, user works and information flows, tailored to the representative users, these are then organized and ranked. This phase is quite important, being that its accuracy and completeness directly affects the quality of the following formative and summative evaluations.

2. Heuristic Evaluation: This step may be the first assessment of an interaction design based on the user task analysis and the application of the guidelines found for the VE user interface design.
   As we have already seen, the goal of heuristic evaluation is to simply identify usability problems in the design early in the development lifecycle so that they may be addressed, and then redesign iteratively refined and evaluated. A set of usability guidelines or heuristics (either general or are tailored for a specific application) is required, however, the current lack of well-formed guidelines and heuristics for VE user interface design and evaluation make this approach more challenging than traditional User Interfaces, as discussed in section xx. Nonetheless, for the authors, it is still a very cost-effective method for early assessment and can simplify and make the next step more efficient. The results of this step are a streamlined user interface design (that may be more rigorously studied in subsequent evaluations) and a representative user task scenario(s) created on the basis of both the heuristic evaluation and the task analysis.

3. Formative Evaluation: A typical formative evaluation cycle (also call user-centred evaluation) may vert around a user-task scenario(s) that are specifically designed to explore many facets of a user interface design, providing ample coverage of tasks identified during a user task analysis. Representative users are recruited to work through the task scenarios as evaluators observe and collect both qualitative and quantitative data, these are then analysed to identify user interface components that both support and detract from user task performance and user satisfaction. Alternating between formative

evaluation and (re)design of the interface, lead to an iteratively refined user interface design, that it efficiently and effectively supports all user.

4. Summative Evaluation: (or comparative evaluation) is an assessment and statistical comparison of two or more configurations of user interface designs, user interface components, and/or Interaction techniques. They enable evaluators to measure and compare the productivity and cost benefits associated with each different user interface designs. A major impact of the formative to summative progression is that the results from the formative evaluation inform the design of summative studies by helping determine the appropriate usability characteristics to evaluate and compare in the subsequent summative studies.

Both testbed and sequential evaluation approach, take different procedure to try to solve the same problem, namely, how to improve usability in AR applications, however, the two approaches have different goals: *Testbed evaluation* tries to find generic performance characteristics in a high-level, abstract way, not in the specific context of a particular application.
Sequential evaluation instead, attempts to iterate towards a better user interface for a specific application, looking very closely at user tasks of these to determine which scenarios and interfaces should be incorporated, and in doing so, produce the best possible interface design for a particular application under development.

2.6.4. User-based studies approach

The last approach we consider is the one from Gabbard and Swan **[147]**, who proposed a procedure that employs user-based studies to inform the design of AR interfaces.
This procedure iteratively inserts a series of user-based studies into a traditional usability engineering lifecycle to better inform the initial user interface designs, trying to mitigate some of the shortfalls of the frameworks that precede it, such as the Sequential evaluation approach from Gabbard, Hix and Swan (see section xx), which needed of expert guidelines that usually are not directly applicable to AR.
The framework emphasizes iterative design activities between the user task analysis phase (where requirements are gathered and user tasks understood), and the formative user-cantered evaluation phase (where the user interface prototype has been developed and is under examination).
Within this approach, they introduced two new steps: the *expert evaluation* and *user-based studies*, to assist the user interface design activity **[Figure 2-5]**.

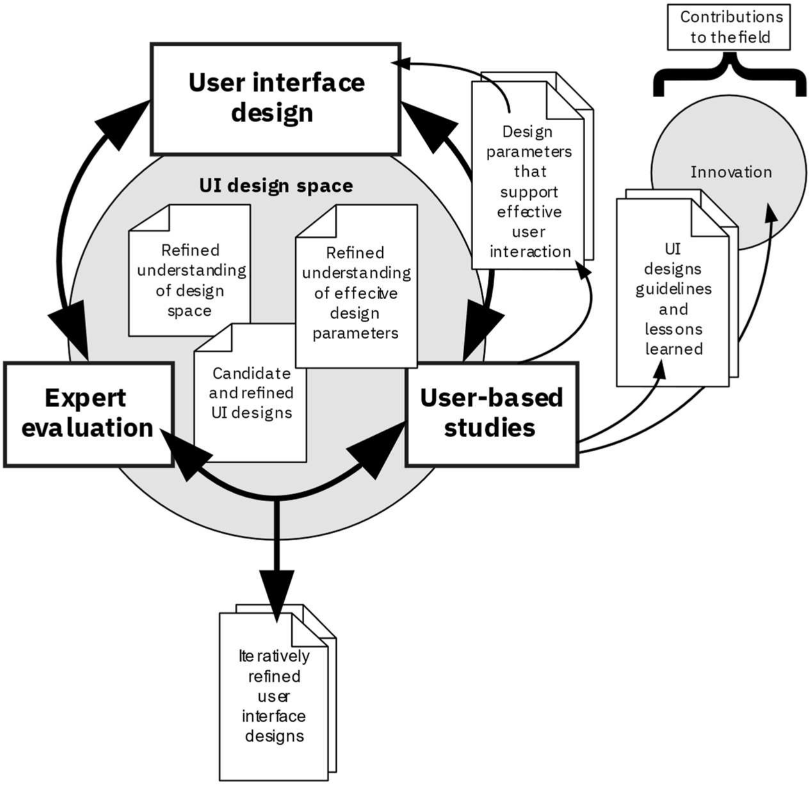


Figure 2-4
User-based studies approach by Gabbard, Hix & Swan (source [148])

These so-called "user-based studies" differ from traditional approaches, as their scope addresses basic user interface or interaction designs rather than using established design guidelines.
On the other hand, expert evaluations can be iteratively combined with the user-based studies to refine the evaluators' understanding of the design space, as well as the effective design parameters (e.g., how to identify the following user-based studies), and, most importantly, how to refine the user interface designs.
A strength of this approach is that the interface design definition phase is driven by several activities, such as inputs from the user task analysis phase, user interface design parameters correlated with good user interface performance (derived from user-based studies), and expert evaluation results.
The authors propose two logical starting points: user interface design and user-based studies.
An advantage of starting with user interface design activities is that the evaluators can start exploring the design space before starting the system development, and moreover, they can explore several candidates designs quickly and easily.
Once a set of designs has been created, expert evaluations can be applied to assess the static user interface designs, rejecting user interface designs that are likely to be less effective than others. These expert evaluations are also useful in terms of further

understanding the design space by identifying potential user-based experimental factors and levels.
Once identified, user-based studies can be conducted to further examine those factors to determine if the findings of the expert evaluation match with the user-based studies.
If the design space is somewhat misunderstood and designers have specific questions on how different design parameters might support different user task performances, the evaluators may be able to choose the user-based study as a starting point, individuating the experimental design parameters before the specific user interface designs.
User-based studies not only identify the user interface design parameters to assist the User Interface (UI) design, but also have the potential to produce UI design guidelines and insights, as well as generate innovation, providing both tangible contributions to the field while also improving the usability of a specific application. Finally, a set of iteratively refined user interface designs are produced and can be the basis for the overall application user interface, this can then be evaluated using formative user-centred evaluation, as described previously in the Sequential evaluation approach by Gabbard, Hix & Swan **[147]**.

2.7. User testing obstacles

As we have definite (in chapter 2.4), user testing is certainly the preferred method to be used to close the gap of available data, however, many methodological problems inherent to the uniqueness of AR application and the limitations of the methods themselves arise. Now we will briefly see these problems using the classification that Bach and Scapin **[133]** proposed, they divided these problems into three different categories, namely limitation posed by the environment, the setup of the evaluation and the users themselves.
All the problems describe complicate the creation of well-designed and carry out experiments, this can explain why often results are disappointing **[133]** when classical graphics environments are compared to VE or AR systems.

2.7.1. Limitations related to the physical environment

One of the major differences between AR systems and traditional interfaces concerns their physical environment.
AR systems require a more sophisticated environment than the one commonly in use, the users rarely just sit in one single position, as it happens with desktop computing, but they can move from one place to place, they talk, they move parts of their body to interact and so on.
This raises several problems in the evaluation space, for instance, the evaluation area must be limited to a certain interaction zone

to avoid collisions with other elements present in the environment and the employed evaluation equipment.
Interaction devices can be an obstacle themselves, not only physical but also in the data collection, for example with some specific hardware solution may be difficult, or even impossible, to capture determinate data (for instance what the user is seeing), in that cases, it could be necessary the use of other devices that can complicate the evaluation and pollute the data collected **[133]**.
AR systems can also be multi-users, thus requiring a larger space for the evaluation, they can be used outdoors, so other determinate limitation necessarily will apply.
Current laboratories, built for traditional interaction evaluations, usually have limited space, so does not facilitate such experiments and data harvesting, thus they should be adapted before performing a proper evaluation in the AR field.

2.7.2. Difficulties in the setup of user testing

The complexity of interactive situations with AR may necessitate more resources than usual user testing, for instance, several evaluators are needed to extract interesting data (e.g., checking on performance, on various modalities, on various media, etc.), as user behavioural sequences are more complex to extract and describe, or to operate the evaluation equipment, that depending on the test and technology used may be drastically different **[133]**.
In addition to the complexity of software programming for such environments, setting up experiments may be also more complex, because it requires more technical skills to calibrate and to tailor every single type of technologies and software supporting the AR system.
In case of devices or system breakdown, it may be more difficult and more time-consuming to restart the devices or system than its traditional counterpart, which may threaten the outcome of the user testing **[121]**, therefore, it is even more important than the assessed systems are stable for all the duration of the evaluation experiments in this type of tests.
Another obstacle specific to AR systems, and in general to all novel systems, is the lack of previous users’ knowledge on how to operate.
This means that extra time is required in describing to the testers the experimental requirements, task goals, and ways to operate the various parts of the environment.
This also leads to the question on which is the best way to design the experiment: how much information is needed to the user to correctly perform the test without influencing the “intuitiveness” of the system at the first use?
Along the same line, it may be also difficult to explain all the features of the system beforehand and may impossible during the test without affecting the results.
In some cases, as current technology is unable to support fully and consistently novel interaction paradigms, there is no way to test those new ideas unless using the “Wizard of Oz” technique, which

requires trained specialists and the creation of a specific, carefully balanced experimental design **[133]**.
In other cases, the techniques used for interacting and those used for gathering the subject's data may conflict, for instance, the use of thinking aloud cannot work when the voice recognition is enabled.

2.7.3. Limitations related to the participants

AR applications are not always guided by application needs, but by the design of new interaction paradigms, this makes difficult the specification of precise and accurate tasks and user requirements and means that also the generalization of the results may be difficult.
Another difficulty arising from this factor and the novelty that surround AR systems concerns the impossibility to distinguish the subjects in terms of experience (e.g., novices or experts) yet.
This is also true for the skills of the "specialists" in charge of the evaluation, which sometimes are even the subjects tested in the evaluation, such as in the guerrilla usability approach **[150]**).
Evaluators may also encounter difficulties in recruiting the right number of subjects needed to cover the many potential variables involved in the system.
For instance, if an experiment wants to compare various combinations of interactive devices in use, such as 3 tasks for each one of 3 user interaction individuated (e.g., voice, gesture and eye-gaze), we would need 27 different testing situations (9 combinations x 3 channels) in order to have all the subjects tested to all possible combinations **[133]**.
This may be a problem, due to the possibility for the subjects to became quickly exhausted, and therefore the data collected potentially useless, after so many tests are performed in one sitting, instead if more sessions are employed, the runtime of the evaluation can become really long.
If alternatively, we decide to set up the experimental design with non-repetitive measures and associate different subjects' groups to each situation, then the number of subjects required becomes very large and consequently quite difficult to recruit and manage, not mentioning keep the sample the more homogeneous possible.
Other limitations that affected the studied subjects and thus must be accommodated for, are related to the topic of "cybersickness" **[121]** and can be both ethical, concerning the decision to run the user testing and in which situations, and practical, concerning the post-experimental arrangements and the evaluation of the data collected.

2.8. Field or Laboratory evaluation?

When discussing user testing, the question that inevitably arises is: should the test be conducted in a real environment (on the field) or in a controlled ambient (laboratory)? This is a valid question and both methods can be adapted to conduct an evaluation, nevertheless, each of them brings certain pros and cons that must be considered when is planning an evaluation.

Field research is the natural means of performing user-based evaluation as it places the user in realistic scenarios, however, compared to controlled laboratory experiments, specific attention is needed **[151]**, as data collection in the field may be difficult and it might not be possible to concentrate the research attention on specific aspects of the interaction **[152]**.

In addition, the use of assessment methods such as Think Aloud or video recording could be of difficult implementation in realistic environments due to external factors such as noise and social norms (I.e. inside office spaces and hospitals).

On the other hand, laboratory evaluation has their problems (as discussed in the previous chapter), and in some determinate situations it can be difficult simulate realistic outside environments in inside settings **[153]**.

For instance, evaluating a jogging application could be difficult to simulate in a realistic manner in a lab setting, if the movement can be substitute with a treadmill, and the visual input can be recreated with a system like a CAVE, the social part of the experiment will be difficult to recreate, as well the physical condition (e.g., weather conditions).

Anyway, inside evaluation has inevitably some advantages, like the possibility to control more strictly determinate variables of the experiment and cost of evaluation that are lower compared with field evaluations **[167]**.

Those differences do not stop at the cost and convenience of building and running the tests, but also the efficiency of the test itself changes according to the method applied, leading to different results.

Focusing only on the product can lead to the identification of some problems, on the opposite, others argue **[151]** that field assessment finds other issues due to different variables: such as atmospheric noise, activity, privacy concerns and so on.

Nielsen et al. **[154]** when discussing on the efficacy of field evaluation concluded that they are "*worth the hassle*", meaning that even though they are more expensive and time-consuming, field studies reveal more problems, identifying issues related to cognitive load, interaction styles and external variables (e.g., noise and privacy) be not investigated in a lab environment due to their difficulty of simulation.

3. RESEARCH METHODOLOGY

As we have seen in chapter 2, some researchers have already tried to identify the main tools that are used in AR. Anyway, if we consider the wide scope that a technology like this could have, a better categorization and organization of these approaches is needed.
Our aim with this work is the creation of a usable framework that could inform and guide future user evaluation in the AR field.
In this chapter, we will formulate the main research questions and procedures that would guide our process in the realization of this goal.

3.1. Research Process and Questions

In order to help future researchers to better evaluate their AR systems, and thus allowing this technology to be adapted by larger and larger number of users, we need to answer three main research questions:

Question 1:

What are the main methodologies for user's evaluation that have been employed in the past in the field of AR, for each determinate domain application?

we need first and foremost look at the past, at what was already done, and what tools and procedures other researchers used.
This will inform what was already attempted, and what tools and approaches have been used to successfully investigate the problem.

Question 2:

What were the aspects of Human-Computer Interactions that these evaluations methodologies investigated?

Only knowing what has been done is not sufficient to guide future evaluations, we need also to understand what aspect of the HCI these tools had investigated.
This is necessary to further understand why these tools have been used, and what aspect of the AR research was more focused on in the past, and so, if future evaluation needs to look at the same facets or need to focus their resources elsewhere.

Question 3:

Based on the results of the first and second questions, is possible to derivate a usable framework to inform and guided future evaluations?

Finally, if the first and second questions have been answered accordantly, we could proceed to the construction of a usable framework that has three main goals:

1. to informs future researchers on what methods and HCI aspects has been investigated,
2. to guide future studies on what are the tools and approaches that have been utilized in the past and demonstrated to be effective,

3. and finally, to educate on why user evaluations are fundamental for the success and adoption of future AR technologies and applications.

Although, as we have seen, there is still no common consensus on what are the most common tools in use today to investigate AR interaction for each specific domain of application, more and more scholars express the importance of focusing both on technology development and evaluation of the user's interaction to further develop AR technologies and push them through a more mature future **[112] [115]**.

3.1.1. Initial Process

The above research questions have been initially addressed by conducting a literature review on the main online databases (Scopus **[155]**, Science Direct **[156]**, IEEE Xplore Digital Library **[157]**, Research Gate **[158]** and Google Scholars **[159]**) to find survey papers on the field of user evaluations and, more specifically, in the domain of HCI, UX, UI, usability, and of course AR.
This first inquiry returned a series of results, where the most promising were:

1. Survey of User-Based Experimentation in Augmented Reality, Swan and Gabbard (2005) **[112]**.

2. A Survey of Evaluation Techniques Used in Augmented Reality Studies, Dünser, Grasset and Billinghurst (2008) **[110]**.

3. Trends in Augmented Reality Tracking, Interaction and Display: A Review of Ten Years of ISMAR, Zhou, Duh and Billinghurst (2008) **[160]**

4. Analytic review of usability evaluation in ISMAR, Bai and Blackwell (2012) **[137]**

5. The future of augmented reality and an overview on the to researches: a study of content analysis, Bal (2018) **[161]**

6. Usability Assessments for Augmented Reality Motor Rehabilitation Solutions: A Systematic Review, Cavalcanti et al. (2018) **[162]**.

7. A Systematic Review of 10 Years of Augmented Reality Usability Studies: 2005 to 2014, Dey, Billinghurst, Lindeman and Swan (2018) **[113]**

8. Revisiting Trends in Augmented Reality Research: A Review of the 2nd Decade of ISMAR (2008–2017), Kim et al. (2018) **[114]**

9. Usability Measures in Mobile-Based Augmented Reality Learning Applications: A Systematic Review, Lim et all. (2019) **[163]**

10. Evaluating Mixed and Augmented Reality: A Systematic Literature Review (2009–2019), Merino et all. (2020) **[164]**

11. Evaluation of Augmented Reality Technologies in Manufacturing – A Literature Review, Zigart and Schlund (2020) **[165]**

12. Evaluation of user experience in augmented reality mobile applications, Davidavičienė, Raudeliūnienė and Viršilait (2021) **[166]**

After a quick analysis of the papers here above reported, was immediately clear that we could not extract the necessary information from these data, due to their different objectives.

[162] [165] investigated a single field of applications **[161]** includes a small sample of papers, **[166]** relates to a specific technology, or **[164] [116]** did not included a large set of studies with real users evaluations and thus they have been excluded.
With this information, we decided to focus the work and structure the investigation into three main phases:

→ Collecting studies that respected specific inclusion criteria and not relying on the data provided by already existing surveys.

→ These studies will be analysed and clustered according to predeterminate groups and categories, which will be derived from the academic literature and would constitute the structure of the framework.

→ The resulting data will be analysed and organised in a graphic form that will constitute the final framework.

3.1.2. Studies Identification

Concerning the collection of the papers, two approaches were evaluated:

→ the first one is a systematic online research on Scopus, following these Boolean keywords terms:

- ("Augmented Reality" OR AR)
- AND ("Evaluation(s)" OR "User Evaluation(s)" OR "Usability Testing" OR "User Study/-ies")
- AND ("Usability" OR "User Experience" OR "UX")
- AND (("participant AND study") OR ("participant AND experiment"))
- AND (("subject AND study") OR ("subject AND experiment"))
- AND (experiment(s))

→ The second one, instead, uses some of the past surveys, has already been discussed in chapter 3.1.2, and presented the same investigation parameters we need. Furthermore, these papers reported all the studies used in their analysis, so were suitable for our needs.

From these resulting studies, a finer selection was conducted to identify the papers that presented the right characteristics to be included in the successive analysis step.
These Inclusion and exclusion criteria were:

- Articles that investigate Augmented Reality systems according to the definition presented in section 1.1.
- Articles including at least one of the analytical and/or empirical user evaluation methods presented in section 2.4.

→ Exclude all:

- Articles that discuss only topics of application development and does not implement user evaluation measures.
- Articles that do not include evaluations with users or experts.

After careful considerations, the second approach was chosen due to the constraint of resources and time dedicated to this first identification phase.

Table 2
List of surveys consider for the analysis

Moreover, the sample that these papers utilize respected, for the most part, the inclusion and exclusion criteria individuated.
The survey papers used for the final elaboration were **[Table 2]**:

Publication	Venues considered	Coverage years	n. publi-cations
Swan and Gabbard (2005) [112]	IEEE ISMAR, ISWC, 1992–2004 21, IEEE VR, and Presence	1992 2004	21
Dünser et al. (2008) [110]	All venues in IEEE, Xplore, ACM Digital, Library, and Springer Link	1992 2007	165
Bai and Blackwell (2012) [137]	IEEE ISMAR	2001 2010	71
Dey, Billinghurst, Lindeman and Swan (2018) [75]	All venues indexed in Scopus	2005 2014	291
Lim et all. (2019) [163]	IEEEXplore, Web of Science, Science Direct, SpringerLink, ACM Digital Library and Google Scholar	2009 2018	72

After an accurate analysis, only the one from Bai and Blackwell (2012) **[95]**, Dey, Billinghurst, Lindeman, Swan (2018) **[75]** and Lim et all. (2019) **[115]** were selected and the number of research to be analysed is 433.
The choice to discard the first two surveys was the result of two main considerations:
First, the publication of Dünser et al. **[72]** was an extension of the one from Swan and Gabbard **[74]** and included the same papers of its predecessor, and above all, these publications refer to a timespan too old for the current AR technology state to be considerate still relevant.
Although these publications respect the parameter described in the previous pages for being analysed, this selection is originated from different sources and venues, that does not use the same criteria of acceptance for their studies, and thus could not represent fully the current state of the art, and the tools used in today AR evaluation.

3.2. Identification of categorization parameters

After we choose the studies to analyse (that we can see as the fundamentals of our framework), we needed to define the main categorization parameters, (that we can compare them as the pillars that will support the structure of our framework).
These parameters concerned three main aspects of the framework:

1. the technology sphere,

2. the domain/field aspect and study design,

3. and finally, the main evaluations methodologies with their relative investigated HCI aspects.

3.2.1. Technology used

As we have seen in the first chapter, an AR interaction can be implemented by following several methods, tools, and devices. This is surely a strength of the AR field, but it can also complicate substantially the work of categorization and parametrization.
Thus, for the creation of a usable framework, we decided to follow the division of the main components presented in section 1.3, with their corresponding sub-categorization (presented in sections 1.3.1, 1.3.2, and 1.3.4), with the exception of the scene generator / computational devices section (1.3.3) **[Table 3]**.
The choice of excluding the computational devices from the classification was motivated by the idea that different type of today computation hardware does not affect too much the HCI nor the evaluations methods used to investigate it,
Instead, they are more related to the technological part of the creation of a functional and reliable AR system more than its evaluation with real users, and thus outside the scope of our work.

Output devices	Input devices	Tracking devices
→ Wearable ▪ Headsets See-through ▪ Headsets Monitor ▪ Contact ▪ Helmet → Handheld ▪ Non fixed ▪ Fixed → Spatial ▪ HUD ▪ Stationary Monitor ▪ Spatial See-trough ▪ Spatial Projected ▪ Spatial Projected (wearable/handheld)	→ Direct Interaction with Device → Gesture Recognition/Hand → Tracking → External Physical Device → Voice Recognition → Head/Eye Tracking Tangible → None	→ Mechanical → Electromagnetic → Wireless → Ultrasonic → Inertia → Optics Marker-based → Optics Marker-less

3.2.2. Domain/Field focus and Studies Design

Table 3 (above) Technology used classification

The second parameter that we will analyse in our investigation is related to the definition of the single study itself, its design and focus, and it can be divided into these different subcategories:

Augmented / Used Senses
The first subgroup concerns the senses augmented, as we have seen, the concept of AR is not only limited to the visual one, but the world perception that can be augmented could affect different senses, as well as a combination of them.

Field / Domain & Field / Sub-Domain
Originally, for this section was planned to use the examples of categorization defined in chapter 1.4, but after an initial analysis of the sample of studies under examination, we found these subdivisions did not match completely the studies sample selected.
This forced us to adopt a newly expanded taxonomy based on the ones already presents inside the surveys of Dünser et al. (2008) **[72]** and Dey, Billinghurst, Lindeman, Swan (2018) **[75]**, those introduced different new categories that in our old classification were too broad or wrongly grouped.

This led to the creation of new categories and the reorganization of others to describe in more detail the domain treated, and better represent the analysed tour sample **[Table 4]**:

Domain (*new categories added)	**Reference**
Business & Services	Included all the applications that could help the retail sectors, as well the adverting and enterprise sectors (see 1.4.8 - Commercial & Enterprise and 1.4.9 Consumer Sector)
Communication & Telepresence	Due to the high presence of this domain inside the paper analyse, was decided to separate this field from the others. It refers to topics such as Telepresence, remote collaboration, as well as remote help. (see 1.4.4 - Architecture, Engineering and Design and 1.4.8 - Commercial & Enterprise)
Cultural & Tourism	That is close to the topics traded in 1.4.7 - Arts & Culture, with museum and art exhibitions, heritage explorations and tourism (both cultural than commercial)
Education & Training	Where can we find all the topics related to education and training with the aid of AR systems (as seen in 1.4.2 - Education & Training)
Entertainment	In this category are present all those domains that have a strong ludic component inside, like games, narratives experiences, toys and so on (1.4.9)
Field Operations*	The introduction of this category was necessary due to the high number of studies that focused on some type of operation (like maintenance or work) conducted in the field.
Generic Interface*	This new group included all those interfaces developed without a clear field of application in mind, and thus were evaluated from a more generic point of view, analysing universal HCI principles (such as information perception, communication, or collaboration), and thus are transversal to more fields.
Health Care & Medicine	As seen in chapter 1.4.3
Industry, logistics, and manufacturing	As seen in chapter 1.4.5 and 1.4.4
Military operations	As seen in chapter 1.4.1
Navigation & Driving	As seen in chapter 1.4.6, also include navigation by foot or inside buildings.
Other	All the entries that could not be classicised in the other categories

Table 4
(previous page)
Field / Domains description

Finally, these new parameters were ampliated with the addition of sub-domains/fields to better describe the field of utilization of each study (as we will discuss in the next phase).

Type Of Study Evaluation
This category describes how the evaluation was conducted, and specifically what was its focus.
The introduction of this specification was made necessary due to the completely different types of approaches that we could in the same domain in the evaluation of an interface.
Here we can find 13 categories (described as in **[Table 5])**.

Study Setting
As discussed in section 2.8, the setting, where the evaluation is conducted, is an important aspect of every study that had to be accounted for, so is important also evaluated where and in which domain/field the evaluation is carried out.
This can be:

→ In Lab, defined as all the evaluations that are conducted in a controlled environment where all (or most) of the variables are under control (i.e., usability lab, previously prepared room, access restricted interior area and so on)

→ On the field, namely every place where the evaluation is conducted without having full (or almost full) control of the environment (i.e., outside, in a classroom during lessons, on the factory floor, and so on.)

→ Both, where the evaluation is conducted both in a controlled environment and on the field, both with the same subjects (as in the case of with-in study design) or with different subjects (as in the case of in-between studies)

Number of participants
We must also consider the number of participants to gather how many subjects are preferred for a determinate evaluation method or domain/field.

Type Of Study Evaluation element	description
Comparison with Traditional	Evaluation created with the scope of evaluating the new AR system in relation to its traditional counterpart.
Concept investigation	Evaluation that aims to investigate a concept, idea or new process that employ an AR system.
Informal feedback or Design process	Evaluation conducted without following a precise study protocol but had the goal to collect “quick and dirty” insights on the developed AR system.
Interaction Evaluation	That had the goal to investigate how the users interact with the AR system.
Interactions Comparison	That instead of investigating how users interact with the system, investigate the differences between various interfaces or interactions methodologies (both new and traditional)
Methodology Evaluation	Investigate the new type of methodology in the related domain that makes use of AR, the difference between the concept investigation and the methodology evaluation is that, here the concept was already definite, and the focus is on testing if the proposed solution, instead of the concept.
Perception Method Evaluation	Investigated how the users’ perceptions behave to determinate aspects or information of the AR system.
Perception Method Comparison	That instead of investigating how user’s percept determinate aspect or information of the system, investigate the differences between different output devices (both new and traditional)
Prototype Evaluation	Evaluations that were created with the aim of investigating a single prototype and are not imitated to the interaction or perception aspects
Prototypes Comparison	That instead of investigating a single prototype, analyse different prototypes that have the same goal, or function (but do not include comparison with traditional interfaces)
Technologies and Solutions Valuation / Comparisons	Evaluations that have as main goal the testing of different solutions or technologies (i.e., different types of display or calibration methodologies, and so on…)

3.2.3. Evaluation methodologies and main investigated HCI aspects

Table 5 (on next page)
Type of Study Evaluation

The third parameter taken into consideration was the central, and most important pillar of the framework, here we can find all the methodologies that can be used in the investigation of AR systems and the focus of why these evaluations were conducted.

Table 6 (below)
Evaluation Methodologies sublevel data structure and example schema

Evaluations Methodologies

This categorization followed closely the one defined in section 2.2, defined by Kostaras and Xenos **[135]**.

Originally this classification had to cover all the cases present in the evaluated papers, but after an initial look at the evaluation's methodologies present inside the papers, we found this categorization to be too restrictive, thus we opted to expand this classification with two additional subgroups (of which the last one facultative) that allowed us to create a more precise and accurate description of the tools used.

So, the evaluation methodologies could be subdivided as:

- → 1st level: (Analytical, Empirical...)
  - → 2nd level: (Experimental, Inquiry, ...)
    - → 3rd level: (Questionnaires, interviews, ...)
      - → 4th level: (SUS, NASA-TLX, ...)
        - → 5th level: (5 Likert scale, range items...) – *if applicable*

1st level	**2nd level**	**3rd level**	**4th level**	**5th level**
Analytic Methods	Inspection methodologies	→ Heuristic Evaluations → Cognitive Walkthroughs → Pluralistic Walkthroughs → (...)	→ (...) → (...) → (...)	→ (...) → (...) → (...)
	Theoretically based models	→ Fitts's Law → GOMS → (...)	→ (...) → (...) → (...)	→ (...) → (...) → (...)
Empiric Methods	Experimental methodologies	→ User observation → Thinking aloud protocol → Co-discovery → (...)	→ (...) → (...) → (...)	→ (...) → (...) → (...)
	Inquiry methodologies	→ User questionnaires → User interviews → Focus groups → (...)	→ SUS → (...) → (...)	→ 5 Likert → (...) → (...)

Main investigated HCI aspects

As we already discussed, just collect data about the evaluation methods employed to give us only half part of the comprehensive picture, to made sense of the data collected and build a useful framework we need to analyse also why these data were collected in the first place.
In the field of HCI, an evaluation could be conducted for a large variety of reasons, these could range from the interface usability to the meaning of an action, as well as how things are perceived and how users behave.
To summarize and make an order from a so large spectrum of possible goals, we initially focus our effort to see what other researchers had individuated in their surveys.
Different types of classifications of evaluations goals have been created during the years, Swan and Gabbard in their original survey in 2005 **[112]** individuated three district fields of research, these were then been later expanded by Dünser, Grasset and Billinghurst in 2008 **[110]** adding a fourth category.
Since then, also other surveys that follow during the years maintained this taxonomy when discussing the topic of User Evaluations in AR.

→ **Perception:** The first category they found concerns Human Perception and Cognition in AR, here found place all the research that examine issues such as perceptual effects of alternative rendering techniques (such as those that employ realistic lighting and shading), depth-perception in AR and effects of AR display viewing conditions and/or display hardware specifications on perception. The main aim of those assessments is to study low-level tasks, with the goal of understanding how human perception and cognition would operate in AR contexts.

→ **Performance:** The second category refers to Performance, thus all the experiments examining user task performance within specific AR applications or application domains, to gain a better understanding of how AR technology could impact the underlying tasks. Often, they measure time and accuracy/errors as main parameters, but some studies also assess aspects such as cognitive load, judgment reliability, distraction, cognitive support, learning effect, and various behaviours **[167]**.

→ **Between user interaction and communication**, the third category touch instead of user interaction and communication between collaborating users, this field is a subset of human-computer interaction research known as computer-supportive cooperative work. All the works where more than one user shares the same AR space at the same time belong to this category.

→ Finally, Dünser, Grasset and Billinghurst proposed a fourth category called **System usability/system design evaluation**, although this category can be similar to articles in the second category (Performance), they stated that these studies do not necessarily include user task performance assessment, but instead focuses on other the identification of device usability issues.

The term usability was used by Dünser et al. in the broadest definition of the term **[121]**, including also concepts like the ease of use, usefulness, learnability, subjective satisfaction, and comfort.
This led other researchers, like Bai and Blackwell **[137]** to substitute the term usability with User Experience (UX) in their 2012 review evaluation, to describe better this category.
They defined UX as "*subjective user issues, such as technology preference, affect, perceptual and physical experiences*", following the work of Hassenzahl et al. **[168]** and the ISO definition of UX **[169]**.
They found, however, that UX was less likely to be investigated using controlled experimental methods, which conduct them to separate this category into two sub-groups: **Formal** and **Informal UX evaluations**.
in the former category, Formal evaluations involved controlled experiments with a fixed sample of users and collected participants' experiences with tools like structured surveys/questionnaires. In the latter instead, Informal evaluations involved unstructured interviews or observations with a casual sample of potential users or domain experts, such as the group of evaluations categorize by Dünser as Informal testing (seen chapter 2.4).
Another insight they found was that many experiments in the other categories also included some methods that could be categorized as UX evaluations, such as a questionnaire at the end of a task performance assessment or an unstructured interview after a collaborative section.
This is quite understandable, as the broad definition of UX includes a lot of aspects of the human experience, and one method cannot be used merely to assess a single factor that contributes to successful Human-Computer Interactions.
This also means these categorizations are not to be taken as rigid and contained, but rather as flexible ones that could accommodate evaluations that refers to more than one category.
The last finding was quite important in our parameters definition phase because leads us to realize that one evaluation method could be used to determinate multiple HCI aspects and cover more evaluations goals than one.

Starting from these considerations and the categorization that other researchers identify so far, we defined the initial subdivision of this parameter as:

→ **Perception**

→ **Performance**

→ **Between user interaction and communication**

→ **Formal User Experience**

→ **Informal User Experience**

Again, after an initial look at the evaluation methodologies presented in previous research, we found the categorization to be too restrictive due to the too-broad definition that these parameters identify.
This forced us to expand and reorder this taxonomy, looking at the works of M. I. Zarour **[170]**, Irshad et al. **[171]**, and Arifin et al. **[172]**, that tried in their studies to better analyse and define all those aspects that could describe a successful and pleasant user interaction, as well the definitions provided by the works of the Rogers and Sharp **[173]**, and Hartson and Pyla **[174]**.
Starting from this work, 15 categories have been identified (and are described in **[Table 7]**, with the relative subgroups (as we will see in the next chapter).

Table 7
Type of Study evaluation classification

Type Of Study Evaluation element	Description
Collaboration & Communication	Based on the definition given by Dünser, Grasset and Billinghurst [72], concern user interaction and communication between collaborating users.
Education specific	This category is mainly used in the education and trading domains to understand if teachers, with the help of AR, are being understood by the students, and here we can find all those evaluations that are carried out to evaluate the level of understanding of the explained topics.
Ergonomics, Loads and Comfort	Here we can find those metrics that aim at investigating the load (both mental and physical), the comfort, sickness, frustration, anxiety, or stress that the users experience in the utilize of the AR system, as well as the effort perceived and the physical ergonomics properties of the product/prototype. In this category, the metrics, linked to usability properties, are not included. This was due to the creation of a specific section for the usability.

Interaction	We used the category interaction as an umbrella term to indicate all the metrics that collected the behaviours, interaction patterns and strategies, attentions, and actions of users during the tests. These data could be collected for model and understand what are the underlying interactional models and cognitive process that occur during the utilization of an AR system
Perception & Cognition	Based on the definition given by Dünser, Grasset and Billinghurst **[72]** already discussed, concern Human Perception and Cognition in AR, so all that metrics that aim to examine issues such as perceptual effects of alternative rendering techniques, depth-perception and so on.
Prototype focus	This group concern all the evaluations that revolve mainly around the evaluation of the prototype itself. Here we have topics such as missing features, general opinions, feedbacks, and suggestions on the prototype itself.
Task performance	As already identify, here there are all the metrics that are referred to the performance that the users provided in their interactions with the system (performances such as time, errors, length travelled, and so on...). This category is used paired with the usability one (see below) and used to measure the efficiency of the system. We decided to divide this category to the usability one, due to the fact that not always this group was used to address the usability of AR systems, and moreover, the tools used to investigate it where completely different from the one used in the usability group.
Treatment Specific	In this category we can find all the metrics that are related to some type of medical treatment, rehabilitation, or phobia study, we can find this group only in the Health Care & Medicine section, being high tied with this application field.
User Experience (subdivided in Emotion, Meaning, Usability, and Usefulness)	We decided to subdivide the category of user experience into four different groups: Emotion, Meaning, Usability, Usefulness, following the definition given by Hartson and Pyla **[174] [173]**. This is necessary due to the complexity and multifaceted nature of the term User experience, that also today does not have a common and agreed definition **[175]**, for instance, the concept of usability is considered for someone separated from user experience, other on the contrary encompass it completely inside the concept of users experience, and for others instead is the term user experience child of usability (seeing it as an elaboration of the satisfaction component of usability **[Figure 3-1]**) **[170]**. This is true also for the concept of usefulness, that someone sees it as a descriptive component of usability [**176**], and others as completely separated subjects **[124]**. To accommodate all these different points of view, we chose to follow the model identified by the authors quoted above (that can be seen in [Table 8]), which provided a good description of each category, as well also a good collection of examples that helped us in the definition of this category.
Other	Here we can find all those parameters that could not be categorized in the other groups.

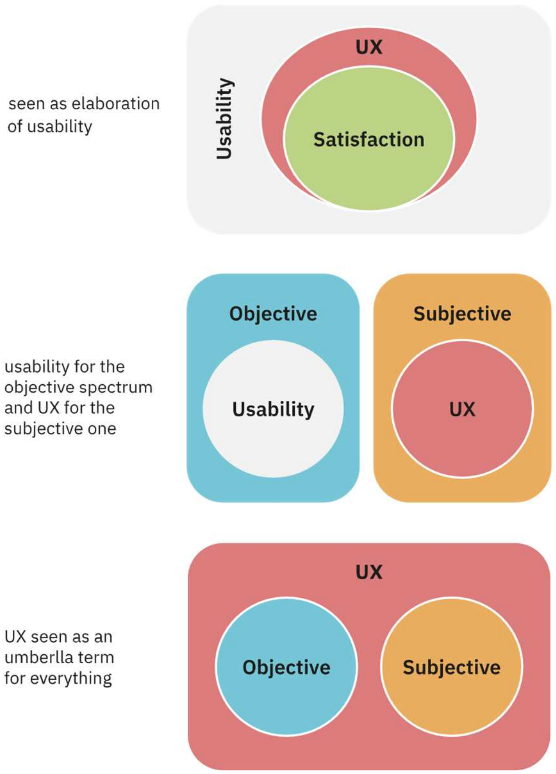


Figure 3-1
M. I. Zarour possible categorizations of User Experience and Usability (source: [170])

User Experience	Usability	▪ Ease of use ▪ User performance ▪ Efficiency ▪ Error avoidance ▪ Learnability ▪ (...)
	Usefulness	Ability to use the system or product to accomplish a determinate goals
	Emotional Impact	The affective component of user experience and user feeling and satisfaction, such as: ▪ Joy of usage ▪ Pleasure ▪ Excitement ▪ Fun and amusement ▪ (...)
	Meaningfulness	The long-term personal relationship with products, the society, personal believes, self-expression (...)

Table 8
Hartson and Pyla [125] subdivision of User Experience component

After all the main parameters were defined, the actual analysis was conducted, as we will see and discuss in the next chapter.

4.
RESULTS & FRAMEWORK DEFINITION

In this chapter we will see and analyse the investigation results (that can be found in their raw form inside **[APPENDIX - B]**) subdivided per the main parameters, we will define and describe the resulting framework, as well as illustrate how it could be used for guiding future evaluations.

4.1. Studies sources and type

The study was conducted on 433 papers, sourced from three structured surveys (as seen in chapter 3.1.2) that referred to a time frame running from 2001 to 2018.
The source with the largest number of papers was the one from Billinghurst, Lindeman, Swan (2018) **[75]**, followed by Bai and Blackwell (2012) **[95]** and Lim et all. (2019) **[115] [Chart 4-1]**.
Of these 433 papers, only 34 were duplicates find in more than one source, bringing the total number of unique papers to 399.
These papers produced 474 unique evaluations, because one paper could refer to more than one study, this number also included 29 pre-studies (studies conducted on a small sample of users), that were included in the analyse, and one study removed because it did not respect the exclusion criteria illustrated in chapter 3.1.2.
A major part of the papers contained only one study, and only 36 (8,3%) contained more than one and followed an iterative structure, finally 24 (5,5%) contained at last one pre-study evaluation **[Chart 4-2]**.

Chart 4-1
Percentage of papers per source

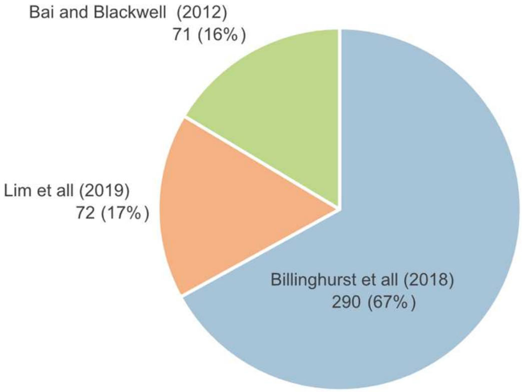
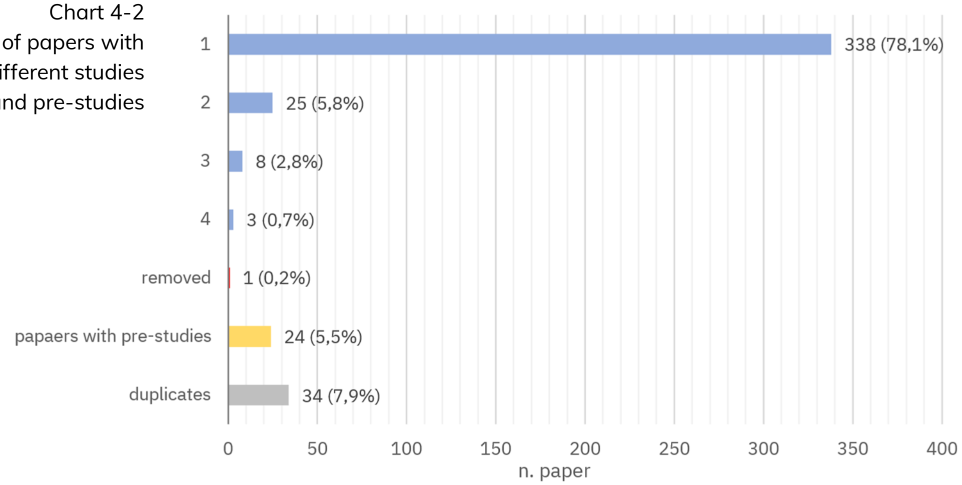


Chart 4-2
Distribution of papers with different studies and pre-studies



4.2. Technology used

4.2.1. Output technologies:

In our analysis, we found that the most used output devices used was of the category handled mobile by far **[Chart 4-4]**.
This is not surprising, being that in the last 12 years tools for these devices have simplified the creation of AR applications in a quick and cheap way, making them a good and fast solution for rapid prototyping.
The second most-used devices belong instead to the category of the wearable headsets see-trough (such as the Sony Glasstron or the nVisor) that in the 2000-2010 decade were commonly used before mobile devices such as smartphones and PDA become more available.
Third category are the common spatial monitors (e.g., traditional pc monitors) that are the easiest and most straightforward method used in the delivery of fast AR prototype.
Then we found the group of wearable headset monitors, which together with wearable see-trough devices, was used more at the beginning of the century, after them, we had the spatial projected category, that was employed mainly in generic interfaces investigation and in the perception studies.
The category of wearable contact (with devices such as headphones) was only used to augment the auditory sense, and like the other devices of the list, were used only in determinate prototypes that made use of these technologies as the main output device.
We found also that about 8% of studies used more than one output device, this mainly because about 5% of the studies focused on the comparison between different types of output technologies, or, more rarely because the prototype employed more than one technology **[Chart 4-3]**.
As we can see in **[Chart 4-5]** (that show the corelation between the different output technologies, here the width of the flow inside the circle represent the number of times a devices has been used with the other one linked by the line), the most paired output technologies were the handled mobile and spatial stationary monitor, with the other one fallowing.
This result is in line with what we found with **[Chart 4-3]**, that indicated that for the major part, the studies that employed more than one output devices, were comparing the different technologies.
This is also shown by the quasi-symmetry of the charts **[Chart 4-5], [Chart 4-6**
], [Chart 4-6], that indicate that these output devices were employ evenly in the same studies.

Chart 4-4
Total number of outputs devices used

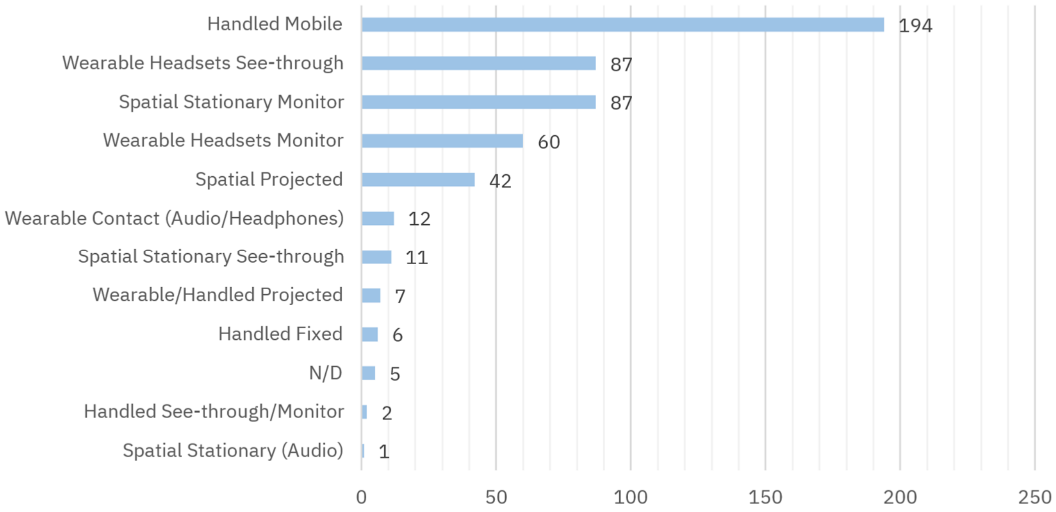


Chart 4-3
Distribution of studies per number of output devices used.

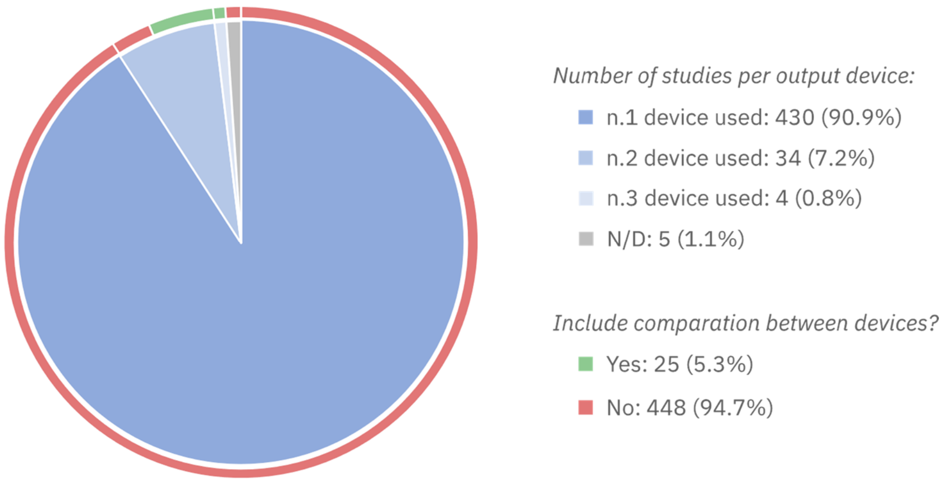
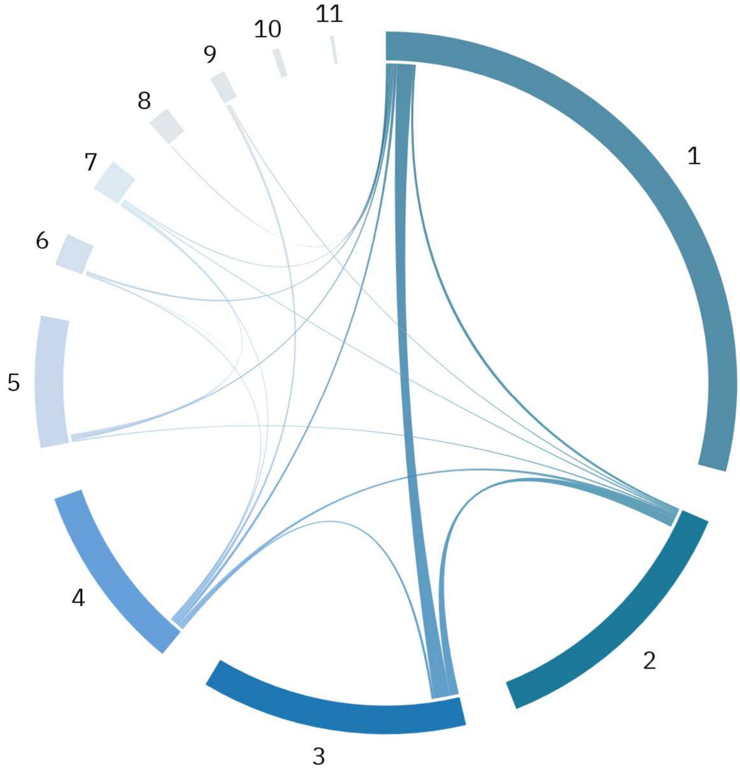


Chart 4-5
Corelation of output devices used between each other (total)



1. Handled Mobile
2. Wearable Headsets See-through
3. Spatial Stationary Monitor
4. Wearable Headsets Monitor
5. Spatial Projected
6. Spatial Stationary See-through
7. Wearable Contact (Audio/Headphones)
8. Wearable/Handled Projected
9. Handled Fixed
10. Handled See-through/Monitor
11. Spatial Stationary (Audio)

Chart 4-7
Corelation of output devices used between each other
(in studies with two devices used)

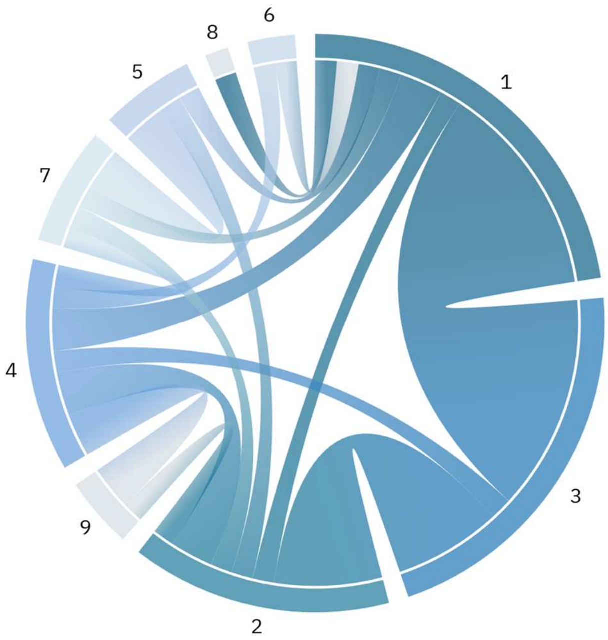
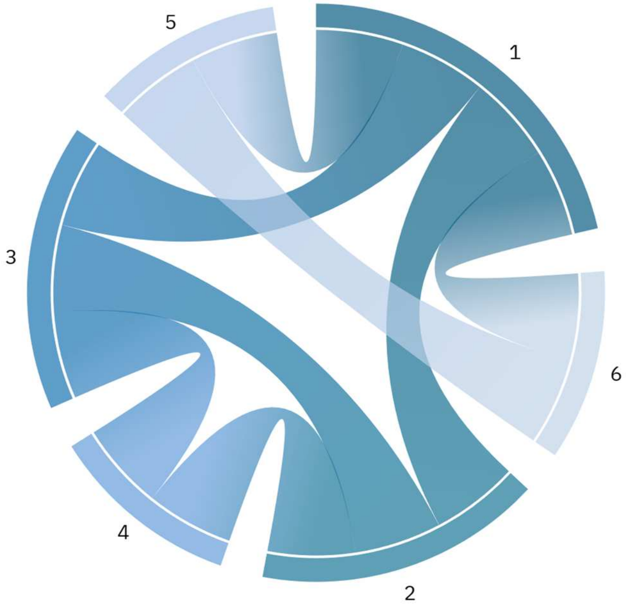


Chart 4-6
Corelation of output devices used between each other
(in studies with at last three devices used)



4.2.2. Input technologies:

We notice that the most used way of interacting was using category “direct interaction with the device” **[Chart 4-8]**, this is not surprising, being one of the most used and traditional ways of interacting with our technologies, moreover, as we have seen in the last chapter, one of the most used devices typologies were hand handled, and direct interaction is the most immediate and easy way of interaction with this category.

The second most used way of interaction was with tangible interfaces (such as physical tokens, real objects, tools and so on), this is interesting because a good number of studies (as we will see in the next chapters) was indeed centre on the studies of tangible interfaces within the context of AR interaction.

Interesting is also the strong presence of gesture and hand tracking interfaces, in our opinion this is the result of the novelty and flexibility that this new type of interaction in 3D space could give to AR systems and the HCI field, and thus the academic interest generated from this.

Following the chart we find the group of external devices, that were used mainly with HMD (both see-through and monitor) and stationary (both monitor and projected) where the direct interaction with the AR device itself would have be impractical.

Only 17 studies did not report any interaction devices, being these focused on the perception evaluation than the interaction itself, and thus did not needed any interaction device.

Finally, interfaces like voice recognition and head or eye tracking were not commonly used, we think due to their low number of use cases, where their use would be beneficial.

Only three devices could not be categorized in the already defended groups, these interfaces made use of special brain interfaces (EEG / EMG amplifier) used in the treatment of ghost pain in amputee patients.

We found that only 5% of studies analysed the comparison between different input devices, although, unlike what happened for the output devices, here the 12% of studies employed more than one interaction device to interact with the AR system **[Chart 4-9]**.

We can see this also in **[Chart 4-10]** (that show the corelation between the different output technologies, with the width of the flow inside the circle representing the number of times a devices has been used with the other one linked by the line), were input metrologies direct interaction and tangible interfaces were used more often together than the others ones, that instead were used more evenly (as we can better see in **[Chart 4-12]** and **[Chart 4-11])**.

Chart 4-8
Total number of Inputs devices used

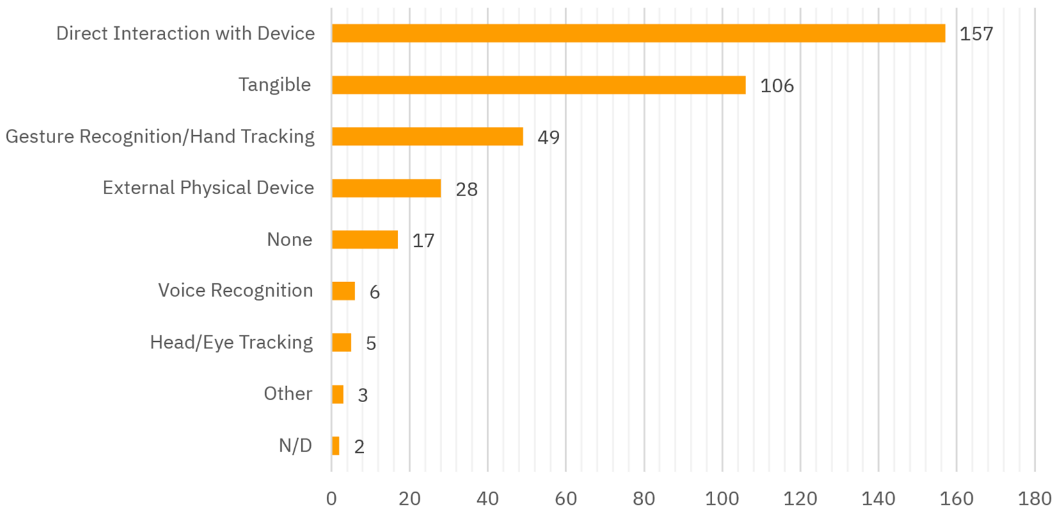


Chart 4-9
Distribution of studies per number of input devices used.

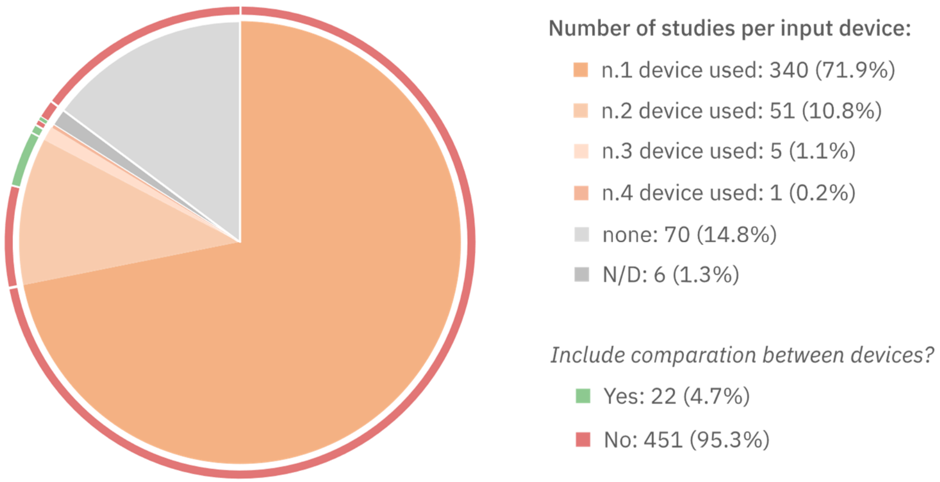


Chart 4-10
Corelation of input devices used between each other (total)

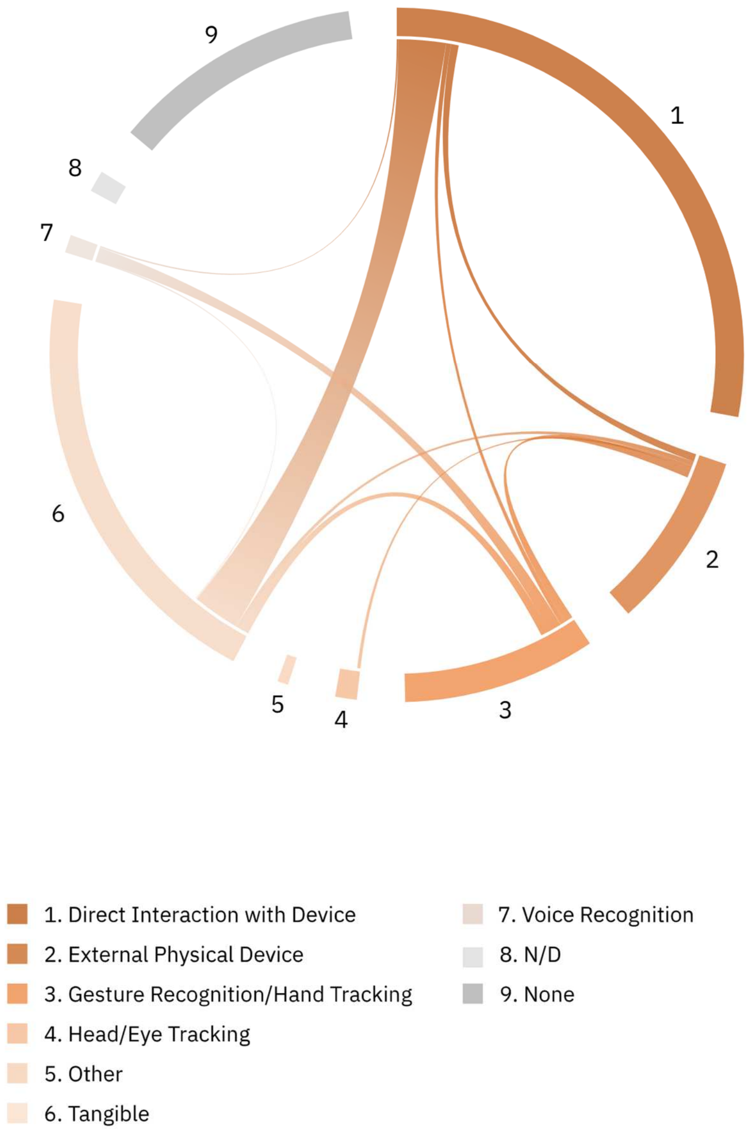


Chart 4-12
Corelation of input devices used between each other
(in studies with two devices used)

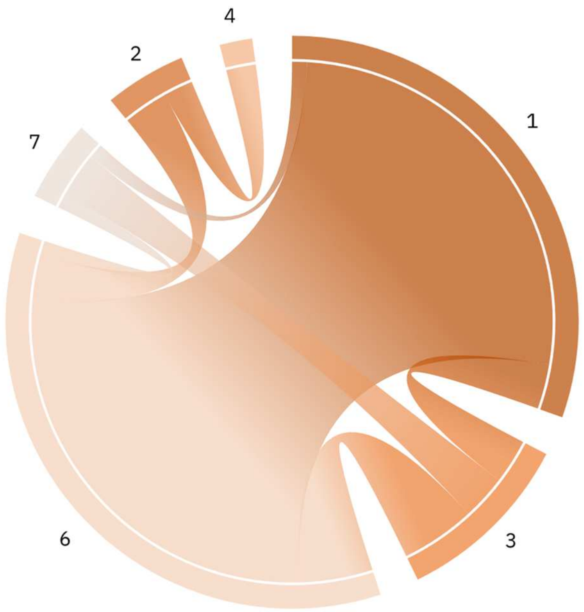


Chart 4-11
Corelation of input devices used between each other
(in studies with at last three devices used)

4.2.3. Tracking technologies:

In tracking technologies, marked-based technique was the most used one, and again we are not surprised, considering the availability in the last decade of frameworks and tools that help creating prototype based on this technique **[Chart 4-13]**.
Marker-less tracking is the second most used tracking technique, that especially in the last years is becoming more and more used, always thanks to the spreading of new tools that integrate this technology and thus help in making it wildly available.
Here, once more, we can see the dominance of methods used mainly on hand-handled devices, such as inertia and wireless tracking methods, that being integrated inside a major part of today smart-phones, make them a rather common choice for tracking in mobile prototypes **[Chart 4-15]**, we can notice this also with optics (both marker-base and marker less) tracking technique, that were often used with hand-handled devices **[Chart 4-16] [Chart 4-17]**, as the result of the highly available framework that simplify the prototype development.
Surprising, we found many evaluations that used any tracking device, this was in part the result of studies that only focus their effort on the comparison of different output or input devices, but for the major part, it was the result of a common workaround that many studies employed.
This consisted in the use of output technologies such as stationary monitors that did not require, one positioned and calibrated, to continually track the user position in space, being his or her position "constrained" in one position.
For this category we did not evaluate if there was a comparison between the different tracking devices, for various reasons:
first, this would go beyond the scope of our work, and second, none of the evaluations selected presented a compressive comparison between tracking technologies **[Chart 4-14]**.
We think that this could be the results of the exclusions criteria (described in chapter 3.1.2) which dictated the need of at last a user evaluation with real users or experts and comparing different tracking technologies could be done without employing real users.

Chart 4-13
Total number of Tracking devices used

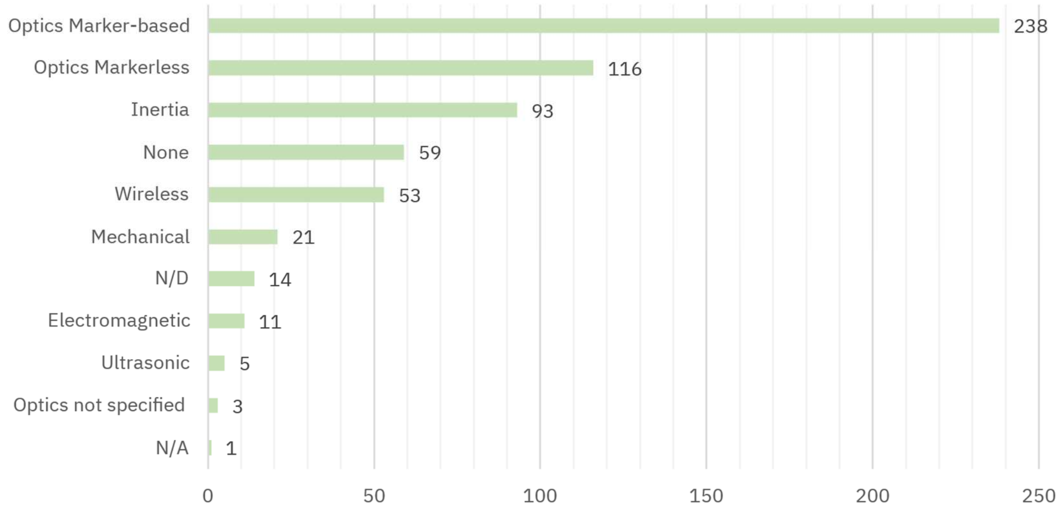


Chart 4-14
Distribution of studies per number of tracking devices used.

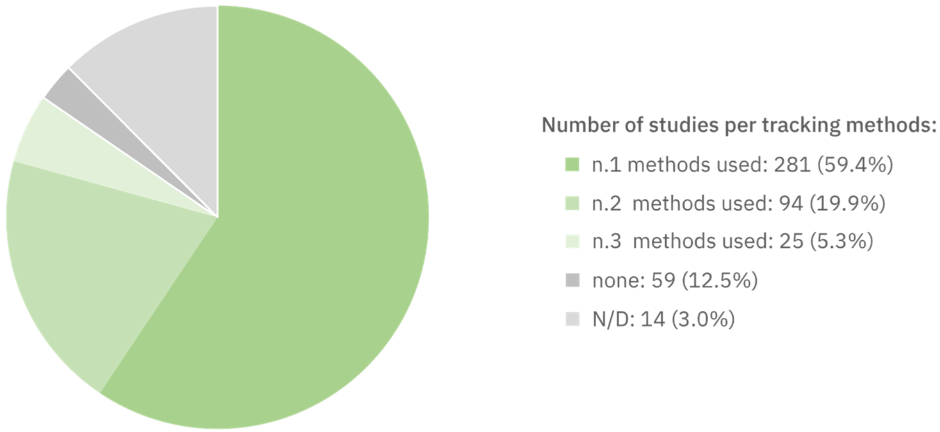


Chart 4-15
Corelation of tracking technologies used between each other (total)

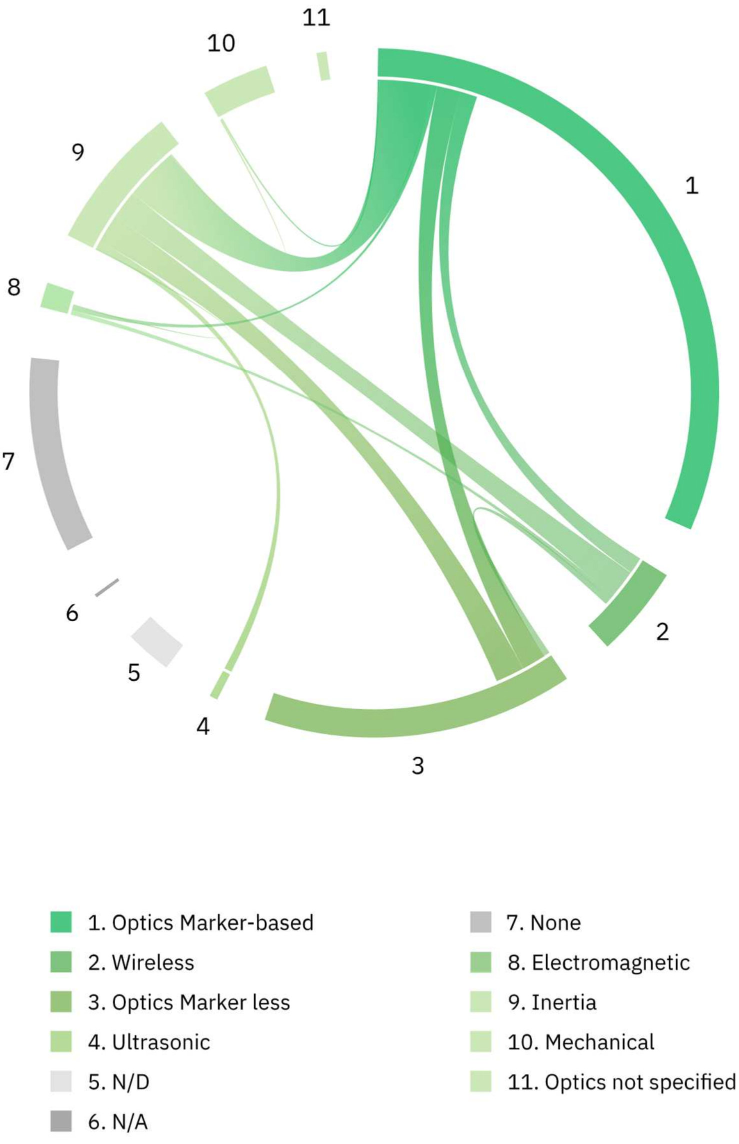


Chart 4-16
Corelation of tracking technologies used between each other
(in studies with at two devices used)

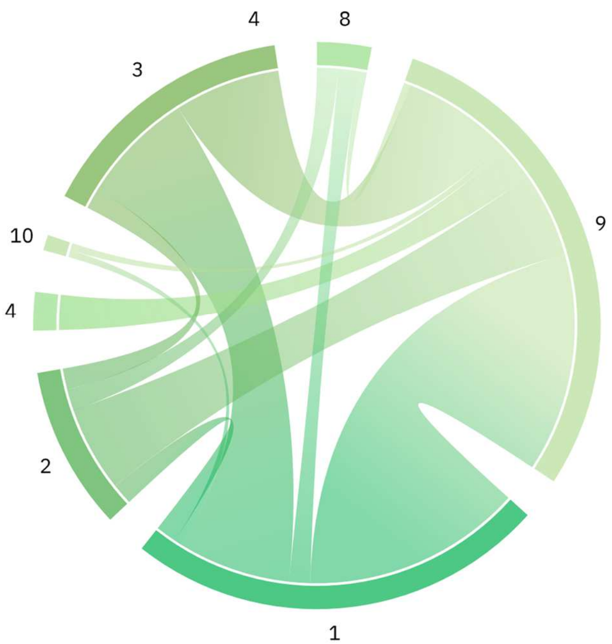


Chart 4-17
Corelation of tracking technologies used between each other
(in studies with at last three devices used)

4.3. Domains and fields of application

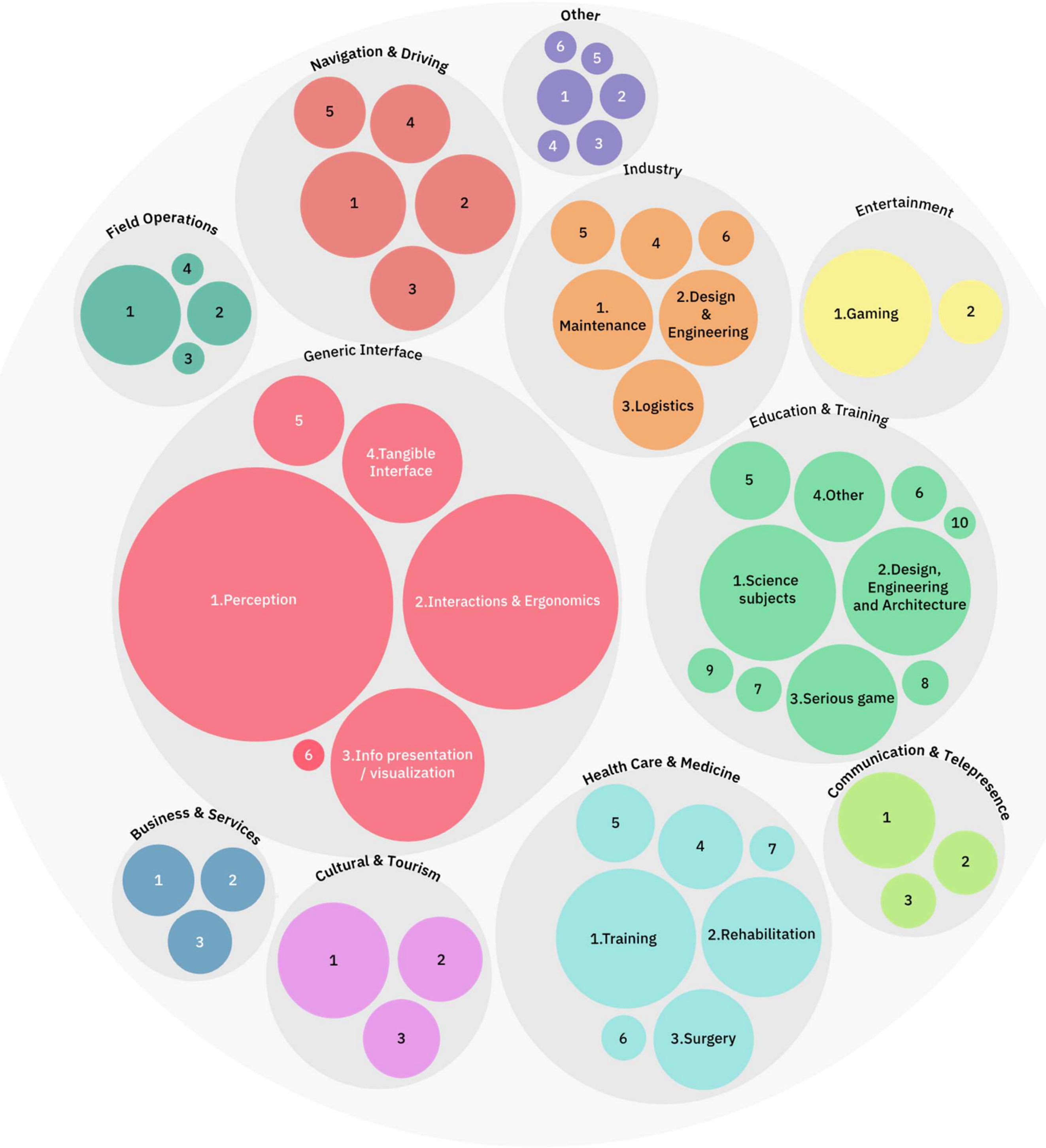


Figure 4-2
Domains and fields of application groups and quantity

As reported in chapter 3.2.2, we decided to subdivide the category of the domains and field of applications into 11 categories, followed by their subgroups, here reported **[Figure 4-1]**.
In this chart (where the area of each circle represents the number of studies in that category) we can see the repartition and where the focus of the evaluation was for the major part aimed.
The first main domain is the one related to the generic interfaces, subdivided into the main sub-domain of perception (that alone is bigger than the second-largest domain), followed by interaction, info presentation and tangible interfaces.
We think that this unbalance between the domains is due to the efforts that researchers have devoted, mainly in the first decade of research, to the exploration of the generic principle of perception and interaction rather than to specific prototype for determinate field and applications. This is also understandable, as also indicated by Gabbard and Swan in their evaluation studies approach (chapter 2.6.4), the investigation (and later definition) of the new HCI paradigms specifically build for AR is a step that is necessary for the development of Augmented Reality.

Generic Interface	**164**	**34,7%**
1. Perception	73	15,4%
2. Interactions & Ergonomics	45	9,5%
3. Info presentation / visualization	23	4,9%
4. Tangible Interface	14	3,0%
5. Collaboration	8	1,7%
6. Calibration	1	0,2%
Education & Training	**70**	**14,8%**
1. Science subjects	18	3,8%
2. Design, Engineering and Architecture	16	3,4%
3. Serious game	12	2,5%
4. Other	8	1,7%
5. Languages	6	1,3%
6. History	3	0,6%
7. Special needs education	2	0,4%
8. Orientation	2	0,4%
9. Music	2	0,4%
10. PA	1	0,2%
Health Care & Medicine	**60**	**12,7%**
1. Training	19	4,0%
2. Rehabilitation	14	3,0%
3. Surgery	10	2,1%
4. Phobia Treatment	7	1,5%
5. Elderly / Disables Help	6	1,3%
6. Personal Help	2	0,4%
7. Emergency	2	0,4%
Industry	**39**	**8,2%**
1. Maintenance	10	2,1%
2. Design & Engineering	9	1,9%
3. Logistics	8	1,7%
4. Training	5	1,1%
5. Assembly	4	0,8%
6. Manufacturing	3	0,6%

Navigation & Driving	**39**	**8,2%**
1. Info / Annotations AR & Remote viewing	11	2,3%
2. Driving	10	2,1%
3. Inside orientation & space navigation	7	1,5%
4. Remote orientation & navigation (i.e. on map)	6	1,3%
5. Outside orientation & space navigation	5	1,1%
Cultural & Tourism	**26**	**5,5%**
1. Museum & Exhibitions	13	2,7%
2. Heritage exploration & discovery	7	1,5%
3. Commercial exploration & discovery	6	1,3%
Entertainment	**20**	**4,2%**
1. Gaming	16	3,4%
2. Narrative experience	4	0,8%
Communication & Telepresence	**16**	**3,4%**
1. Telepresence & Remote collaboration	9	1,9%
2. Telepresence Surgery	4	0,8%
3. Remote Help	3	0,6%
Field Operations	**16**	**3,4%**
1. On site planning / maintenance	10	2,1%
2. CSI	4	0,8%
3. Archaeological	1	0,2%
4. Military Operations	1	0,2%
Business & Services	**13**	**2,7%**
1. Retail	5	1,1%
2. Advertising / Product preview	4	0,8%
3. Fashion / Makeup	4	0,8%
Other	**10**	**2,1%**
1. Security	3	0,6%
2. Generic Perception on AR - Privacy	2	0,4%
3. Generic Perception on AR - State of the art	2	0,4%
4. human/robot/AI interaction	1	0,2%
5. Generic Perception on AR - Expectations / acceptanc	1	0,2%
6. Generic Perception on AR - Immersion / motivation	1	0,2%

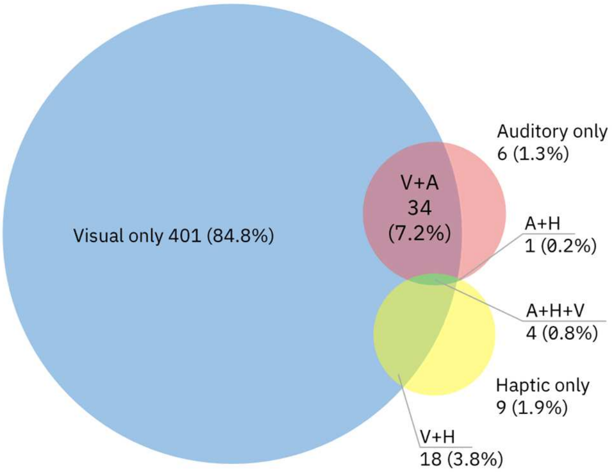
We decided to group the training subdomains of health care and industry in their correspondents' main domains.
Even with this decision, the second most represented group after the general interface one was the one of Education and Training, where many evaluations investigated different types of traditional subjects, such as science, language, history and so on.
We also notice an interest in evaluating the use of AR for teaching complex topics such as design, engineering, and architecture, where the visualization properties of AR could be very beneficial.
The third domain most investigated was the Health Care and medicine one, in this domain the largest focus was on teaching and training of future surgeons, nursery and emergency personal, specifically in delicate and dangerous situations where more realistic training could be helpful.
Followed this sub-category the groups of rehabilitation and phobia treatment, that also relied on the possible realism that AR interfaces could bring to these applications.
Another important field of application was the surgical one, where many evaluations investigated innovative and less invasive visualization and interaction techniques with the surgical instrumentation and the patients.
Inside the industry field, the first sub-group is the one from the maintenance sector, where the focus was mainly on the possibility to visualize quick contextual information, then the design and engineering sector, where there were evaluations designed to compare new design interfaces with traditional ones (similar evaluations that we could find in the Field operations domain, where the ability to previsualize information directly on the real world was one of the most investigated.
Less frequent were evaluations on a specific task, such as assembly, logistics or manufacturing, as well as training.
In the domain of Navigation and Driving the main efforts found were subdivided mainly into three fields: info visualization and authoring of information inside AR, driving (mainly using HUD inside simulators), and Indoor/Outdoor navigation.
Interesting also the part linked to the Cultural and entrainment domains, where the use of augmentation was used mainly inside museal exhibition and to evaluated new and innovative interaction with video games.
Finally, domains such as telepresence, business and services, and security were rarely touched. Here the evaluations were more focused on the large concept of AR inside these fields, its meanings, potentialities, and foreseen issues.
We think that this could be the result of the lack of stable and usable AR solutions in these domains, as well as the lack of uses case where the potential of this technology could be beneficial.

4.4. Study design and characteristics

4.4.1. Senses augmented

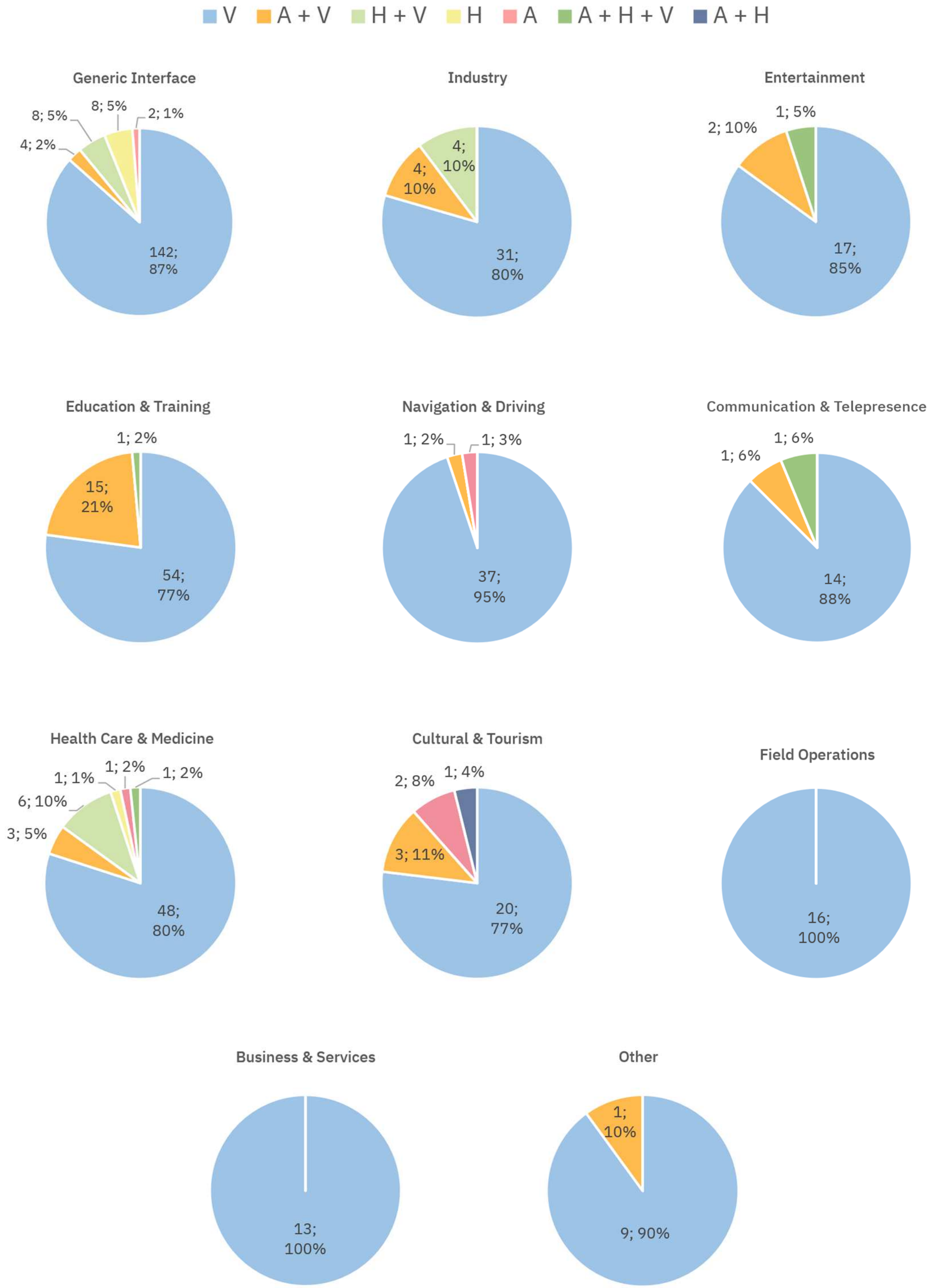
Unsurprising the sense most augmented was the visual one, followed by a mix of visual plus auditory and then visual plus hepatic.

Chart 4-18
Diagram of Ven of senses augmented per studies
Visual (V)
Audio (A)
Haptic (H)



In barely rare cases the senses augmented was only auditory or only haptic, this is true also for those evaluations that augmented all three senses **[Chart 4-18]**.
Only one study investigated the pair auditory plus haptic, other senses (like the olfactory or the kinaesthetic one) instead were not touched in this sample of studies.
We can here see how the visual senses are the most used and investigated for what concern the field of AR, and as we already discussed, we think is due to the tendency in tractional HCI interfaces of using the visual channel to fast share information large amount of information, with the other senses relegate to secondary functions only.
For what concern the distribution of the senses augmented per domain of application **[Chart 4-19]**, we can clary see that (set aside the dominance of the visual sense in all the categories), the auditory sense was used with a rather frequency in the field of education, cultural, and entertainment, all fields that already make highly uses of this sense in traditional interfaces.
The haptic sense instead, was used mainly as feedback support to direct interaction interfaces, or in all that places that provided direct contact with an object, of course, is the result of the technical difficulty of providing efficiently haptic feedback "in mid-air", and only in the last years relabel technologies has been made available to deliver this type of feedback (like the ultra-leap Stratos-Inspire) **[177]**

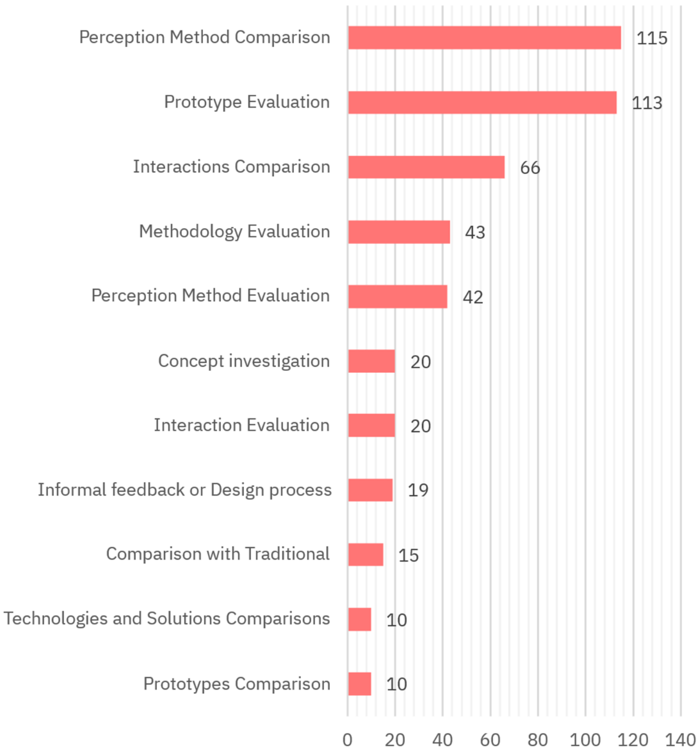
Chart 4-19
Distribution of senses used per domain
Visual (V), Audio (A), Haptic (H)



4.4.2. Type of evaluations

The main type of evaluation was related to the comparison of different perception methods, followed closely by prototype evaluation, this was expected, being the perception sub-domain one of the largest groups evaluated **[Chart 4-20]**.
Indeed, it is almost completely finding inside that sub-domain, with only some cases where we can find it inside groups like navigation (where the focus was understanding how the information delivered to the user), industry (mainly in the logistic sector) and finally in telepresence (where the perception of the environment and the other users is fundamental) **[Chart 4-21]**.
For what concern the prototype evaluation, it is one of the most used types of evaluation, being it used to evaluate prototypes that respond to a specific task and being this transversal to all fields.
About the mereology evaluation, we can find them almost exclusivity inside the domain of education and training, is it almost used to understand if this new learning approach would be beneficial to students and workers.
Also, the interaction comparison and the perception method evaluation are found mainly inside the generic interfaces group, being these evaluations designated often without a specific case study in mind.

Chart 4-20
Evaluation types distribution (total)



For what concerns all the other methodologies, they do not find any correlation with any specific application field, but we can find them every distribution.
Instead, is interesting the case of the concept investigation, that we can find mainly in those domains that are underrepresented in the sample (like business and others), as we already discussed in the last chapter, this could be the result of the lack of AR solution in these domains, as well as the lack of important uses case.

Chart 4-21

Distribution of different Type of evaluations used per domain / field

4.4.3. Evaluation setting

The most used evaluation setting was inside specialized Labs, **[Chart 4-22]**
We think this is due to the difficulties of designing and running a user evaluation in uncontrollable environments that could be quite difficult (as discussed in 2.8).
We can also notice that of the 28% of evaluations conducted on the field, a good amount is subdivided between the education, navigation, cultural and healthcare domains, we think this is related mainly to the main characteristics of these fields, which is difficult to recreated inside a lab environment, necessitate of a direct evaluation on the field.
For instance, lets considerate the education field, and more specifically the use of AR with a group of elementary students, here conducting an experiment in a controlled environment will be quite challenging, being these types of evaluations (as we will see) conducted during long periods of time (like a semester), with many students, and in equipped environments.
This is similar to what happened within the heartcare domain, where specialized tools and equipment could not easily replicate or moved, this is also true for the users (like in the case of AR systems for treatment, rehabilitation and early help), who could have difficulties in reaching the evaluation lab.
This is an issue that must be counted for, during the experiment design phase, being that the evaluated system should be easy to move assemble, ad disassemble on site.
Finally, about 6% of studies could not be categorized, being these studies conducted online or remotely, like in the case of online serveries and phone interviews.

Chart 4-22
Total proportion of evaluation settings

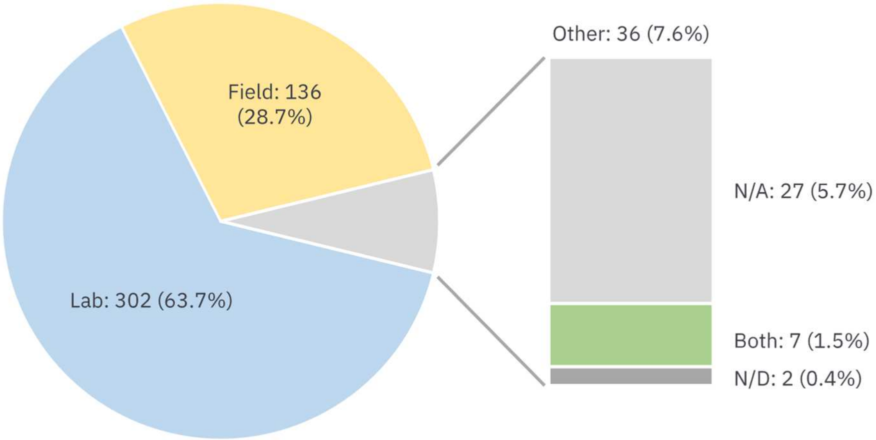
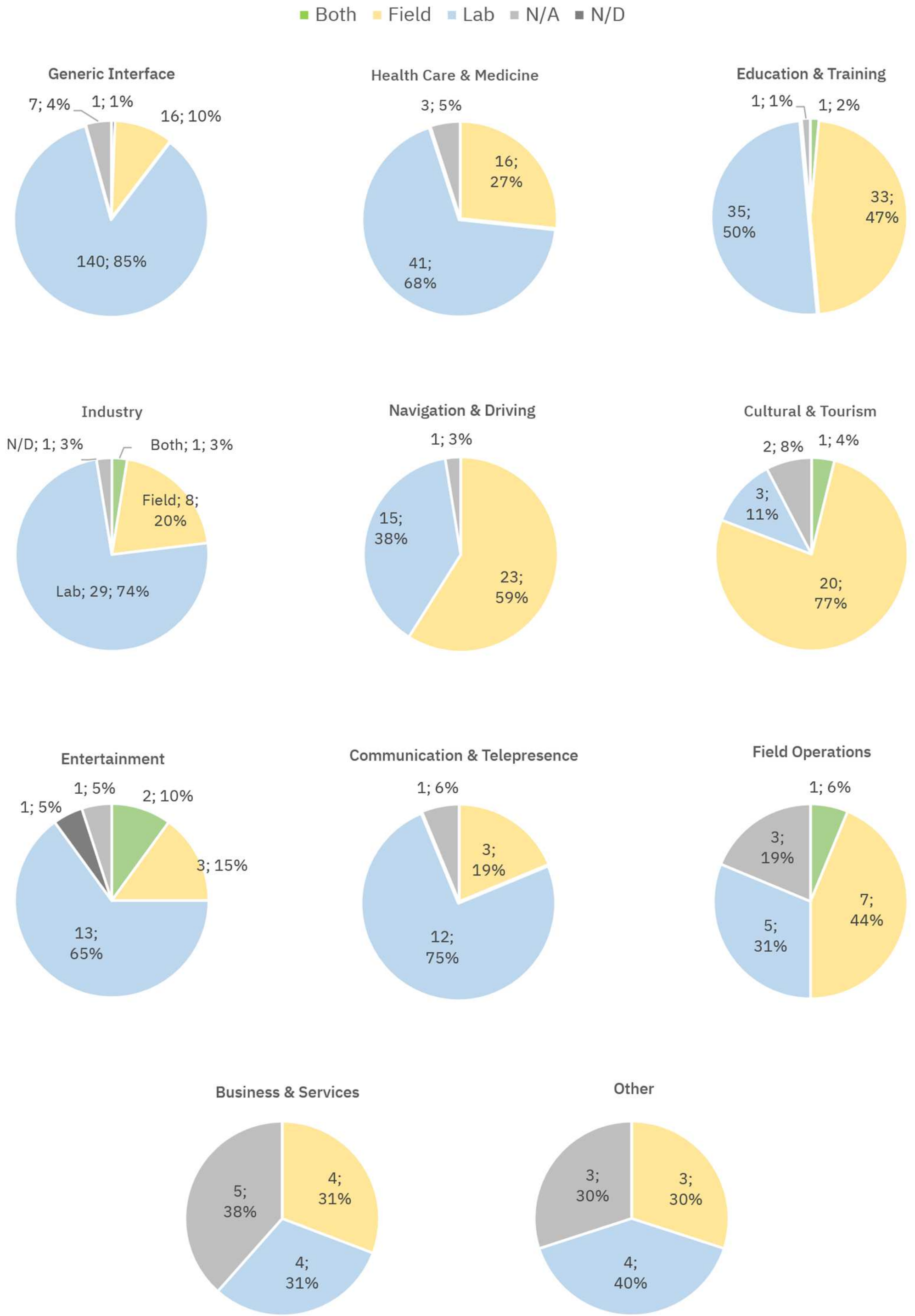


Chart 4-23
Distribution of senses used per domain / fields



4.4.4. Number of participants

The number of participants evolved in the evaluation range from 1 (mainly in the pre-studies evaluations) to more than 500 (in the case of studies that employed online serveries), this large span gives us an average of 55,70 users (a value that does not give us a good indication of the common number of participants, being this value polluted by the numbers of online evaluations, as seen **in** the next page **[Chart 4-25]**).
indeed, the 1st quartile, if we also consider the online evaluations, gives us 10,75 users, the 2nd quartile (the centre of the data) gives us 17, and the 3rd quartile 31.
This is in line with what we can see in **[Chart 4-25]**, where the more common number of evaluations is between 10 and 30.

4.5. Evaluation methodologies employed and main HCI aspects investigated

4.5.1. Methodologies

For what concerns the main methodologies used (1st and 2nd level of our classification), the Empirical Inquiry was by far the most used (68.6%), followed by the experimental one (30.1%), and the analytical inspections (1,4%) **[Chart 4-24]**.

Chart 4-24
Proportion of total evaluation methodologies used (2nd level)

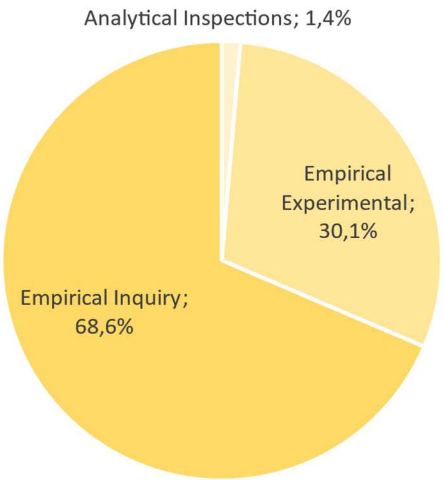
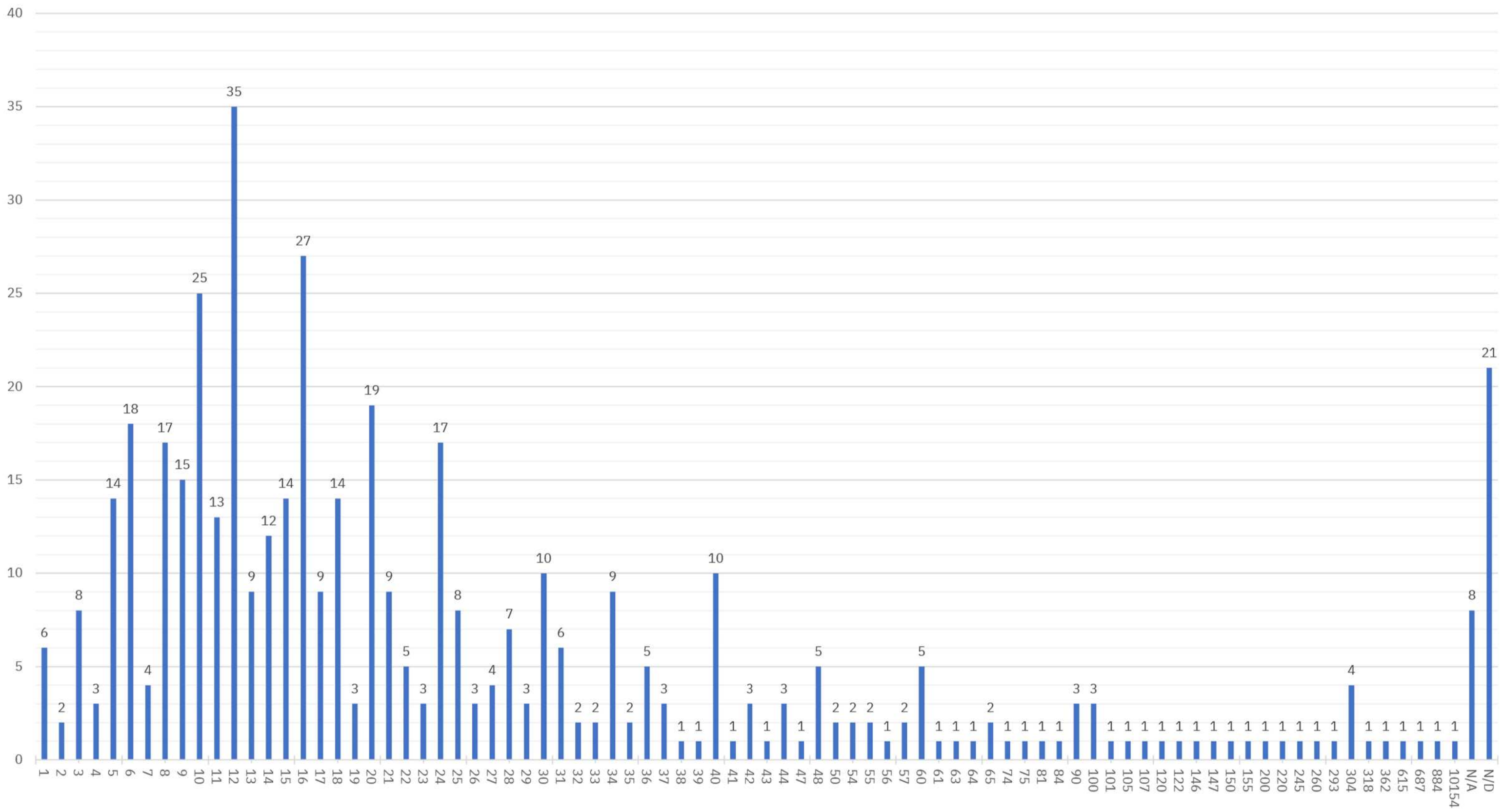
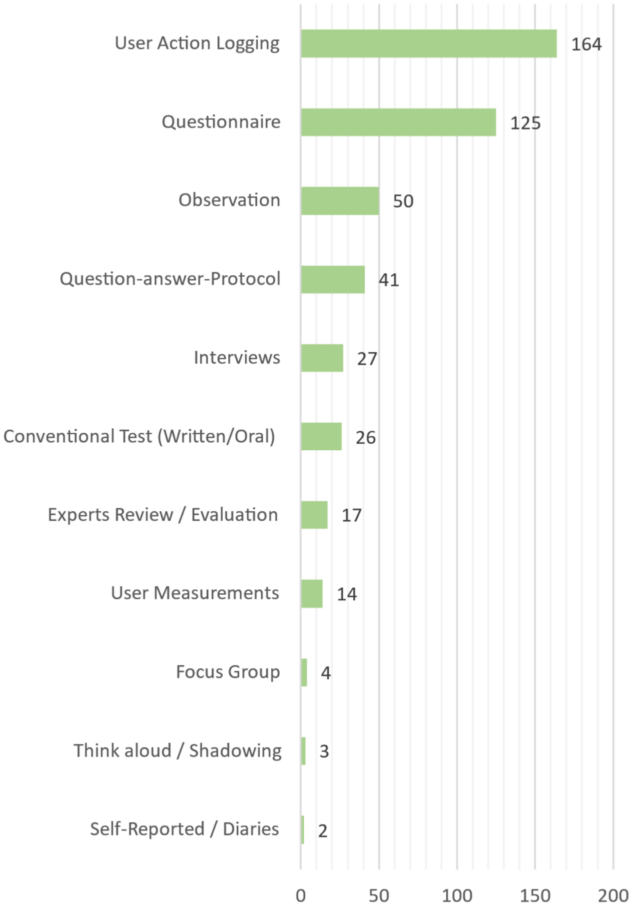


Chart 4-25
count of studies (X-axis) per number of users involved during the evaluation.



We can also see this net distinction in the 3rd level of our classification, where questionnaires were the most used (as we can see in chart), followed by user action logging, observation, and interviews activities.
Rarer were used other evaluations such as question answer protocol, conventional tests, and direct user's measurements, even less used were methodologies such as expert reviews, focus groups, shadowing and think aloud, finally other types such as diaries studies co-discover and cognitive walkthrough, were not used (as we can see in **[Chart 4-26]**).

Chart 4-28
Distribution of methods used per studies (3rd level)



This is not surprising at all, being these results in line with the ones founded by others (such as Bach and Scapin **[133]** and Kostaras and Xenos **[124] [134]**, as seen in 0), that attribute this unbalance of methodologies used to the difficulties of adopting and defining effective analytical methodologies.
Also expected was the use of methodologies such as user action logging (time and error recording), and direct (or on recorded material) observation, being these of the most used in common usability

Table 9
Table of evaluations methods, 2nd, 3rd, and 4th level with percentage of total uses

Empirical Inquiry	**68,44%**
Questionnaire	**55,00%**
custom-made	34,14%
NASA TLX	3,37%
ISO 9241	1,65%
Technology Acceptance Model (TAM)	1,65%
remote survey	1,45%
System Usability Scale (SUS)	1,18%
presence questionnaire	1,18%
Education specific Questionnaire	1,18%
adapted from previous/similar research	1,10%
Intrinsic Motivation Inventory (IMI)	0,82%
Unified Theory of Acceptance and Use of Technology (UTAUT2)	0,63%
Wearability Levels (WL) scale Knight et al.	0,55%
Treatment / Rehabilitation specific Questionnaire	0,51%
Questionnaire for User Interface and Satisfaction (QUIS)	0,51%
Usability Satisfaction Questionnaires	0,51%
Software Usability Measurement Inventory (SUMI)	0,47%
Flow State Scale (FSS)	0,43%
Bipolar Laddering (BLA system)	0,43%
QUIM (Quality In Use Integrated Measurement)	0,39%
Post-Study System Usability Questionnaire (PSSUQ)	0,39%
Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	0,35%
AttrakDiff	0,27%
Computer-Mediated Collaborative Learning: An Empirical Evaluation	0,24%
Perceived Usefulness Perceive Ease of Use (PUEU)	0,24%
Simulator Sickness Questionnaire (SSQ)	0,20%
Short Feedback Questionnaire (SFQ)	0,20%
Profile of Mood States questionnaire (POMS)	0,16%
Flow experience questionnaire by Chang et al. (2012)	0,12%
Ben Schneiderman's acceptance test	0,12%
Cornell Musculoskeletal Discomfort Questionnaires (CMDQ)	0,12%
Sensitivity scale questionnaire by Detlev von Zerssen	0,08%
EZ-Scale	0,08%
illusion evaluation questionnaire by Pusch, Martin, and Coquillart	0,08%
After-Scenario Questionnaire (ASQ)	0,04%
Santa Barbara Sense of Direction (SBSOD)	0,04%
GameFlow questionnaire	0,04%
Rating Scale for Mental Effort (RSME)	0,04%
ITU-R BT - Methodology for the Subjective Assessment of the Quality of Television Pictures	0,04%
Technical self-efficacy (TSE) Questionnaire	0,04%
Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	0,00%
Interviews	**9,76%**
semi-structured	3,10%
structured	1,96%
unstructured	1,72%
unstructured post-experiment discussion	1,45%
with proxy users	1,06%
later coded	0,35%
remote interview	0,04%
custom-made	0,04%
closed response (during evaluation)	0,04%
Conventional Test (Written/Oral)	**1,18%**
test with evaluation given by teacher	0,39%
test with evaluation given by teacher (PRE + POST evaluation)	0,31%
test with evaluation given by teacher (Control + Experiment groups)	0,31%
test with evaluation given by teacher (PRE + Post -> Control + Experiment group)	0,16%

Focus Group	**1,10%**
Post-test focus group	0,74%
Pre focus group	0,24%
Paper wireframe creation with users	0,08%
workshop with students	0,04%
Experts Review / Evaluation	**0,94%**
Treatment / Rehabilitation specific tests Experts Evaluation	0,78%
Experts Interview	0,16%
Self-Reported / Diaries	**0,47%**
Self-reported data / Diaries	0,27%
Participant’s artefacts (notebooks, emails, drawings, produced materials etc.)	0,16%
Factor-Referenced Cognitive Tests (Paper-folding test)	0,04%
Empirical Experimental	**30,18%**
User Action Logging	**16,35%**
tracking logs	6,47%
system logs	5,84%
evaluators count/measure	2,31%
evaluators timing	1,72%
Observation	**9,25%**
evaluators observations	6,00%
evaluators coded/structured observations	2,63%
Treatment / Rehabilitation specific tests Experts Evaluation	0,47%
comments collection during test	0,16%
Question-answer-Protocol	**2,78%**
open response (during evaluation)	1,84%
closed response (during evaluation)	0,78%
Virtual element finding / matching	0,16%

User Measurements	**1,33%**
eye tracking	0,55%
Heart Rate Variability (HRV)	0,27%
Electromyography (EMG)	0,12%
Galvanic Skin Response (GSR)	0,08%
eye accommodation	0,08%
grasping / press force	0,08%
Electroencephalography (EEG)	0,08%
gait tracking	0,08%
Think aloud / Shadowing	**0,47%**
Think aloud on prototype	0,27%
Think aloud on task	0,12%
Shadowing	0,08%
Analytical Inspections	**1,37%**
Experts Review / Evaluation	**1,37%**
Heuristic evaluation	0,71%
Experts Interview	0,27%
Cognitive Walkthrough	0,16%
Tasks analysis	0,16%
Digital Ethnography	0,08%

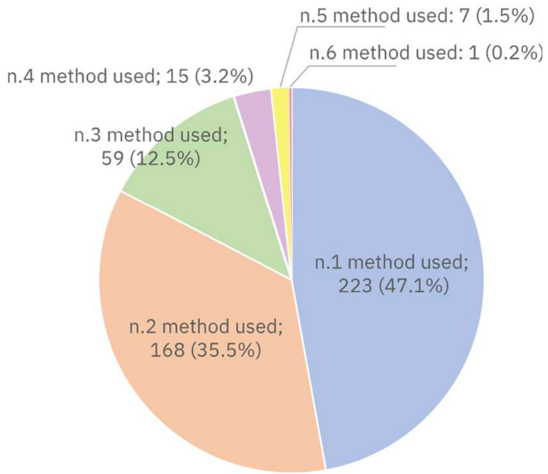
evaluation (see chapter 2.2), were task performance (with the use of user action tracking metrologies) and usability inquiries (with standardize questionaries and inversions) are the norm.

Instead, more interesting is the repartition of the 4th level (as we can see in **[Table 9]** next page), where there is an irregular distribution inside the group of questionnaire inquiries, where the major tool used were not standardized, but customs made for the specific situation.

This practice is quite normal in prototype evaluation, but the large gap between the first entry (custom-made) and the second one (NASA TLX), denote anyway the immaturity of the evaluations methods for AR systems, that as the result of the lack of standard evaluations protocols, tools, and the vast number of possibilities, make the task of finding common evaluation tools that could be used in more fields and solutions quite challenging.

The number of second-level methodologies used per single study varied from 47.1% used only one type (mainly only interview, questionnaire or user action logging), the 35.5% used two methods (such as questionnaire inquiry or interview with user action logging), rarer were the case with 3 (12.5%), 4 (3,2%) 5 (1,5%) and only one study used 6 methodologies (0.2%) **[Chart 4-27]**.

Chart 4-29
Percentage of number of 2nd level evaluation methodologies used inside a single study



4.5.2. HCI aspects

Interesting was the reparation of the investigated HCI aspects with a more equal division between the different categories **[Chart 4-28]**.

Here we can see that the usability aspects were the most investigated (25,62%), in line with what Kim et al. (2018) **[114]** reported in theirs survey, as was also expected the second and third group, respectively perception/cognition (12.2%) and Task performance (12,0%), being former a large subdomain of interest for AR interfaces (as seen in chapter 4.3) and the latter a common usability practice, used to assess the efficiency of a system (as seen in 3.2.3).

Fallow the prototype focus and the ergonomics, loads, and comfort group, and surprisingly we found the cluster of the UX-Emotions (7,5%), that was mainly used to address the amusement, motivation and the general interest towards the system and the technology (as we can see in **[Table 10]** next page).
The interaction group is just slightly behind (with 7.1%) with the UX-Usefulness (4.5%) category, that, despite the importance that it presents for the success and the adaptation of new devices, we found is rarely investigate and considerate in this type of evaluation.
We think that this lack of efforts spent on this category could be the result of the technological push that drive the development of AR technologies, and the consequent lack of user-centring approaches in the field of AR systems **[110]**.
The remaining categories are the sectoral ones, namely Communication (3,5%), Education specific (2,3%), Mixed background questions (1,8%) and treatment-specific (1,3%).
Almost at the tile end, we found the UX - Meaning (1,7%) category, which as expected, is rarely explored due to the immaturity of the technology and thus the lack of experiences that surrounding it.
If we decide to look at the proportions of aspects investigated per domain/fields (as seen in **[Chart 4-29]**), the situation does not change much, with usability almost always at the first place, followed by task perforce, only in some fields (the one less explored)we can notice more prevalence of other aspects, such as communication and interaction for entertainment, more prototype focus for field operation (indeed, in this domain we notice more efforts put into the evaluation of real prototypes, and how they would be used in real (or simulated) situations.
Interesting is also see a higher prevalence of the UX – Meaning aspect inside domains such as the cultural, the educational, and the entrainment one, all fields where this aspect has been detected more frequently.

Chart 4-30
Total distribution of investigated HCI aspects

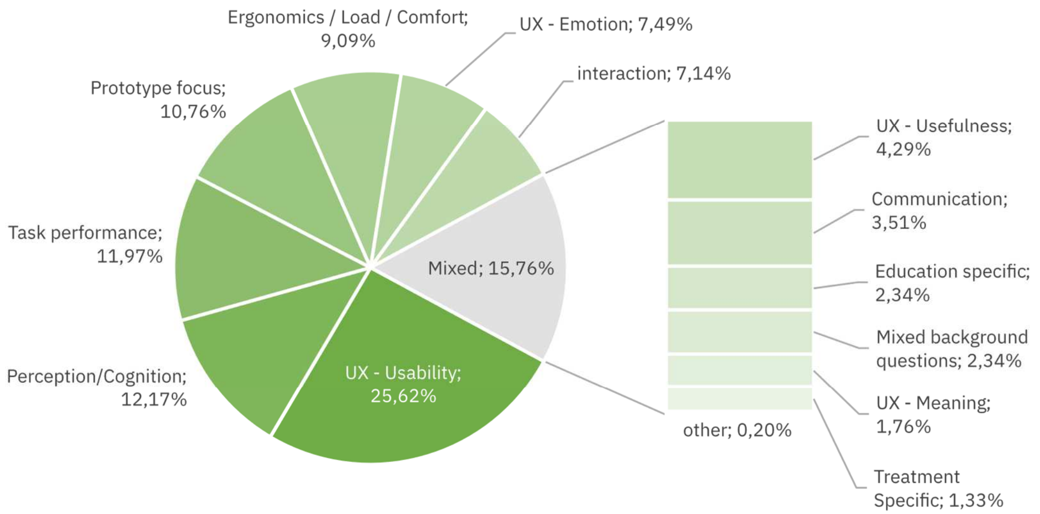


Table 10
Table of HCI investigated aspects, with relative subgroups and percentage of total uses

UX - Usability	
ease of use	3,8%
preference	3,6%
perceived performance	3,5%
satisfaction	2,1%
efficiency	1,9%
effectiveness	1,4%
learnability	1,2%
system status information and feedback	1,1%
intuitiveness	1,1%
perceived task/interaction difficulty	0,9%
system perceived control / interactivity	0,8%
understandability	0,8%
usability - unspecified	0,8%
aesthetic	0,7%
system perceived accuracy	0,5%
naturalness	0,4%
system smoothness / response time	0,3%
system perceived robustness / stability	0,3%
system flexibility	0,2%
system consistency / standards	0,2%
system errors recovery, prevention and warning	0,2%

Perception/Cognition	
virtual environment / object recognition	2,2%
sense of presence / immersion	1,9%
perception related errors	1,4%
virtual environment / object perceived quality	1,2%
real environment / object recognition	1,0%
perceived (or evaluated) depth or distance	1,0%
perception related completion time	0,7%
hepatics	0,6%
perception related accuracy	0,6%
perception completion time	0,5%
perception related response time	0,4%
physical body responses	0,4%
sense of orientation / navigation	0,2%
perception related n. attempts	0,2%

Task performance	
completion time	4,0%
accuracy	2,5%
errors	2,1%
task completion time	0,9%
n. trails	0,6%
distance	0,5%
reaction time	0,3%
score	0,3%
n. interactions	0,3%
field specific amount	0,2%
interaction time	0,2%

Prototype focus	
feedbacks / insights	3,2%
comments / suggestions	2,7%
problem individuation	2,2%
requirements and missing features	1,1%
feature usefulness / importance	0,8%
possible use / potentials of system	0,5%
co-design	0,3%

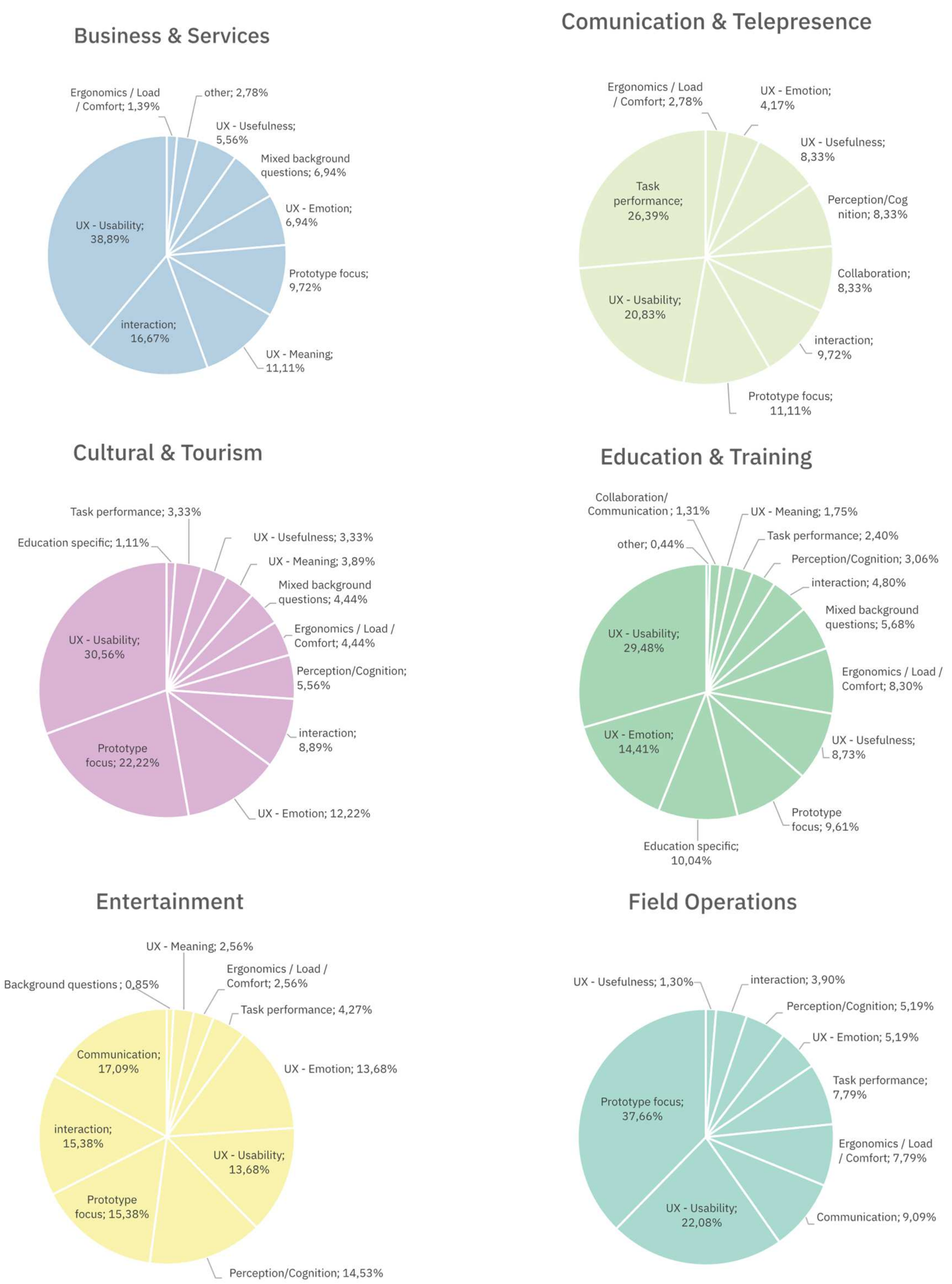
Ergonomics / Load / Comfort	
physical load	2,1%
cognitive load	1,8%
frustration / stress / anxiety	1,6%
comfort / sickness	1,5%
task perceived effort	1,4%
ergonomic properties	0,7%

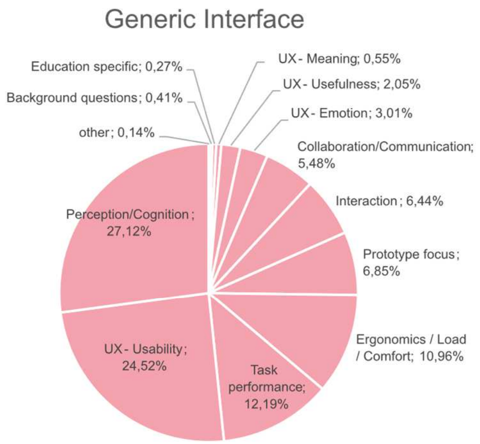
UX - Emotion	
amusement / fun	2,6%
interest / attractiveness	1,2%
motivation	1,2%
arousal / engagement	0,9%
trust (perceived safety)	0,9%
reactions and emotion individuation / shifting	0,5%
perceived innovativeness / wow factor	0,3%

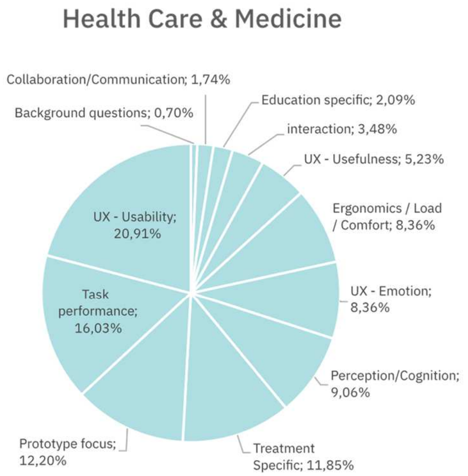
interaction	
general interaction behaviour	1,4%
interaction strategy and system use	1,3%
attention / focus	1,1%
users movements / gestures / physical utilization of prototype	0,9%
common general live / interaction behaviour	0,7%
learning / problem coping strategy	0,6%
interaction patterns	0,6%
gaming style / behaviour	0,2%
long period interactions studies with system	0,2%
UX - Usefulness	
perceived usefulness	3,1%
would use again in future	0,7%
would recommend the use	0,4%
Collaboration/Communication	
Social presence / interaction impact	0,5%
ease of communication	0,5%
communication behaviour	0,5%
speech / dialog protocols and communication	0,4%
ease of collaboration	0,4%
gaze / head communication	0,4%
communication - score / errors / accuracy	0,2%
collaboration - completion time	0,2%
organization behaviour and strategies between users	0,2%
gestures / hands / body communication	0,2%
individual action vs collaboration	0,2%
Education specific	
learning performance (error / score comparation)	1,2%
learning performance POST (error / score comparation)	0,4%
learning attitude (self-regulation / autonomy / motivation)	0,3%
learning performance PRE (error / score comparation)	0,2%
learning performance POST (free discussion)	0,2%
learning performance POST (meta test comparation)	0,1%

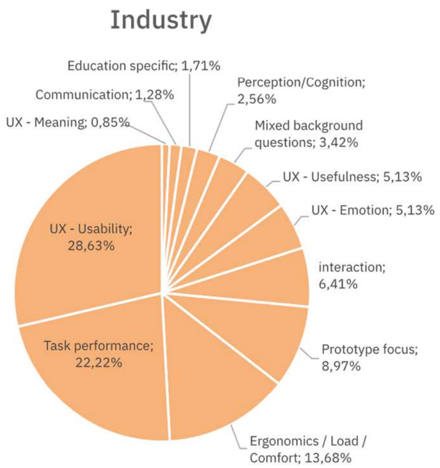
Mixed background questions	
subject technological comfort / general use	1,3%
subject interest / knowledge on topic	0,7%
mixed background questions	0,3%
UX - Meaning	
believes/opinions	0,4%
price / value	0,4%
meaning of context / place / interaction	0,3%
Privacy	0,2%
hedonic quality	0,1%
captivating / delightful experience	0,1%
pragmatic quality	0,0%
aspirations	0,0%
acceptance	0,0%
self-expression	0,0%
memories	0,0%
perception of brand	0,0%
Treatment Specific	
fears / phobias	0,9%
rehabilitation	0,4%
other	
documentation	0,1%
users tasks	0,0%
Digital Ethnography - Apps adaption	0,0%
Digital Ethnography - Apps perception / rating	0,0%

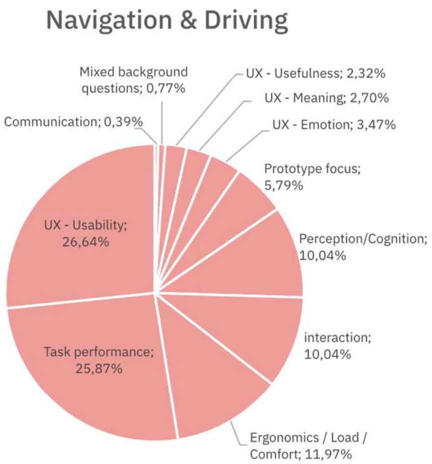
Chart 4-31
Distribution of investigated HCI per Domain / Field

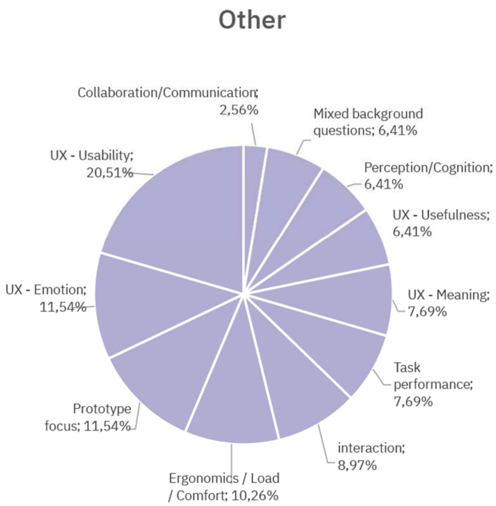



Generic Interface
Education specific; 0,27%
Background questions; 0,41%
other; 0,14%
UX - Meaning; 0,55%
UX - Usefulness; 2,05%
UX - Emotion; 3,01%
Collaboration/Communication; 5,48%
Interaction; 6,44%
Prototype focus; 6,85%
Ergonomics / Load / Comfort; 10,96%
Task performance; 12,19%
UX - Usability; 24,52%
Perception/Cognition; 27,12%


Health Care & Medicine
Collaboration/Communication; 1,74%
Background questions; 0,70%
Education specific; 2,09%
interaction; 3,48%
UX - Usefulness; 5,23%
Ergonomics / Load / Comfort; 8,36%
UX - Emotion; 8,36%
Perception/Cognition; 9,06%
Treatment Specific; 11,85%
Prototype focus; 12,20%
Task performance; 16,03%
UX - Usability; 20,91%


Industry
Education specific; 1,71%
Communication; 1,28%
UX - Meaning; 0,85%
Perception/Cognition; 2,56%
Mixed background questions; 3,42%
UX - Usefulness; 5,13%
UX - Emotion; 5,13%
interaction; 6,41%
Prototype focus; 8,97%
Ergonomics / Load / Comfort; 13,68%
Task performance; 22,22%
UX - Usability; 28,63%


Navigation & Driving
Mixed background questions; 0,77%
Communication; 0,39%
UX - Usefulness; 2,32%
UX - Meaning; 2,70%
UX - Emotion; 3,47%
Prototype focus; 5,79%
Perception/Cognition; 10,04%
interaction; 10,04%
Ergonomics / Load / Comfort; 11,97%
Task performance; 25,87%
UX - Usability; 26,64%


Other
Collaboration/Communication; 2,56%
Mixed background questions; 6,41%
Perception/Cognition; 6,41%
UX - Usefulness; 6,41%
UX - Meaning; 7,69%
Task performance; 7,69%
interaction; 8,97%
Ergonomics / Load / Comfort; 10,26%
Prototype focus; 11,54%
UX - Emotion; 11,54%
UX - Usability; 20,51%

4.6. Framework definition, description, and usage

After we saw what the main evaluation methodologies employed and what HCI aspects they investigated, we are now ready to define our evaluation framework.
Starting from the first and second research questions defined in 3.1 we can determinate that the framework to be usable and useful (Q3) must respond to two main questions: to illustrated what are the main user evaluations methodologies that have been employed in the past for each domain of application (Q1), and thus have been already been proved to be usable in those contexts, and then what aspect of Human-Computer Interactions these methodologies investigated (Q2), as a means to better guide the choice of the right tool and therefore of the whole evaluation.
To accomplish this, we based the framework mainly on the works conducted by previous researchers, works that act as a guide for both questions.
Based on the data analysed in this chapter, we decided to choose as main framework parameters the following categories:

→ Domain/Fields of application

→ Evaluation methodologies used

→ Investigated HCI aspects

This choice was detected to the need to keep the framework organized and readable, and these three parameters allowed us to balance the framework usability with usefulness.
Thus, the framework (that can be found in **[APPENDIX - A]**) is composed of the results of the three parameters of the evaluation analysed and categorized, and is composed of four main sections **[Figure 4-2]**:

A. **Reference tables:** a collection of tables that serve to better illustrate the differences between each domain, evaluations methods, and HCI aspects. Their main goal is to illustrate the main differences between the various category, to allow an easier section of the right one.

B. **Correlation charts:** graphs of correlation of methods used, and most investigated HCI aspects subdivide per domain. In the metrologies correlation graphs, we can see if a determinate method is often used paired with another, one looking at each link, and its width. in the HCI aspect pie instead, we can see the percentage of studies that were investigated each aspect.

C. **Method Used & Aspects Matrix:** this bubble graph put in correlation the method used for each HCI aspect within each domain, here we can easily see if one pair is more used than the other through the size of each bubble.

D. **Lookup tables:** As we have discussed in section 3.2.3, due to the number of tools and methodologies used, we decided to sub-divided the used methodologies into 5 levels, this was necessary because only knowing the main evaluations group used does not allow us to create a framework with the right level of detail to be considerate usable.

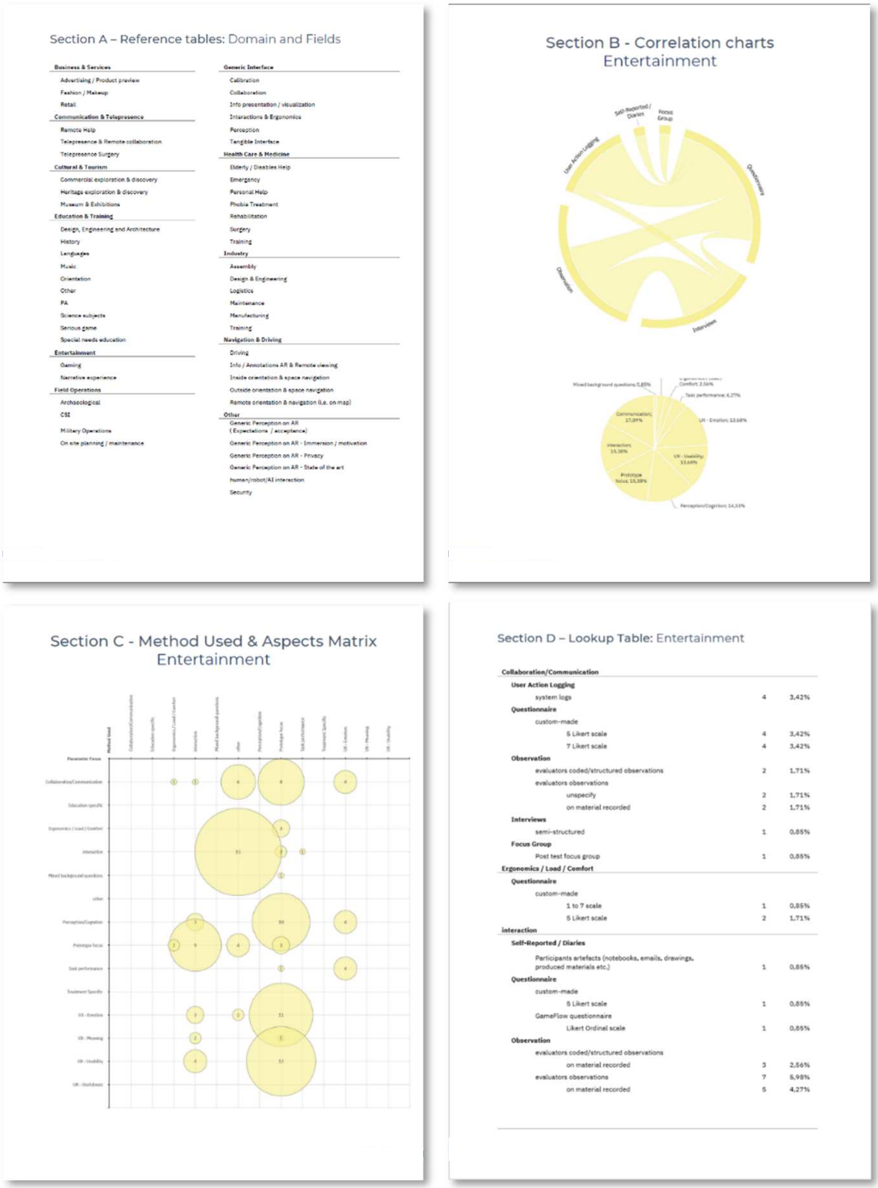


Figure 4-3
Framework sections preview

In order to use the framework, during the evaluation design phase, the evaluators must follow a determinate procedure **[Figure 4-3]**, inspired by the evaluation procedures defined by Gabbard et al. **[147]** and Swan et al. **[148]**, where there is the possibility to revert to the previous steps if the need should arise.

1. In the first step, evaluators had to choose the most appropriate field of application for their AR system, this can be done with the help of the tables present in section **A**.

2. After that, using the correspondent domain chart found in section **B**, evaluators should decide (if this was not already decided) what type of HCI investigations they want to conduct on the analysed system. This section could be also used to understand what has been already explored in the past and evaluate if there is the need to investigate determinate aspects over others.

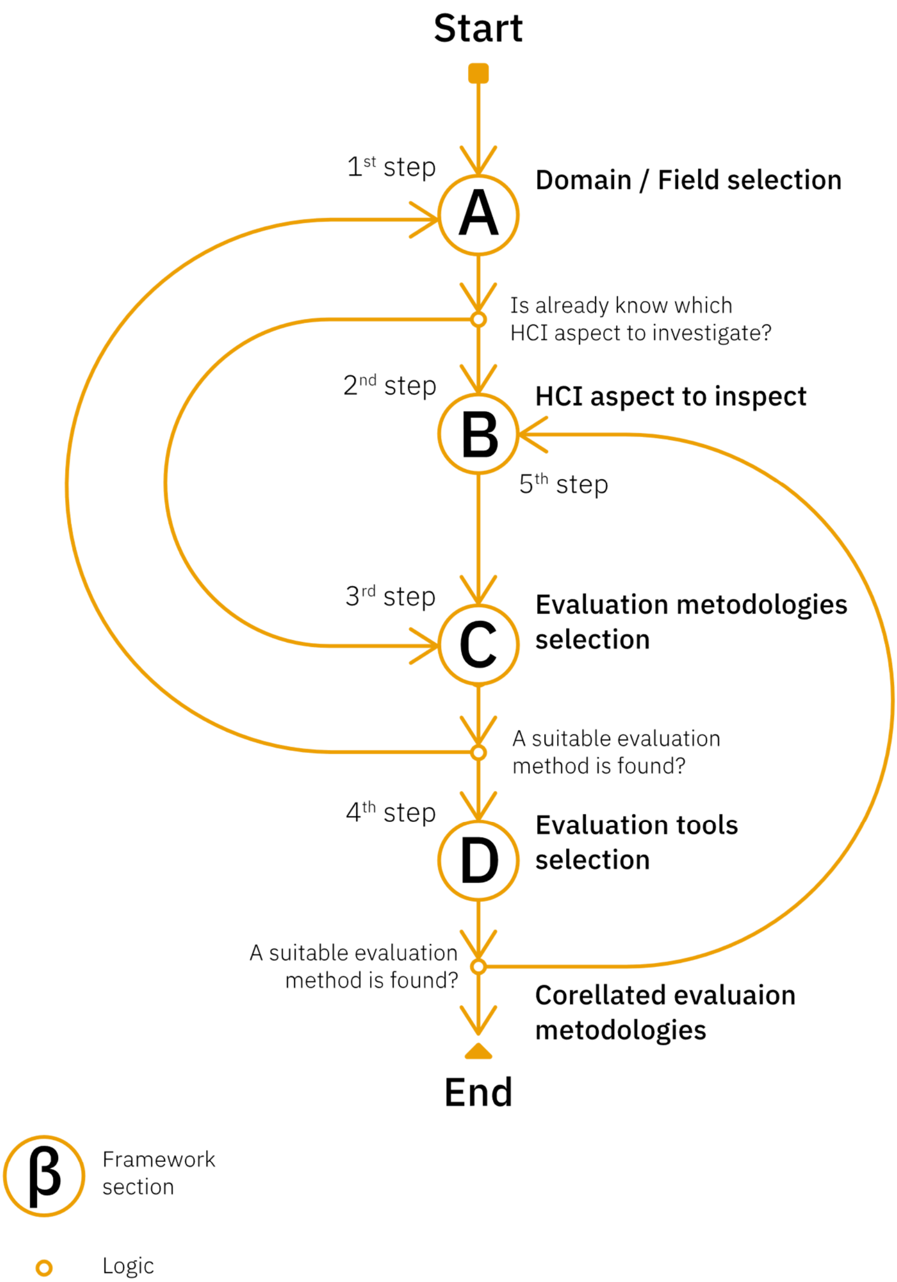
3. Then, using the correspondent domain matrix found in section **C**, evaluators should decide what method was the most used in the past linked to the selected HCI aspect. Due to the large number of possible methodologies that could be used, here are reported only the 3rd level of our evaluation classification (see chapter 3.2.3).

4. When the right method is decided, evaluators should use the lookup table of the correspondent domain present in section **D** to evaluate more in detail the possible tools and their specifications (4th and 5th level of our classification).

5. Finally, evaluators could also use the correlation chat used in section **B** to better decide what other type of evaluation methods they could pair with the selected one, to better cover different HCI aspects of the evaluated system.

If during the resulting method of the framework is irrelevant, would not work, or is not relevant for the current evaluated AR system, we suggest searching inside similar fields, or in the generic interfaces domain, as this is usually the result of the lack of studies in the corresponding sector, or probability the HCI aspect investigated is still not yet explored.
This is clary a strong limitation of the framework, that analysed only a small sample of papers, and to be more usable and useful need to incorporate more and more studies, than the one present right now.
In the next chapter, we will see two case studies where this procedure could apply, with the aim to better illustrate the framework use in more detail.

Figure 4-4
Framework usage process steps



5.
CASE STUDY

In this chapter, we will test the framework derived from our analysis and described both how it is composed and, its use, in the last chapter.
We will address it through the use of two cases study coming from the academic lecture that would represent two real situations in which the framework could be used.
Those situations will consist of two real projects, where a real AR system has been defined or build, and where there is the need to choose the right evaluation method for the situation at hand.
These case studies would have two main goals, the first to test its current state, its potentials, main issues and limits, and thus we will try to validate the work made until now, and so answer our third research question.
The second aim of this section is to better illustrate how the framework is used, what are the main expected results, and the principal steps that a hypothetical evaluator would encounter with this tool.

5.1. First Case study

The first case study we will explore is based on the work of Dadhich, Caruso, and Shi **[178]**, and concern the evaluation of novel interfaces for personal road vehicles which utilize AR and 5G technologies to increase the safety of the passengers on board.
This study focuses mainly on testing new warning interfaces for dangerous situations derived from blind spots and improvises obstacles entering inside the field of view of the driver, severe situations that could happen at road intersections or traffic lights.
To test this technology in a safe way, they decided to create a simulation in Virtual Reality on the iDrive simulator **[179]**, that can reproduce in a realistic and safe way the worst-case scenario to investigate if the proposed interfaces are suitable for this kind of situations **[Figure 5-1]**.

Figure 5-1
iDrive simulator
(source Dadhich et al. [178])

They divided the simulation into two main situations to test the advantage of 5G technology, and inside each one was present two conditions to test: with 5G turned ON and with 5G turned OFF, with different environmental conditions, like night and day.

Situation 1 - Blindspot warnings:
in this scenario different blind spots are introduced inside the virtual city environment, so the driver needs to approach these spots with the proper speed to avoid accidental collision with various obstacles **[Figure 5-2 – left]**.

Situation 2 - Prior warning to hazard:
this scenario involves instead lane change assistance provided with the help of V2X communication and 5G technology, thus the driver needs to drive the vehicle inside the simulation paying attention to any warring that could come from the tested interface and the environment **[Figure 5-2 – right]**.

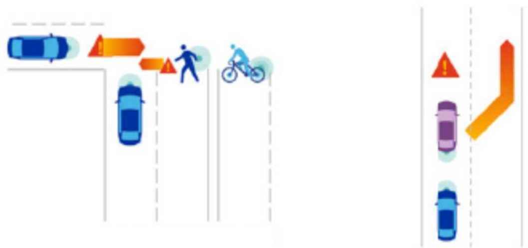


Figure 5-2
(left) Situation 1
(right) Situation 2
(source Dadhich et al. [180])

A lot of attention was spent by the authors on the individuation of the right UI elements, that could provide to the driver an engaging driving experience, but at the same time needs to be clear and deliver the right message at the right moment, avoiding unnecessary elements of distraction that could be dangerous.
The final interfaces that Dadhich et al. proposed make use of an AR windscreen display, that would not divert the driver's attention from the road, and at the same time would visualise the relevant data directly Infront of them **[Figure 5-3]**.

Figure 5-3
Screenshots of the virtual scenario build by Dadhich et al. for testing new types of AR interfaces and 5G technologies inside personal vehicles
(source Dadhich et al. [180]

Use of the framework:

After the scenario has been individuated, and the prototype builds, researchers now should evaluate the AR system created (in this case study new AR interfaces for driving), to investigate if it fully satisfies the users' needs and expectations, and it is precisely at this moment that our framework comes into play.
As we have seen in chapter (4.6), the first step consists in the individuation of the right domain of application for the evaluated AR system, operation that can be performed thanks to the *reference tables* present in section A (that can be found inside the **[APPENDIX - A]**), and we can individuate this application inside the domain *Navigation & Driving*.
Now, in the second step, we should consult the chats present in section B, to select the right HCI aspect to investigate, doing this we can individuate as the most investigated aspects inside this domain are the ones belonging to UX – Usability, task performances, ergonomics, and interaction **[Figure 5-4 – Left]**.

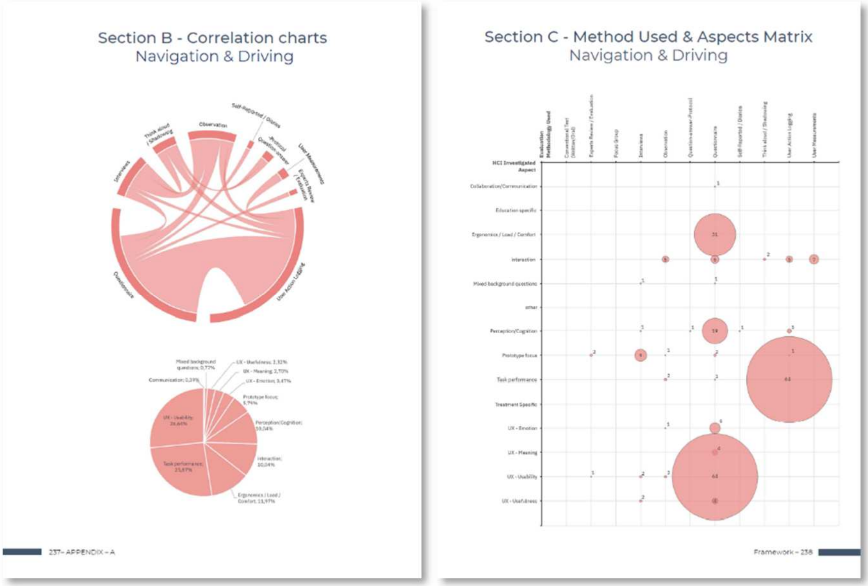


Figure 5-4
(Left) Section B – Corelation Chart

(Right) Section C – Method Used & Aspects Matrix

Knowing this, we can proceed to the third step, where using the Method Used & Aspects Matrix for this domain, we can select what evaluations methodologies have been used in the past to investigate the HCI aspects individuated in the last step.
Here we can see as, for Usability, the most used evaluations method was the questionnaire one **[Figure 5-4 – Right]**, now we can easily look at the lookup tablet to search, in better detail, what questionaries tools were the most used. Here we can find that the most used tools were custom-made for their evaluation, but more interesting are the following results: with the Software Usability Measurement Inventory (SUMI), the System Usability Scale (SUS), the Short Feedback Questionnaire (SFQ), and the ISO 9241 part 9.

Here the evaluators should investigate what of these tools are the most usable and appropriate for the situation at hand, in our case the SUNI is the right for us.
Then for the final step of our framework, we should look back at the charts of section B, and here see what the most used tools were paired with the one that we have investigated.
For our case study, we can see that the questionnaire methodology was paired for the major part with the user action logging methodology.
If now we look again at the Method Used & Aspects Matrix, but we reverse our research and we search for the HCI aspects investigated with the action logging methodology, we can see that this methodology was employed mainly to investigate how the users' performance in completing a determinate task.
This measurement could be relevant for our system; thus, we can check what tools were used in detail in the lookup table.
Here we found that the tools most used for gathering data were systems logs and tracking logs.
These methodologies could be easily implemented in our simulation and can be useful in the comparison between sceneries, to tack the responses time of the users and the virtual distances between the car and the obstacles.
Finally, we could try to check a third time to the correlation chart in section B, where we can see that the most used methodologies paired with user action logging after the questionaries are interviews, the think-aloud/shadowing, observation, and the user measurements.
Of these methodologies, the one that we think could be the more interesting in using is the user measurements, and if we exam the lookup table, we found that the most used tool inside this category is eye tracking.
The use of this tool can be beneficial to investigate where the driver attention is spent, and if the AR interface under exam provides too many distractions to be considered dangerous.
Here anyway a problem arises, the iDrive simulator in the configuration created for this experiment uses a VR headset, which makes the implementation of an eye-tracking methodology difficult.
There are however some workarounds, such as the use of devices that incorporated the eye-tracking sensor directly in the VR headset (such as the Varjo VR-3 headset **[180]**), these devices could anyway add a layer of complexity to the evaluation, and thus must be taken in consideration accordantly.
When we decided that the solution that the framework present could work fine for our solution, in our case study an investigation that will employ the SUNI questionnaire, user action logging from the simulator, and attention detection through the use of eye-tracking), we could start to prepare the real evaluation and the experiment design.

5.2. Second Case study

For what concerns the second case studies we chose to analyse the work of Aleksy et al. **[181]**, they designed and prototyped a HoloLens AR application to help field services workers in Remote support, Repair takes, and technical "on the field" information access.

The authors also conducted a quick informal user evaluation to gather some initial feedback and insights but did not conduct a structured user study, thus the data they collected was only subjective and qualitative, and focused exclusively on some features of the interfaces they developed.

The prototype was built with the help of the game engine Unity3D and made use of marker-based tracking (QR codes).

It presented three main features, once for each individuated task: Remote, Repair, and Access to technical details.

Remote support:

they implemented inside their application a live video & audio stream between the service engineer working the field and wearing the HoloLens device, and a remote expert, they also added the possibility to augment the video stream with notes, warning signs to highlight inside the point to view of the users the areas of interest and the potential sources of danger.

Repair tasks:

consisted of several features (such as safety instructions, checklists, required tools and spare parts, maps, and step-by-step repair instructions) that help the user performing the maintenance activities.

1. First, they started presenting the safety instructions and checklists to ensure that all necessary safety actions have been taken into consideration.

2. Second, a checklist of all the required tools and spare parts is present to ensure that all the necessary components for the job at hand are available.

3. Then, navigational support is shown to help the users find where the equipment to be serviced can be found, as well as all the correlated facilities and implants.

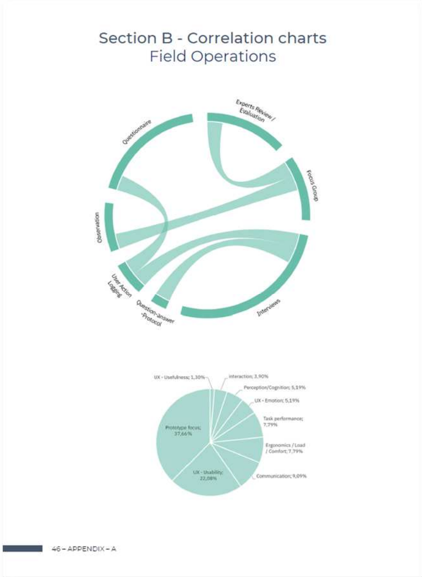
4. Finally, step-by-step instructions regarding the repair task are provided to help perform the required service activity in an efficient way.

Access to technical details:
the last task that the authors identified concerns the access to various types of technical product documentation, such as prior service reports, technical drawings, and manuals that are not often stored near the place of serviced equipment.
Moreover, also other features could be beneficial to the field workers, such as accessing 3D models of industrial components without being forced to remove them from their place or retrieving information directly from the on-site devices to get a quick and comprehensive view of the current system status.

Figure 5-5
Screenshots of the prototype build by Aleksy et al., to help field workers.
(source Aleksy et al. [181])

Use of the framework:

Here, considering that the AR system build is quite complex and presents different types of tasks and interactions modalities, we should decide on what we want to focus our evaluation, to get the best results from the framework and the evaluation itself.
Of the three main features developed, we can say that the first one could be easily identified (always using section A of our framework) within the domain of Communication & Telepresence, and more specifically, inside the sub-domain Remote Help, and Telepresence & Remote collaboration.
Instead of the other two main tasks, we can see that it can be part of both generic interfaces (Info presentation / Visualization) and Field Operations (On-site planning/maintenance).
In this case, when the AR system evaluated can be used for more than one field, we suggest using the more specific one (in this case Field Operations), and if the results of the framework are not usable for the situations or are too generic, to tray also with results of the other domains, to check, (and eventually marge) more than one possible solution.
For this case study, we decided to focus our attention on the second domain, the Field Operations one, and not concentrate our effort on the collaboration domain.
After the domain has been individuated, we can proceed with the second step, looking in section B of the framework where we can see that the most investigated HCI aspects were focused on the prototype feature evaluation and usability.
Now looking at the comparison matrix, under the voices prototype focus and usability, we can see that the methodologies more used



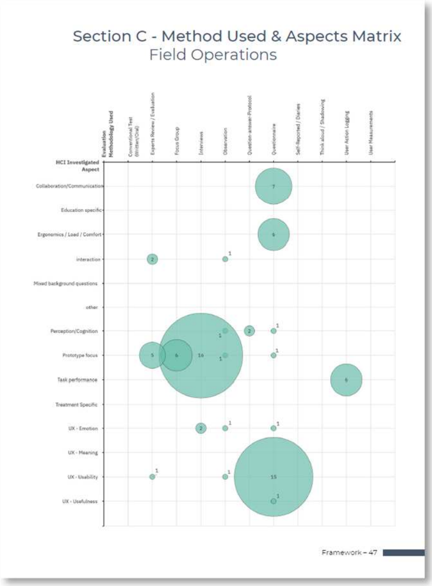


Figure 5-6
(Left) Section B – Corelation Chart

(Right) Section C – Method Used & Aspects Matrix

in the past were Interviews, Focus groups and Experts reviews. Knowing this, we can now check the lockups tables (section D) and we can see that the tools used in the past are too generic and do not fit our situation, so we try to see the second most used method, the focus groups and expert evaluations, and here we can find that the post-test focus group and the heuristic evaluation and cognitive walkthrough could be used in our situation and, as we can constate from the correlation chart in section B, easily paired together.
Now could stop here and conduct an expert evaluation (maybe also if experts fields work) later followed by a post-evaluation focus group.
Another possible solution could be also searching for the second most used HCI aspects, in our case the usability aspect, and repeat all the framework steps, this will give us that the most used methodology for investigated usability inside the fieldwork domain is with questionnaires, and more specifically the Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology questionnaire by D. Davis, another methodology that could be easily integrated inside this system evaluation, between the cognitive walkthrough and the focus groups.

6. DISCUSSION & CONCLUSIONS

This work focused on the evaluation methodologies currently in use inside the field of Augmented and Mixed Reality, and more specifically, on how to choose the best tools to evaluate these novel systems and interfaces.
Starting from the understanding of what commonly is defined as Augmented Reality (and, to an extent, also Virtual Reality and Mixed Reality), we introduce why it is considered the “next-generation interface”, what is its long history of developments in the last and current century, and what are its prospects for the future.
We tried to better classify the foundational elements that allow it to work, as well as showing the particularities and limitations of each element.
We briefly saw its main field of application in which is already in use, or it is expected to have a disruptive impact in the future, as well its current shortcomings and potential future issues.

Indeed, as discussed in the first part of this work, AR has right now more than three decades of active research on its behalf, anyway very few solutions have come onto the market, and those that did had not the desired adoption, a clear signal of the immaturity of this technology, and that many problems need yet to be resolved, both on the technical field and on the user side.

Anyway, as we have seen, most of the research conducted up to this point have spent their efforts mainly on technical problems, with little focus reserved to the user-centric side of the field.

This has been individuated as one of the main issues that hindered this technology inside research and development centres, and the success of AR devices will come only after a strong push towards user-centred design-oriented research that will produce well-designed user experiences.

Exploring this concept, we have found that previous surveys conducted on this matter found that too little research addressed these HCI aspects within the AR field, with an even smaller number of articles contain any formal user-based experiment.

The absence of formal user evaluations has been attributed by the survey authors to the research's lack of knowledge on what tools use for their specific situation, being the AR field too large and fragmented.

Is clear that an effort is needed to rearrange and then re-evaluate what type of evaluations has been conducted until now, to create from the existent state of the art a solid foundation for future user evaluations of AR systems, always keeping at the centre of the development process the end-users, their needs, emotional aspects, and desirers (that often are dismissed by the strong technology-driven push of the AR field).

From this motivation, this work draws its main objective: to create a working framework to inform and help in the selection of the best user evaluation methods for Augmented Reality systems.

To accomplish this, a literature review was conducted to explore the most common evaluations techniques to address both AR and traditional interfaces.

We started understanding what means conducting a user evaluation, and what are the main tools and approaches commonly used, as well as how these methodologies are classified, and what are their pro and cons.

We quickly discover that there is not a standardized procedure or tools to evaluated AR interfaces due to the particularities of Augmented Environments such as multimodal interactions possibilities and explorable 3D environments and interfaces make the generalization of common evaluations procedure, tools, and guidelines, quite challenging.

The results of this first literature review led leads us to the creation of three main research questions, that we need to answer to allow the creation of our framework that will help future researchers to better evaluate their AR systems, and thus allowing this technology to be adopted by larger and larger number of users.

Question 1:

What are the main methodologies for user's evaluations methodologies that have been employed in the past in the field of AR, for each determinate domain application?

Question 2:

What were the aspects of Human-Computer Interactions that these evaluations methodologies investigated?

Question 3:

Based on the results of the first and second questions, is possible to derivate a usable framework to inform and guided future evaluations?

After we defined these three questions, we started defining the main steps of the framework creation: a collection of the studies that respected specific inclusion criteria, then the analysis and classification of these studies according to pre-determinate groups and categories (derivate from the academic literature), and finally the production of the results and creation of the final framework upon those results.
The studies were collected from three field servery that explored the field of user evaluations, more specifically, in the domain of HCI, UX, UI, usability, and of course AR.
Then we individuated the main categorization parameters, divided into 3 main sections:
The first was relative to the technological sphere and was structured as: Output device (composed of 11 categories), Input device (composed of 7 categories), and tracking device (composed of 7 categories).
The second section was the basis on the study design, and it was in turn divided into: domain/field of application (12 categories with relative subdomains), types of Study evaluation (11 groups), study settings (3 groups), and number of participants per study,
And finally, main evaluations methodologies with their relative investigated HCI aspects.
This last category was divided into two main parameters: the evaluations methodologies (composed of an ordinated structure of 5

nested layers) and the investigated HCI aspects (divided into 10 groups with relative sub-groups).
From this parameter systematic literacy reviews were conducted on 433 papers, resulting in 474 individual studies that cover a time frame running from 2001 to 2018.

6.1. Contribution to knowledge

From our systematic literacy reviews we tried to answer our main research questions: namely, what tools have been used in the past inside the various AR application fields (Q1), as well as what are the main HCI aspects touched by these investigations (Q2), questions that constitute the guidelines for the creation of our work.
The result is a working framework based on three main parameters derived from our analysis results: Domain/Fields of application, Evaluation methodologies Used, and Investigated HCI aspects.
The framework is composed of four main sections: Reference tables, Correlation charts, Method Used & Aspects Matrix and Lookup tables, and its use is straightforward.
During the evaluation design phase, the researchers who are in need to choose the right evaluation methodology need to follow a simple procedure: first, select the most appropriate field of application for the AR system currently under examination with the help of the reference tables, then, using the correspondent domain chart found in the correlations section, the researchers should decide (if there is the necessity) what type of HCI investigations they want to conduct on the analysed system.
After that, the domain matrix is used to find the most used method inside the determinate domain and the selected HCI aspect.
When this method is found, thanks to the Lookup tables the researcher can find out in more detail which method to use.
Finally, the correlation chat could also be used to select what evaluation methods could be pair with the selected one, in order to better cover different HCI aspects of the evaluated system.
If during this procedure, the resulting method is irrelevant, would not work, or is not relevant for the current evaluated AR system, the researcher has two main options: look inside similar fields, or search inside the generic interfaces domain.
At the end of this work, we also try to validate our framework with the use of two theoretical case studies resultants from the academic literature and that could represent two real situations in which this tool could be employed.
This had two main goals: Illustrate in detail how to use it, and to investigated if it responded to our third and last question (Q3): is this framework usable to guide future evaluations in the field?

6.2. Open issues and future developments

There are yet many open issues that must be addressed to make the framework usable within a real evaluation environment.
Right now, a small test run with real evaluators and a real system is needed to test if our third research question is fully answered, or if any changes are needed.
This necessity arises from the consideration that, being the two test cases proposed in chapter 5 highly hypothetical, they do not give us a full picture of how the framework could be used and its real limits and issues.
Another issue that arises from the use of the framework is its low number of results that can be restitutive in some cases, namely when an investigating inside domains such as business, services, and field operations, that contenting a lower sample of studies, not always could answer the researchers needs totally.
To cope with this problem, a larger survey in the domain of user evaluations with AR technologies is needed, also including other scientific databanks and venues, being that the majority of the sample used in our work is sourced by publications from ISMAR.
Indeed, also as Kim et al. **[114]** point out, concentrating the analysis and the scope of our work exclusively on a few sources and venues might exclude potentially insightful and impactful research, while also not cover influential research works from other fields, that also consider AR/MR for its potential uses.
This is not only a problem for the quantity of the data collected and thus a lack of potential framework results, but also a quality issue.
Indeed, many fields servery used looked mainly at one specific domain or research field (i.e., from Lim et all. **[163]** looked only in the educational one for their study), a sample discrepancy that can constitute a bias toward some type of evaluations and HCI aspects.
Moreover, in our research, during the first step of our analysis (see chapter), we used different systematic reviews to source our main sample.
Although these studies collection respected the defined inclusion parameters, the different origins of these sources do not use the same acceptance criteria between them, a discrepancy that could create another bias, and so could not represent fully the current state of the art, and the tools used in today AR evaluation.
An example of this aspect can be found in the survey of Lim et all. **[163]**, the main goal of their goals was to map what tools and procedures were used in the evaluation of AR technologies inside the domain of education and training.
After a careful analysis, we choose to also insert this publication in the sample of papers, since a good proportion of the papers reported do not cover the domain of education or trading, but also navigation, general interfaces and more.
Nevertheless, this could be a potential indicator that these papers could not represent a compressive sample of the state of the art,

and worst could give a distorted view of the field, these considerations must be always taken into consideration when working with this framework.
In the future, we also plan the creation of an interactive online platform, where all the data could be accessed by the research in an easy, efficient, and quick way.
This platform could also allow, in its future iteration, to share possible evaluation conducted within the AR field, and more specifically their evaluation methods and investigated HCI aspects, to allow a larger and larger sample of studies, that would expand the framework data, and thus making it more and more usable.
This platform could also work as a repository of the studies used, as well as a meeting point for all those researchers that need to conduct or are conducting, AR systems evaluations with real users.
We also plan in the future the inclusion of also other parameters (such as the technologies used and the evaluation design) inside the framework.
These parameters were excluded from the current framework to keep it organized and readable, this anyway could not be a necessity in the future, if we decide to create the above online platform, that could allow us more flexibility than the one possible by the current framework.
Finally, we want to specify that this framework is meant to be seen as a continuous work, always growing, changing, and improving to propose the most appropriate tools to, hopefully, a larger and larger group of researchers.
Researchers, that using this work as a guide would further develop this field, making this technology become more mature and adopted in ours everyday lives, thus achieving what someone **[4]** once called the "*next-generation interface*".

7.
REFERENCES

[1] Bezegová, E., Ledgard, M.A., Molemaker, R.-J., Oberč, B.P. and Vigkos, A. (2016). Virtual Reality and its potential for europe. [online] European Commission. Ecorys. Available at:
https://ec.europa.eu/futurium/en/system/files/ged/vr_ecosystem_eu_report_0.pdf [Accessed Jan. 2021].

[2] Wellner, P., Mackay, W. and Gold, R. (1993). Back to the real world. Communications of the ACM, 36(7), pp.24–26.

[3] Mackay, W.E. (1998). Augmented reality. *Proceedings of the working conference on Advanced visual interfaces - AVI '98.*

[4] Jacob (2006). What is the next generation of human-computer interaction? *CHI '06 extended abstracts on Human factors in computing systems - CHI EA '06.*

[5] Caudell, T.P. and Mizell, D.W. (1992). Augmented reality: an application of heads-up display technology to manual manufacturing processes. *Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences.*

[6] Springer Science and Business Media, Inc. (2006). Augmented Reality. In: Encyclopedia of Multimedia. [online] pp.29–31
Available at: *https://link.springer.com/referenceworkentry/10.1007%2F0-387-30038-4_10* [Accessed Jan. 2021].

[7] Cambridge Dictionary (2019). AUGMENTED REALITY. In: Cambridge.org. [online]
Available at: *https://dictionary.cambridge.org/dictionary/english/augmented-reality* [Accessed Jan. 2021].

[8] *UX Daily.* [online] Available at: *www.interaction-design.org/literature/topics/augmented-reality* [Accessed Jan. 2021].

[9] Milgram, P. and Colquhoun, H.W. (1999). A Framework for Relating Head-Mounted Displays to Mixed Reality Displays. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 43(22), pp.1177–1181.

[10] Milgram, P., Takemura, H., Utsumi, A. and Kishino, F. (1995). Augmented reality: a class of displays on the reality-virtuality continuum. Telemanipulator and Telepresence Technologies.

[11] Azuma, R.T. (1997). A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments, 6(4), pp.355–385.

[12] Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S. and MacIntyre, B. (2001). Recent advances in augmented reality. IEEE Computer Graphics and Applications, 21(6), pp.34–47.

[13] Normand, J. and G. Moreau (2012). DoF-based classification of augmented reality applications.

[14] Benford, S., Greenhalgh, C., Reynard, G., Brown, C. and Koleva, B. (1998). Understanding and constructing shared spaces with mixed-reality boundaries. ACM Transactions on Computer-Human Interaction, 5(3), pp.185–223.

[15] Mann, S. (1994). Mediated reality. Technical Report MIT-ML Percom TR-260, University of Toronto. [online]
Available at:
https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.48.5056&rep=rep1&type=pdf [Accessed Jan. 2021].

[16] Hugues, O., Fuchs, P. and Nannipieri, O. (2011). New Augmented Reality Taxonomy: Technologies and Features of Augmented Environment. In: B. Furht, ed., Handbook of Augmented Reality. Springer, pp.47–63.

[17] Bergson, H. (1911). Matter and Memory. Essay on the relation of body and spirit. [online] London: Swan *Sonnenschein.*
Available at: https://archive.org/details/matterandmemory00berguoft.

[18] James, W. (1907). Pragmatism: A new name for some old ways of thinking. [online] New York: Longman Green and Co.
Available at: *https://archive.org/details/157unkngoog*.

[19] Auvray, M. and Fuchs, P. (2007). Immersion et interaction en environnement virtuel : Une approche sensorimotrice. Réalité Virtuelle et Cognition. Numéro spécial de Intellectica, 45(1), pp.23–35.

[20] Goldman, D. (2012). Google unveils "Project Glass" virtual-reality glasses. CNNMoney. [online] 4 Apr.
Available at: *https://money.cnn.com/2012/04/04/technology/google-project-glass/* [Accessed Jan. 2021].

[21] Kickstarter. (2012). Oculus Rift: Step Into the Game. [online]
Available at: *https://www.kickstarter.com/projects/1523379957/oculus-rift-step-into-the-game*.

[22] Pandher, G.S. (2016). Microsoft HoloLens Preorders: Price, Specs Of The Augmented Reality Headset - The Bitbag. [online] Available at: *https://web.archive.org/web/20160304102828/http://www.thebitbag.com/microsoft-hololens-preorders-price-specs-of-the-augmented-reality-headset/137410* [Accessed Jan. 2021].

[23] Irvine, K. (2017). XR: VR, AR, MR—What's the Difference? [online] *www.viget.com*.
Available at: *https://www.viget.com/articles/xr-vr-ar-mr-whats-the-difference* [Accessed Jan. 2021].

[24] Toptal Design Blog. Augmented Reality vs. Virtual Reality vs. Mixed Reality – An Introductory Guide. [online] [Accessed Jan. 2021].
Available at: *https://www.toptal.com/designers/ui/augmented-reality-vs-virtual-reality-vs-mixed-reality*

[25] North of 41 (2018). What really is the difference between AR / MR / VR / XR? [online] Medium.
Available at: *https://medium.com/@northof41/what-really-is-the-difference-between-ar-mr-vr-xr-35bed1da1a4e* [Accessed Jan. 2021].

[26] Brooker, J. (2007). THE POLYTECHNIC GHOST. Early Popular Visual Culture, 5(2), pp.189–206.

[27] L Frank Baum (1901). The Master Key: An Electrical Fairy Tale, Founded Upon the Mysteries of Electricity and the Optimism of its Devotees. p.94.

[28] NASA History Division. (n.d.). SP-3300 Flight Research at Ames, 1940-1997 - Gunsight Tracking and Guidance and Control Displays. [online] Available at: *https://history.nasa.gov/SP-3300/ch6.htm* [Accessed Jan. 2021].

[29] Peddie, J. (2017). Historical Overview. In: Augmented Reality: Where We Will All Live. Cham, Switzerland: Springer, pp.62–63.

[30] Heilig, M.L. (1961). Sensorama simulator. [online] Available at: *https://patents.google.com/patent/US3050870A/en* [Accessed Jan. 2021].

[31] Heilig, M.L. (1992). EL Cine del Futuro: The Cinema of the Future. Presence: Teleoperators and Virtual Environments, 1(3), pp.279–294.

[32] C. Comeau (1961). Headsight television system provides remote surveillance. Electronics, pp.86–90.

[33] Third Eye for Space Explorers. (1962). Popular Electronics, p.84.

[34] Sutherland, I.E. (1963). Sketchpad: A man-machine graphical communication system. Available at:
https://www.cl.cam.ac.uk/techreports/UCAM-CL-TR-574.pdf

[35] Sutherland, I.E. (1965). The Ultimate Display. Proceedings of the IFIP Congress, [online] Proceedings of the IFIP Congress, pp.506–508. Available at: *http://cacs.usc.edu/education/cs653/Sutherland-HeadmountedDisplay-AFIPS68.pdf* [Accessed Jan. 2021].

[36] Sutherland, I.E. (1968). A head-mounted three dimensional display. Proceedings of AFIPS, [online] 2(68), pp.757–764. Available at:
http://cacs.usc.edu/education/cs653/Sutherland-HeadmountedDisplay-AFIPS68.pdf [Accessed Jan. 2021].

[37] Krueger, M.W. (1983). Artificial reality. Boston, Massachusetts, Stati Uniti: Addison-Wesley.

[38] As seen in Mitchell, M. (2013). Meet Steve Mann, father of wearable computing. [online] University of Toronto News.
Available at: *https://www.utoronto.ca/news/meet-steve-mann-father-wearable-computing* [Accessed Jan. 2021].

[39] Mann, S. (1997). Wearable computing: a first step toward personal imaging. Computer, 30(2), pp.25–32.

[40] Mistry, P. and Maes, P. (2009). SixthSense. ACM SIGGRAPH ASIA 2009 Art Gallery & Emerging Technologies: Adaptation on - SIGGRAPH ASIA '09.

[41] Feiner, S., MacIntyre, B., Hollerer, T. and Webster, A. (1997). A touring machine: prototyping 3D mobile augmented reality systems for exploring the urban environment. Digest of Papers. First International Symposium on Wearable Computers.

[42] Raskar, R., Welch, G. and Fuchs, H. (1998). Spatially Augmented Reality. First International Workshop on Augmented Reality, San Francisco, November 1, 1998.

[43] Piekarski, W. and Thomas, B. (2002). ARQuake: the outdoor augmented reality gaming system. Communications of the ACM, [online] 45(1).

[44] Mohring, M., Lessig, C. and Bimber, O. (2004). Video see-through AR on consumer cell-phones.

[45] Billinghurst, M., Clark, A. and Lee, G. (2015). A Survey of Augmented Reality. Foundations and Trends in Human–Computer Interaction, [online] 8(2-3), pp.73–272, pp.96.

[46] Attractions Magazine. (2009). Cool 3D animated Digital Box at the Lego store. [online] Available at: *attractionsmagazine.com/cool-3d-animated-digital-box-at-the-lego-store/* [Accessed Jan. 2021].

[47] Esquire. (2009). Behind the Scenes of Augmented Esquire. [online] Available at: *www.esquire.com/news-politics/news/g371/augmented-reality-technology-110909/?slide=8* [Accessed Jan. 2021].

[48] Associated Press (2016). Magic raises $1.4 billion. [online] Yahoo Tech. Available at: *web.archive.org/web/20160602054531/https://www.yahoo.com/tech/google-backed-magic-leap-alleges-workers-stole-secrets-183901969.html* [Accessed Jan. 2021].

[49] Hammond, E. (2020). Magic Leap Cuts Half of Jobs In Major Restructuring. Bloomberg.com. [online] 22 Apr.
Available at: *https://www.bloomberg.com/news/articles/2020-04-22/magic-leap-is-said-to-cut-half-of-jobs-in-major-restructuring*
[Accessed Jan. 2021].

[50] Subin, S. (2021). Is 2021 finally the year for smart glasses? Here's why some experts still say no. [online] CNBC.
Available at: *www.cnbc.com/2021/01/23/why-experts-dont-expect-smart-glasses-to-surge-in-2021.html*
[Accessed 24 Jan. 2021].

[51] Fink, C. (2019). Might Meta Rise Again? A Silicon Valley Story. [online] Forbes.
Available at: *www.forbes.com/sites/charliefink/2019/01/22/might-meta-rise-again-a-silicon-valley-story/*
[Accessed Jan. 2021].

[52] Business, H.K., CNN (2019). Microsoft's new $3,500 HoloLens 2 headset means business. [online] CNN.
Available at: *https://edition.cnn.com/2019/02/24/tech/microsoft-hololens-2/index.html* [Accessed 24 Jan. 2021].

[53] Altinpulluk, H. (2017). Current trends in Augmented Reality and forecasts about the future. In: ICERI2017 Proceedings. 10th annual International Conference of Education, Research and Innovation.

[54] Gartner (2018). Hype Cycle Research Methodology. [online] Gartner. Available at: *https://www.gartner.com/en/research/methodologies/gartner-hype-cycle* [Accessed 24 Jan. 2021].

[55] Reif, R., Günthner, W.A., Schwerdtfeger, B. and Klinker, G. (2010). Evaluation of an Augmented Reality Supported Picking System Under Practical Conditions. Computer Graphics Forum, 29(1), pp.2–12.

[56] Grant, P., Spencer, L., Arnoldussen, A., Hogle, R., Nau, A., Szlyk, J., Nussdorf, J., Fletcher, D.C., Gordon, K. and Seiple, W. (2016). The Functional Performance of the BrainPort V100 Device in Persons who Are Profoundly Blind. Journal of Visual Impairment & Blindness, 110(2), pp.77–88.

[57] Bimber, O. and Raskar, R. (2006). Modern approaches to augmented reality. ACM SIGGRAPH 2006 Courses on - SIGGRAPH '06.

[58] Bloomberg Technology (2015). Daqri Smart Helmet: Augmented Reality for the Workplace. Bloomberg Technology. Available at: *www.bloomberg.com/news/videos/2015-06-26/daqri-smart-helmet-augmented-reality-for-the-workplace* [Accessed Jan. 2021].

[59] Tekla, S.P. (2020). Augmented Reality in a Contact Lens: It's the Real Deal. [online] IEEE Spectrum: Technology, Engineering, and Science News. Available at: *spectrum.ieee.org/view-from-the-valley/consumer-electronics/portable-devices/ar-in-a-contact-lens-its-the-real-deal* [Accessed 2 Jan. 2021].

[60] Hutchinson, L. (2013). $17,000 Linux-powered rifle brings "auto-aim" to the real world. [online] Ars Technica.
Available at: *arstechnica.com/gadgets/2013/01/17000-linux-powered-rifle-brings-auto-aim-to-the-real-world/*
[Accessed Feb. 2021].

[61] "Phantom Omni – 6 DOF Master Device." Delft Haptics Lab,
www.delfthapticslab.nl/device/phantom-omni/
[Accessed Feb. 2021].

[62] Yoshimoto, S., Hamada, Y., Tokui, T., Suetake, T., Imura, M., Kuroda, Y. and Oshiro, O. (2010). Haptic canvas. ACM SIGGRAPH 2010 Emerging Technologies on - SIGGRAPH '10.
[63] Kelly, S. (2021). CES 2021: Transparent screens are the cool new tech trend. [online] CNN Business.
Available at: *https://edition.cnn.com/2021/01/12/tech/ces-2021-transparent-tvs/index.html* [Accessed Jan. 2021].

[64] Cruz-Neira, C., Sandin, D.J., DeFanti, T.A., Kenyon, R.V. and Hart, J.C. (1992). The CAVE: audio visual experience automatic virtual environment. Communications of the ACM, 35(6), pp.64–72.

[65] Leiber, N. (2013). Technical Illusions' Hologram Glasses. Bloomberg.com. [online] 27 Nov.
Available at: *https://www.bloomberg.com/news/articles/2013-11-27/innovation-technical-illusions-hologram-eyeglasses* [Accessed Jan. 2021].

[66] Yi-bo, L., Shao-peng, K., Zhi-hua, Q. and Qiong, Z. (2008). Development Actuality and Application of Registration Technology in Augmented Reality. 2008 International Symposium on Computational Intelligence and Design.

[67] As seen in Craig, A.B. (2013). Mechanical Tracking - an overview | Understanding Augmented Reality. [online] www.sciencedirect.com.
Available at: *https://www.sciencedirect.com/topics/computer-science/mechanical-tracking* [Accessed Jan. 2021].

[68] As seen in Preim, B. and Botha, C. (2014). Magnetic Tracking - an overview | ScienceDirect Topics. [online] www.sciencedirect.com.
Available at: *https://www.sciencedirect.com/topics/computer-science/magnetic-tracking* [Accessed Jan. 2020].

[69] Dad, A., Arora, B., Parkar, N. and Rachh, T. (2017). Augmented Reality: Tracking Methods. International Journal of Engineering Research & Technology (IJERT), 5(1).

[70] As seen in Berrabah, S.A. and Baudoin, Y. (2011). Inertial Navigation System - an overview | ScienceDirect Topics. [online] www.sciencedirect.com. Available at: *https://www.sciencedirect.com/topics/engineering/inertial-navigation-system* [Accessed Jan. 2021].

[71] Papagiannakis, G., Singh, G. and Magnenat-Thalmann, N. (2008). A survey of mobile and wireless technologies for augmented reality systems. Computer Animation and Virtual Worlds, 19(1), pp.3–22.

[72] Carmigniani, J. and Furht, B. (2011). Augmented Reality: An Overview. In: B. Furht, ed., Handbook of Augmented Reality. Springer, pp.12, 14.

[**73]** Taheri, H. and Xia, Z.C. (2021). SLAM; definition and evolution. Engineering Applications of Artificial Intelligence, 97, p.104032.

[74] Lopez, H., Navarro, A. and Relano, J. (2010). An Analysis of Augmented Reality Systems. 2010 Fifth International Multi-conference on Computing in the Global Information Technology.

[**75]** Unity Technologies (2019). Augmented reality | Unity. [online] Unity. Available at: *https://unity.com/unity/features/ar*.

[**76]** Vuforia.com. (2019). Vuforia Developer Portal |. [online] Available at: *https://developer.vuforia.com/*.

[**77]** Google Developers. (2019). ARCore - Google Developers | Google Developers. [online] Available at: *https://developers.google.com/ar*.

[78] Rutherford, S. (2019). HP's Revamped VR Backpack Delivers the Closest Thing to True VR Freedom Yet. [online] gizmodo.com.
Available at: *https://gizmodo.com/hps-revamped-vr-backpack-delivers-the-closest-thing-to-1835010729* [Accessed Jan. 2021].

[79] Fink, C. (2020). Nreal Smartglasses Launch In Japan. [online] Forbes.
Available at: *https://www.forbes.com/sites/charliefink/2020/11/10/nreal-smartglasses-launch-in-japan/* [Accessed Jan. 2021].

[80] Mann, S. (1998). Closing Keynote Speech: Reconfigured Self as Basis for Humanistic Intelligence. In: Proceedings of the Annual Conference on USENIX Annual Technical Conference. Berkeley, CA, USA: USENIX Association

[81] Norman, D.A. (2010). The way I see it: Natural user interfaces are not natural. interactions, 17(3), p.6.

[82] Hollerer, T.H. (2004). User Interfaces for Mobile Augmented Reality Systems. PhD Thesis

[83] Van Krevelen, D.W.F. and Poelman, R. (2010). A Survey of Augmented Reality Technologies, Applications and Limitations. International Journal of Virtual Reality, 9(2), pp.1–20.

[84] Feiner, S., Macintyre, B. and Seligmann, D. (1993). Knowledge-based augmented reality. Communications of the ACM, 36(7), pp.53–62.

[85] Zazulia, N. (2018). F-35: Under the Helmet of the World's Most Advanced Fighter. [online] Aviation Today.
Available at: *https://www.aviationtoday.com/2018/08/24/f-35-helmet-worlds-advanced-fighter/* [Accessed Feb. 2021].

[86] Mizokami, K. (2018). The See-Through Tanks Are Coming. [online] Popular Mechanics.
Available at: *https://www.popularmechanics.com/military/a22853524/the-see-through-tanks-are-coming/* [Accessed Feb. 2021].

[87] Cass, S. (2018). How Will the U.S. Military Use the Hololens on the Front Line? [online] IEEE Spectrum: Technology, Engineering, and Science News. Available at: *https://spectrum.ieee.org/tech-talk/consumer-electronics/portable-devices/how-will-the-military-use-the-hololens-on-the-front-line* [Accessed Feb. 2021].

[88] Zhu, E., Hadadgar, A., Masiello, I. and Zary, N. (2014). Augmented reality in healthcare education: an integrative review. PeerJ, 2, p.e469.

[89] Bichlmeier, C., Wimmer, F., Heining, S.M. and Navab, N. (2007). Contextual Anatomic Mimesis Hybrid In-Situ Visualization Method for Improving Multi-Sensory Depth Perception in Medical Augmented Reality. 2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality.

[90] Xun Luo, Kline, T., Fischer, H.C., Stubblefield, K.A., Kenyon, R.V. and Kamper, D.G. (2005). Integration of Augmented Reality and Assistive Devices for Post-Stroke Hand Opening Rehabilitation. 2005 IEEE Engineering in Medicine and Biology 27th Annual Conference.

[91] Juan, M.C. and Pérez, D. (2011). Augmented Reality in Psychology. Handbook of Augmented Reality, pp.449–462.

[92] Ortiz-Catalan, M., Guðmundsdóttir, R.A., Kristoffersen, M.B., Zepeda-Echavarria, A., Caine-Winterberger, K., Kulbacka-Ortiz, K., Widehammar, C., Eriksson, K., Stockselius, A., Ragnö, C., Pihlar, Z., Burger, H. and Hermansson, L. (2016). Phantom motor execution facilitated by machine learning and augmented reality as treatment for phantom limb pain: a single group, clinical trial in patients with chronic intractable phantom limb pain. The Lancet, 388(10062), pp.2885–2894.

[93] Peddie, J. (2017). Key Applications. In: Augmented Reality: Where We Will All Live. Cham, Switzerland: Springer, pp.87–164.

[94] Qualcomm Technologies, Inc. (2018). The mobile future of augmented reality. [online].
Available at: *https://www.qualcomm.com/media/documents/files/the-mobile-future-of-augmented-reality.pdf*
[Accessed Feb. 2021].

[95] Schneider, Z. (2016). The Museum of Stolen Art. [online] The Museum of Stolen Art. Available at: *http://mosa.ziv.bz/* [Accessed Feb. 2021].

[96] NO AD | Transforming subway ads into art. (2014). About | NO AD. [online] Available at: *https://noad-app.com/about/* [Accessed Feb. 2021].

[97] Donato Maniello (2014). Realtà aumentata in spazi pubblici: tecniche base di video mapping. Brienza (Pt): Le Penseur.

[98] Aurora Baréalisse (2015). Coca-Cola Magic Augmented Reality. [online]. Available at: *https://www.slideshare.net/AuroraBarealisse/cocacola-magic-augmented-reality* [Accessed Feb. 2021].

[99] Redaelli, C., Pellegrini, S., Mottura, M. and Sacco, M. (2009). Shoe customers' behaviour with new technologies: the Magic Mirror case.

[100] Snap Inc. (2019). Lens Studio - Lens Studio by Snap Inc. [online] Snapchat.com. Available at: *https://lensstudio.snapchat.com/*.

[101] Henrysson, A., Billinghurst, M. and Ollila, M. (2006). AR tennis. ACM SIGGRAPH 2006 Emerging technologies on - SIGGRAPH '06.

[102] www.dexigner.com. (2010). Recon-Zeal Transcend Goggles: GPS Goggles with Head-Mounted Display. [online]
Available at: *https://www.dexigner.com/news/21540* [Accessed Feb. 2021].

[103] Craig, A.B. (2013). Augmented Reality Hardware. Understanding Augmented Reality, pp.69–124.

[104] Livingston, M.A. (2005). Evaluating Human Factors in Augmented Reality Systems. IEEE Computer Graphics and Applications, 25(6), pp.6–9.

[105] Bhutta, Z.I., Umm-e-Hani, S. and Tariq, I. (2015). The next problems to solve in augmented reality. 2015 International Conference on Information and Communication Technologies (ICICT).

[106] Sorce, S., Augello, A., Santangelo, A., Gentile, A., Genco, A., Gaglio, S. and Pilato, G. (2010). Interacting with Augmented Environments. IEEE Pervasive Computing, 9(2), pp.56–58.

[107] Feldman, A., Tapia, E.M., Sadi, S., Maes, P. and Schmandt, C. (2005). ReachMedia: on-the-move interaction with everyday objects. In: Ninth IEEE International Symposium on Wearable Computers. ISWC'05. IEEE, pp.52–59.

[108] Mistry, P., Maes, P. and Chang, L. (2009). WUW - wear Ur world. Proceedings of the 27th international conference extended abstracts on Human factors in computing systems - CHI EA '09.

[109] Roesner, F., Kohno, T. and Molnar, D. (2014). Security and privacy for augmented reality systems. Communications of the ACM, [online] 57(4), pp.88–96.

[110] Dünser, A., Grasset, R. and Billinghurst, M. (2008). A survey of evaluation techniques used in augmented reality studies. ACM SIGGRAPH ASIA 2008 courses on - SIGGRAPH Asia '08.

[111] Dϋnser, A., Grasset, R., Seichter, H. and Billinghurst, M. (2007). Applying HCI principles to AR systems design. University of Canterbury, Human Interface Technology Laboratory.

[112] Swan, J.E. and Gabbard, J.L. (2005). Survey of User-Based Experimentation in Augmented Reality. Proceedings 1st International Conference on Virtual Reality

[113] Dey, A., Billinghurst, M., Lindeman, R.W. and Swan, J.E. (2018). A Systematic Review of 10 Years of Augmented Reality Usability Studies: 2005 to 2014. Frontiers in Robotics and AI, [online] 5.

[114] Kim, K., Billinghurst, M., Bruder, G., Duh, H.B.-L. and Welch, G.F. (2018). Revisiting Trends in Augmented Reality Research: A Review of the 2nd Decade of ISMAR (2008–2017). IEEE Transactions on Visualization and Computer Graphics, 24(11), pp.2947–2962.

[115] Mautino, S. and Melnykowycz, M. (2013). User-experience in wearable displays: a proposal for standards definition. AR Standards Meeting 2013.

[116] Sharp, H., Rogers, Y. and Preece, J. (2019). Chapter 14: Introduction evaluation. In: Interaction design: beyond human-computer interaction, 5th ed. Indianapolis, In: Wiley.

[117] Madan, A. and Kumar, S. (2012). Usability evaluation methods: a literature review. International Journal of Engineering Science and Technology (IJEST), 4(2).

[**118**] Nielsen, J. (1994). Heuristic Evaluation: How-To: Article by Jakob Nielsen. [online] Nielsen Norman Group. Available at:
https://www.nngroup.com/articles/how-to-conduct-a-heuristic-evaluation/
[Accessed Jul. 2021].

[119] Dünser, A. and Billinghurst, M. (2011). Evaluating Augmented Reality Systems. In: B. Furht, ed., Handbook of Augmented Reality. Springer, pp.289–307.

[120] Greenberg, S. and Buxton, B. (2008). Usability evaluation considered harmful (some of the time). Proceeding of the twenty-sixth annual CHI conference on Human factors in computing systems - CHI '08.

[121] Bowman, D.A., Gabbard, J.L. and Hix, D. (2002). A Survey of Usability Evaluation in Virtual Environments: Classification and Comparison of Methods. Presence: Teleoperators and Virtual Environments, 11(4), pp.404–424.

[122] Mahrin, M.N., Strooper, P. and Carrington, D. (2009). Selecting Usability Evaluation Methods for Software Process Descriptions. 2009 16th Asia-Pacific Software Engineering Conference.

[123] Barkhuus, L. and Rode, J.A. (2007). From Mice to Men - 24 Years of Evaluation in CHI. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '07, 10

[124] Kostaras, N. and Xenos, M. (2012). Usability evaluation of Augmented Reality systems. Intelligent Decision Technologies, 6(2), pp.139–149.

[125] Nielsen, J. (2009). Usability engineering. Amsterdam: Morgan Kaufmann.

[126] Nielsen Norman Group. (2017). Quantitative vs. Qualitative Usability Testing. [online]
Available at: *https://www.nngroup.com/articles/quant-vs-qual/*
[Accessed Jun. 2021].

[127] Budiu, R. (2018). Between-Subjects vs. Within-Subjects Study Design. [online] Nielsen Norman Group.
Available at: *https://www.nngroup.com/articles/between-within-subjects*
[Accessed Mar. 2021].

[128] Martìnez, H. and Bandyopadhyay, P. (2014). Analysis of Four Usability Evaluation Methods Applied to Augmented Reality Applications. Helsinki Institute for Information Technology (HIIT).

[129] Dow, S., Lee, J., Oezbek, C., MacIntyre, B., Bolter, J.D. and Gandy, M. (2005). Wizard of Oz interfaces for mixed reality applications. CHI '05 extended abstracts on Human factors in computing systems - CHI '05.

[130] Sutcliffe, A.G. and Kaur, K.D. (2000). Evaluating the usability of virtual reality user interfaces. Behaviour & Information Technology, 19(6), pp.415–426.

[131] Nielsen, J. and Molich, R. (1990). Heuristic evaluation of user interfaces. Proceedings of the SIGCHI conference on Human factors in computing systems Empowering people - CHI '90.

[132] Stanney, K.M., Mollaghasemi, M., Reeves, L., Breaux, R. and Graeber, D.A. (2003). Usability engineering of virtual environments (VEs): identifying multiple criteria that drive effective VE system design. International Journal of Human-Computer Studies, 58(4), pp.447–481.

[133] C. Bach and D. Scapin (2004). Obstacles and perspectives for evaluating mixed reality usability

[134] Kostaras, N. and Xenos, M. (2009). Assessing the Usability of Augmented Reality Systems. In: PCI2009, Proceedings. 13th Panhellenic Conference on Informatics. Corfu, Greece: p.197-201.

[135] C. Bach and D. Scapin (2004). Obstacles and perspectives for evaluating mixed reality usability

[136] Cavalcanti, V.C., Santana, M.I. de, Gama, A.E.F.D. and Correia, W.F.M. (2018). Usability Assessments for Augmented Reality Motor Rehabilitation Solutions: A Systematic Review. International Journal of Computer Games Technology, 2018, pp.1–18.

[137] Bai, Z. and Blackwell, A.F. (2012). Analytic review of usability evaluation in ISMAR. Interacting with Computers, 24(6), pp.450–460.

[138] A. Rizzo, Kim, G., Shih-Ching Yeh, M. Thiébaux, J. Hwang and J. Galen Buckwalter (2005). Development of a benchmarking scenario for testing 3D user interface devices and interaction methods.

[139] Sutcliffe, A. and Gault, B. (2004). Heuristic evaluation of virtual reality applications. Interacting with Computers, [online] 16(4), pp.831–849.

[140] Gabbard, J.L. (2001). Researching Usability Design and Evaluation Guidelines for Augmented Reality (AR) Systems.

[141] Ko, S.M., Chang, W.S. and Ji, Y.G. (2013). Usability Principles for Augmented Reality Applications in a Smartphone Environment. International Journal of Human-Computer Interaction, 29(8), pp.501–515.

[142] Kourouthanassis, P.E., Boletsis, C. and Lekakos, G. (2013). Demystifying the design of mobile augmented reality applications. Multimedia Tools and Applications, 74(3), pp.1045–1066.

[143] Vi, S., da Silva, T.S. and Maurer, F. (2019). User Experience Guidelines for Designing HMD Extended Reality Applications. Human-Computer Interaction – INTERACT 2019, pp.319–341.

[144] Endsley, T.C., Sprehn, K.A., Brill, R.M., Ryan, K.J., Vincent, E.C. and Martin, J.M. (2017). Augmented Reality Design Heuristics: Designing for Dynamic Interactions. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 61(1), pp.2100–2104.

[145] Gabbard, J., Swan II, J.E., Hix, D., Lanzagorta, M.O., Livingston, M., Brown, D.B. and Julier, S.J. (2002). Usability engineering: domain analysis activities for augmented-reality systems. Stereoscopic Displays and Virtual Reality Systems IX.

[146] BOWMAN, D.A. and HODGES, L.F. (1999). Formalizing the Design, Evaluation, and Application of Interaction Techniques for Immersive Virtual Environments. Journal of Visual Languages & Computing, [online] 10(1), pp.37–53.

[147] Gabbard, J.L., Hix, D. and Swan, J.E. (1999). User-centered design and evaluation of virtual environments. IEEE Computer Graphics and Applications, 19(6), pp.51–59.

[148] Gabbard, J.L. and Swan, J.E. (2008). Usability Engineering for Augmented Reality: Employing User-Based Studies to Inform Design. IEEE Transactions on Visualization and Computer Graphics, 14(3), pp.513–525.

[149] As seen in “Waterfall Methodology - an Overview | ScienceDirect Topics.” Sciencedirect.com, 2015, *www.sciencedirect.com/topics/computer-science/waterfall-methodology* [Accessed Feb. 2021].

[150] As seen in Li, Angie. “Employees as Usability-Test Participants.” Nielsen Norman Group, 4 Sept. 2016, www.nngroup.com/articles/employees-user-test/. Accessed Feb. 2021. and Nielsen, Jakob. “Guerrilla HCI: Using Discount Usability Engineering to Penetrate the Intimidation Barrier.” Nielsen Norman Group, 1 Jan. 1994, *www.nngroup.com/articles/guerrilla-hci/*. [Accessed Feb. 2021].

[151] Nielsen, C. (1998). Testing in the field. Proceedings. 3rd Asia Pacific Computer Human Interaction (Cat. No.98EX110), pp.285–290.

[152] Pascoe, J., Ryan, N. and Morse, D. (2000). Using while moving: HCI issues in fieldwork environments. ACM Transactions on Computer-Human Interaction, 7(3), pp.417–437.

[153] Bonnet, P. (2014). Evaluation of Augmented Reality Applications in a Laboratory Context. Human-Computer Interaction with Augmented Reality - Advances in Embedded Interactive Systems Technical Report – Summer 2014, 2(4).

[154] Nielsen, C.M., Overgaard, M., Pedersen, M.B., Stage, J. and Stenild, S. (2006). It’s worth the hassle! Proceedings of the 4th Nordic conference on Human-computer interaction changing roles - NordiCHI ’06.

[155] www.scopus.com. Scopus. [online]
Available at: *https://www.scopus.com*. [Accessed Jun. 2021].

[156] Sciencedirect.com. (2019). ScienceDirect.com | Science, health and medical journals, full text articles and books. [online]
Available at: *https://www.sciencedirect.com/* [Accessed Jun. 2021].

[157] Ieee.org. (2017). IEEE Xplore Digital Library. [online]
Available at: *https://ieeexplore.ieee.org/Xplore/home.jsp*
[Accessed Jun. 2021].

[158] Research Gate (2019). ResearchGate | share and discover research. [online] ResearchGate. Available at: *https://www.researchgate.net/*
[Accessed Jun. 2021].

[159] Google (2000). Google Scholar. [online] Google.com.
Available at: *https://scholar.google.com/* [Accessed Jun. 2021].

[160] Zhou, F., Duh, H.B.-L. and Billinghurst, M. (2008). Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR. 2008 7th IEEE/ACM International Symposium on Mixed and Augmented Reality. [online] Available at: *https://dl.acm.org/citation.cfm?id=1605333*.

[161] Bal, E. (2018). The future of augmented reality and an overview on the to researches: a study of content analysis. Quality & Quantity, 52(6), pp.2785–2793.

[162] Cavalcanti, V.C., Santana, M.I. de, Gama, A.E.F.D. and Correia, W.F.M. (2018). Usability Assessments for Augmented Reality Motor Rehabilitation Solutions: A Systematic Review. International Journal of Computer Games Technology, 2018, pp.1–18.

[**163]** Lim, K.C., Selamat, A., Alias, R.A., Krejcar, O. and Fujita, H. (2019). Usability Measures in Mobile-Based Augmented Reality Learning Applications: A Systematic Review. Applied Sciences, 9(13), p.2718.

[164] Merino, L., Schwarzl, M., Kraus, M., Sedlmair, M., Schmalstieg, D. and Weiskopf, D. (2020). Evaluating Mixed and Augmented Reality: A Systematic Literature Review (2009-2019). arXiv:2010.05988 [cs]. [online] Available at: *https://arxiv.org/abs/2010.05988*.

[165] Zigart, T. and Schlund, S. (2020). Evaluation of Augmented Reality Technologies in Manufacturing – A Literature Review. Advances in Intelligent Systems and Computing, pp.75–82.

[166] Davidavičienė, V., Raudeliūnienė, J. and Viršilaitė, R. (2020). EVALUATION OF USER EXPERIENCE IN AUGMENTED REALITY MOBILE APPLICATIONS. Journal of Business Economics and Management, 22(2), pp.467–481.

[167] Kubiak, A. (2014). Human-Computer Interaction with Augmented Reality - Evaluation of Augmented Reality in the Field. Advances in Embedded Interactive Systems Technical Report, 2(4).

[168] Law, E.L.-C., Roto, V., Hassenzahl, M., Vermeeren, A.P.O.S. and Kort, J. (2009). Understanding, scoping and defining user experience. Proceedings of the 27th international conference on Human factors in computing systems - CHI 09.

[169] International Organization for Standardization (ISO) (2008). ISO DIS 9241-210:2008. Ergonomics of Human System Interaction – Part 210: Human-Centred Design for Interactive Systems (Formerly Known as 1340). Ginevra, Switzerland:

[170] Zarour, M. and Alharbi, M. (2017). User experience framework that combines aspects, dimensions, and measurement methods. Cogent Engineering, 4(1).

[171] Irshad, S. and Rambli, D.R.A. (2015). Preliminary user experience framework for designing mobile augmented reality technologies. 2015 4th International Conference on Interactive Digital Media (ICIDM).

[172] Arifin, Y., Sastria, T.G. and Barlian, E. (2018). User Experience Metric for Augmented Reality Application: A Review. Procedia Computer Science, 135, pp.648–656.

[173] Preece, J., Rogers, Y. and Sharp, H. (2015). What is Interaction design? In: Interaction design : beyond human-computer interaction. Chichester, West Sussex: John Wiley & Sons Ltd.

[174] Hartson, R. and Partha Pyla (2012). What Are UX and UX Design? In: The Ux Book : Process and Guidelines for Ensuring a Quality User Experience. Morgan Kaufmann Pub.

[175] Lallemand, C., Gronier, G. and Koenig, V. (2015). User experience: A concept without consensus? Exploring practitioners' perspectives through an international survey. Computers in Human Behavior, [online] 43, pp.35-48.
Available at: *https://linkinghub.elsevier.com/retrieve/pii/S0747563214005718* [Accessed 24 Apr. 2020].

[176] Abbasi, M., Lew, P., Rafique, I. and Weng, J. (2012). Modeling User Experience An integrated framework employing ISO 25010 standard. The Seventh International Multi-Conference on Computing in the Global Information Technology.

[177] www.ultraleap.com. Ultraleap | Stratos Inspire | Ultraleap. [online] Available at: *https://www.ultraleap.com/product/stratos-inspire/*
[Accessed Jun. 2021].

[178] Dadhich, P. (2021). Integrating 5G technology in the vehicle HMI design to increase the safety. MSc Thesis.

[179] Shi, Y., Azzolin, N., Picardi, A., Zhu, T., Bordegoni, M. and Caruso, G. (2020). A Virtual Reality-based Platform to Validate HMI Design for Increasing User's Trust in Autonomous Vehicle. Computer-Aided Design and Applications, 18(3), pp.502–518.

[180] Varjo.com. VR headset - Varjo VR-3 | Highest resolution virtual reality | Varjo. [online] Available at:
https://web.archive.org/web/20210710222936/https://varjo.com/products/vr-3/ [Accessed Jul. 2021].

[181] Aleksy, M., Troost, M., Scheinhardt, F. and Zank, G.T. (2018). Utilizing HoloLens to Support Industrial Service Processes. 2018 IEEE 32nd International Conference on Advanced Information Networking and Applications (AINA).

APPENDIX - **A**

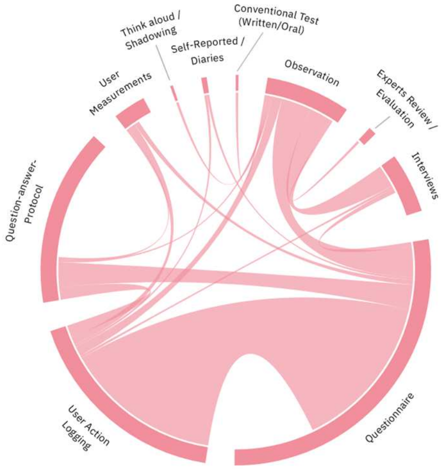
Framework

Table Of Contents Appendix – A

Section A ____ 3
Section B Section B C and D ____ 8

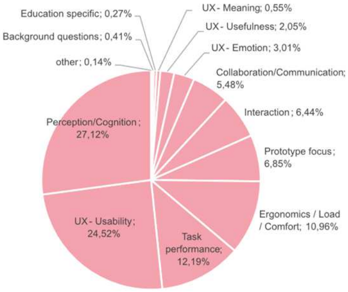
Business & Services ____ 8
Communication ____ 14
Cultural & Tourism ____ 19
Education & Training ____ 25
Entertainment ____ 34
Entertainment ____ 35
Field Operations ____ 40
Generic Interface ____ 44
Health Care & Medicine ____ 54
Industry ____ 62
Navigation & Driving ____ 68
Other ____ 76

How to read the framework



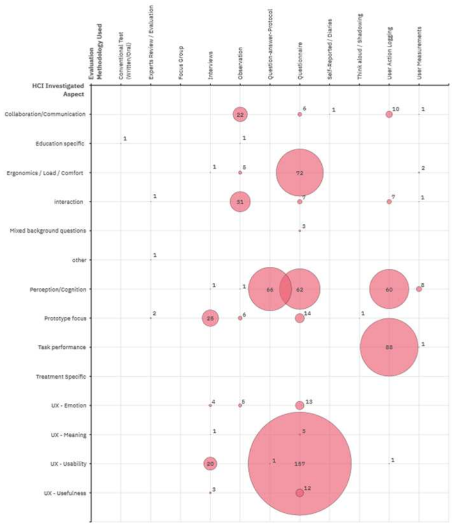
Methodologies used correlation chart

Correlation chart between methodologies used, the width of the flows corresponds to the number of times the methodology has been used. The external arches correspond to the total use within the domain/field.



Investigated HCI aspects pie

Repartition of the HCI aspects investigated within the domain/field.



Method Used & Aspects matrix

Bubble graph that puts in correlation the method used for each HCI aspect within the domain. Here we can easily see if one pair is more used than the other through the size of each bubble.

Section A – Reference tables: Domain and Fields

Business & Services

- Advertising / Product preview
- Fashion / Makeup
- Retail

Communication & Telepresence

- Remote Help
- Telepresence & Remote collaboration
- Telepresence Surgery

Cultural & Tourism

- Commercial exploration & discovery
- Heritage exploration & discovery
- Museum & Exhibitions

Education & Training

- Design, Engineering and Architecture
- History
- Languages
- Music
- Orientation
- Other
- PA
- Science subjects
- Serious game
- Special needs education

Entertainment

- Gaming
- Narrative experience

Field Operations

- Archaeological
- CSI
- Military Operations
- On site planning / maintenance

Generic Interface

- Calibration
- On site collaboration
- Info presentation / visualization
- Interactions & Ergonomics
- Perception
- Tangible Interface

Health Care & Medicine

- Elderly / Disables Help
- Emergency
- Personal Help
- Phobia Treatment
- Rehabilitation
- Surgery
- Training

Industry

- Assembly
- Design & Engineering
- Logistics
- Maintenance
- Manufacturing
- Training

Navigation & Driving

- Driving
- Info / Annotations AR & Remote viewing
- Inside orientation & space navigation
- Outside orientation & space navigation
- Remote orientation & navigation (i.e., on map)

Other

- Generic Perception on AR (Expectations / acceptance)
- Generic Perception on AR - Immersion / motivation
- Generic Perception on AR - Privacy
- Generic Perception on AR - State of the art
- human/robot/AI interaction
- Security

Investigated HCI Aspects

Collaboration/Communication

- collaboration - completion time
- communication - score / errors / accuracy
- communication behaviour
- ease of collaboration
- ease of communication
- gaze / head communication
- gestures / hands / body communication
- individual action vs collaboration
- organization behaviour and strategies between users
- Social presence / interaction impact
- speech / dialog protocols and communication

Education specific

- learning attitude (self-regulation / autonomy / motivation)
- learning performance (error / score comparation)
- learning performance POST (error / score comparation)
- learning performance POST (free discussion)
- learning performance POST (meta test comparation)
- learning performance PRE (error / score comparation)

Ergonomics / Load / Comfort

- cognitive load
- comfort / sickness
- ergonomic properties
- frustration / stress / anxiety
- physical load
- task perceived effort

interaction

- attention / focus
- common general live / interaction behaviour
- gaming style / behaviour
- general interaction behaviour
- interaction patterns
- interaction strategy and system use

(from previous page)

- learning / problem coping strategy
- long period interactions studies with system
- users' movements / gestures / physical utilization of prototype

Mixed background questions

- mixed background questions
- subject interest / knowledge on topic
- subject technological comfort / general use

other

- Digital Ethnography - Apps adaption
- Digital Ethnography - Apps perception / rating
- documentation
- users' tasks

Perception/Cognition

- hepatics
- perceived (or evaluated) depth or distance
- perception completion time
- perception related accuracy
- perception related completion time
- perception related errors
- perception related n. attempts
- perception related response time
- physical body responses
- real environment / object recognition
- sense of orientation / navigation
- sense of presence / immersion
- virtual environment / object perceived quality
- virtual environment / object recognition

Prototype focus

- co-design
- comments / suggestions
- feature usefulness / importance
- feedbacks / insights
- possible use / potentials of system
- problem individuation
- requirements and missing features

Task performance

- accuracy
- completion time
- distance
- errors
- field specific amount
- interaction time
- n. interactions
- n. trails
- reaction time
- score
- task completion time

Treatment Specific

- fears / phobias
- rehabilitation

UX - Emotion

- amusement / fun
- arousal / engagement
- interest / attractiveness
- motivation
- perceived innovativeness / wow factor
- reactions and emotion individuation / shifting
- trust (perceived safety)

UX - Meaning

- acceptance
- aspirations
- believes/opinions
- captivating / delightful experience
- hedonic quality
- meaning of context / place / interaction
- memories
- perception of brand
- pragmatic quality
- price / value
- Privacy
- self-expression

UX - Usability

- aesthetic
- ease of use
- effectiveness
- efficiency
- intuitiveness
- learnability
- naturalness
- perceived performance
- perceived task/interaction difficulty
- preference
- satisfaction
- system consistency / standards
- system errors recovery, prevention, and warning
- system flexibility
- system perceived accuracy
- system perceived control / interactivity
- system perceived robustness / stability
- system smoothness / response time
- system status information and feedback
- understandability
- usability - unspecified

UX - Usefulness

- perceived usefulness
- would recommend the use
- would use again in future

Evaluations Methods

Analytical Inspections

Experts Review / Evaluation

- Cognitive Walkthrough
- Digital Ethnography
- Experts Interview
- Heuristic evaluation
- Tasks analysis

Empirical Experimental

Observation

- comments collection during test
- evaluators coded/structured observations
- evaluators observations
  Treatment / Rehabilitation specific
  tests Experts Evaluation

Question-answer-Protocol

- closed response (during evaluation)
- open response (during evaluation)
- Virtual element finding / matching

Think aloud / Shadowing

- Shadowing
- Think aloud on prototype
- Think aloud on task

User Action Logging

- evaluators count/measure
- evaluators timing
- system logs
- tracking logs

User Measurements

- Electroencephalography (EEG)
- Electromyography (EMG)
- eye accommodation
- eye tracking
- gait tracking
- Galvanic Skin Response (GSR)
- grasping / press force
- Heart Rate Variability (HRV)

Empirical Inquiry

Conventional Test (Written/Oral)

- test with evaluation given by teacher
  test with evaluation given by teacher
  (Control + Experiment groups)
  test with evaluation given by teacher
  (PRE + Post -> Control + Experiment group)
  test with evaluation given by teacher
  (PRE + POST evaluation)

Experts Review / Evaluation

- Experts Interview
  Treatment / Rehabilitation specific tests
  Experts Evaluation

Focus Group

- Paper wireframe creation with users
- Post-test focus group
- Pre focus group
- workshop with students

Interviews

- closed response (during evaluation)
- custom-made
- later coded
- remote interview
- semi-structured
- structured
- unstructured
- unstructured post-experiment discussion
- with proxy users

Questionnaire

- adapted from previous/similar research
- After-Scenario Questionnaire (ASQ)
- AttrakDiff
- Ben Schneiderman’s acceptance test
- Bipolar Laddering (BLA system)
  Computer-Mediated Collaborative Learning:
  An Empirical Evaluation
  Cornell Musculoskeletal Discomfort
  Questionnaires (CMDQ)
- custom-made
- Education specific Questionnaire
- EZ-Scale

(from previous page)

Flow experience questionnaire by Chang et al. (2012)

Flow State Scale (FSS)

GameFlow questionnaire
illusion evaluation questionnaire by Pusch, Martin, and Coquillart

Intrinsic Motivation Inventory (IMI)

ISO 9241
ITU-R BT - Methodology for the Subjective Assessment of the Quality of Television Pictures

NASA TLX
Perceived Usefulness Perceive Ease of Use (PUEU)
Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)
Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)
Post-Study System Usability Questionnaire (PSSUQ)

presence questionnaire

Profile of Mood States questionnaire (POMS)
Questionnaire for User Interface and Satisfaction (QUIS)
QUIM (Quality In Use Integrated Measurement)

Rating Scale for Mental Effort (RSME)

remote survey

Santa Barbara Sense of Direction (SBSOD)
Sensitivity scale questionnaire by Detlev von Zerssen

Short Feedback Questionnaire (SFQ)

Simulator Sickness Questionnaire (SSQ)
Software Usability Measurement Inventory (SUMI)

System Usability Scale (SUS)

Technical self-efficacy (TSE) Questionnaire

Technology Acceptance Model (TAM)
Treatment / Rehabilitation specific Questionnaire
Unified Theory of Acceptance and Use of Technology (UTAUT2)

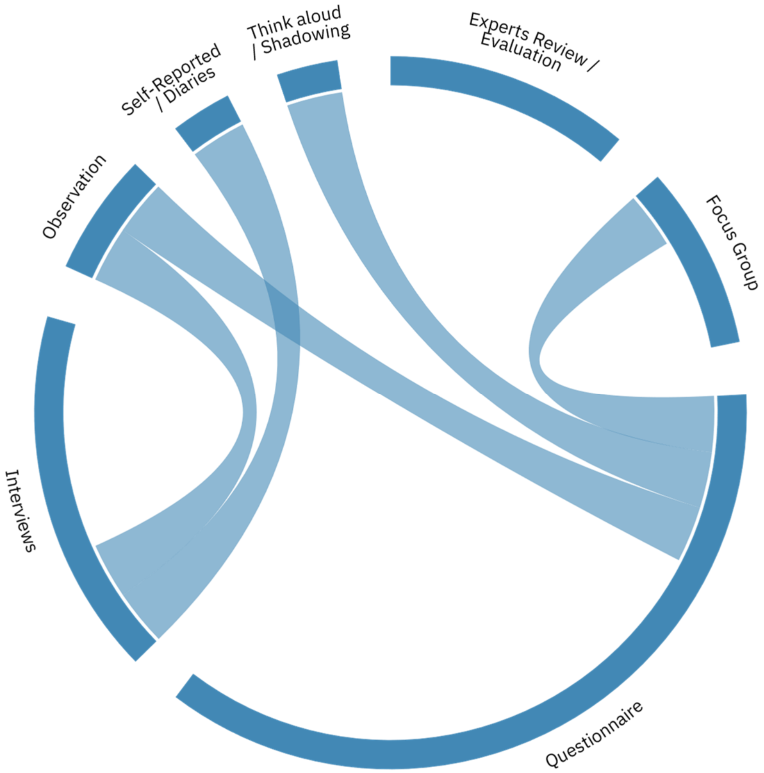
Usability Satisfaction Questionnaires

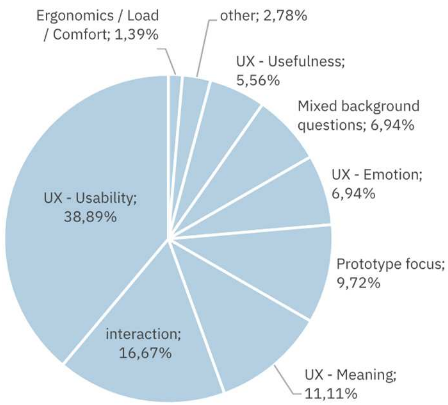
Wearability Levels (WL) scale Knight et al.

Self-Reported / Diaries

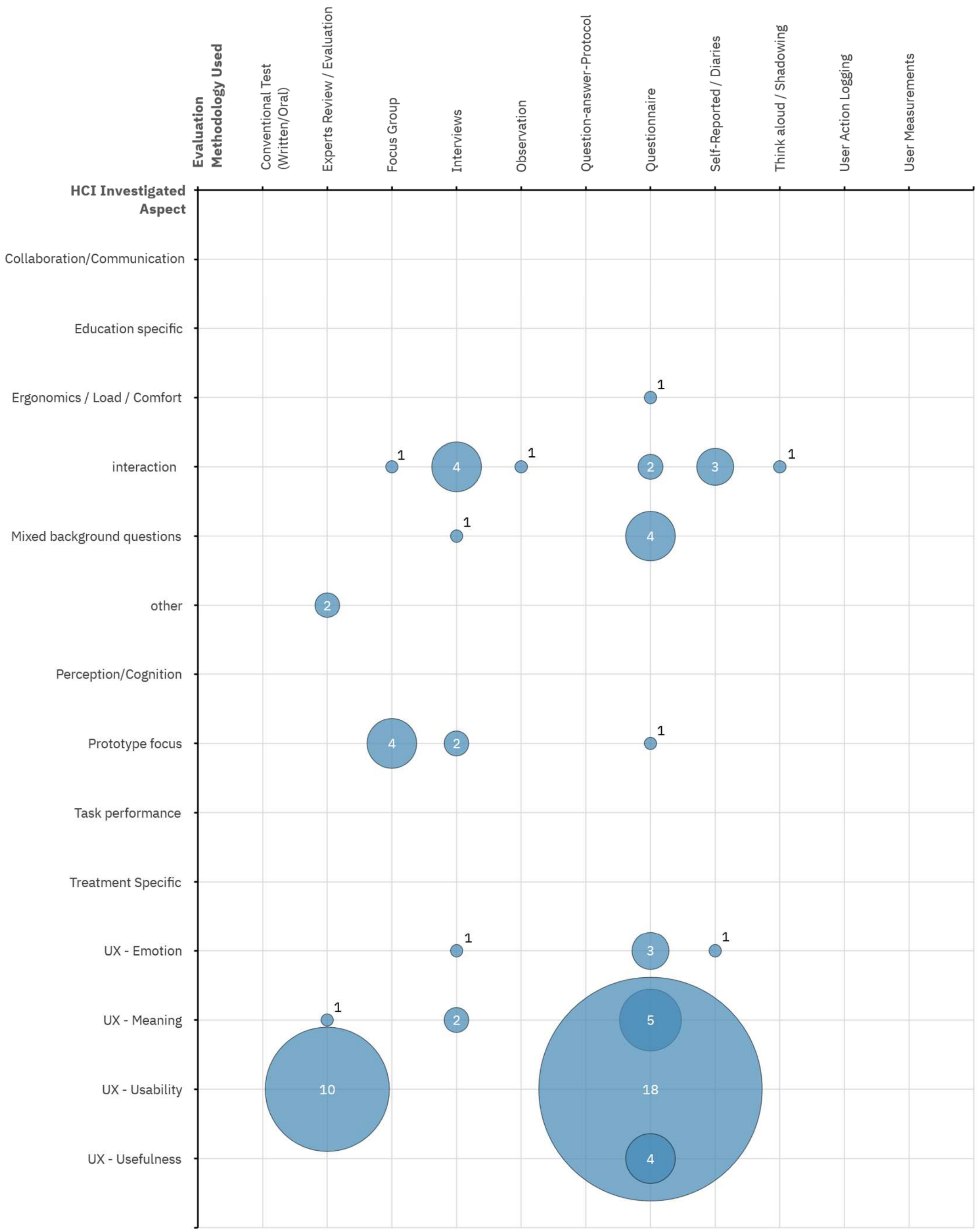
Factor-Referenced Cognitive Tests (Paperfolding test)
Participants artefacts (notebooks, emails, drawings, produced materials etc.)

Section B - Correlation charts
Business & Services





Section C - Method Used & Aspects Matrix
Business & Services



Section D – Lookup Table: Business & Services

Ergonomics / Load / Comfort	**1**	**1,39%**
Questionnaire		
adapted from previous/similar research		
A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	1	1,39%
interaction	**12**	**16,67%**
Interviews		
semi-structured	3	4,17%
structured	1	1,39%
Self-Reported / Diaries		
Self-reported data / Diaries	3	4,17%
Questionnaire		
Technology Acceptance Model (TAM)		
Unspecified	1	1,39%
7 Likert scale	1	1,39%
Observation		
evaluators observations		
on material recorded	1	1,39%
Focus Group		
Paper wireframe creation with users	1	1,39%
Think aloud / Shadowing		
Shadowing	1	1,39%
Mixed background questions	**5**	**6,94%**
Questionnaire		
custom-made		
1 to 5 scale	2	2,78%
closed ended question/s	1	1,39%
remote survey		
online survey	1	1,39%
Interviews		
structured	1	1,39%
other	**2**	**2,78%**
Experts Review / Evaluation		
Digital Ethnography	2	2,78%

Prototype focus	**7**	**9,72%**
Focus Group		
Post-test focus group	3	4,17%
Paper wireframe creation with users	1	1,39%
Interviews		
structured		
7 Likert scale	1	1,39%
semi-structured	1	1,39%
Questionnaire		
remote survey		
online survey	1	1,39%

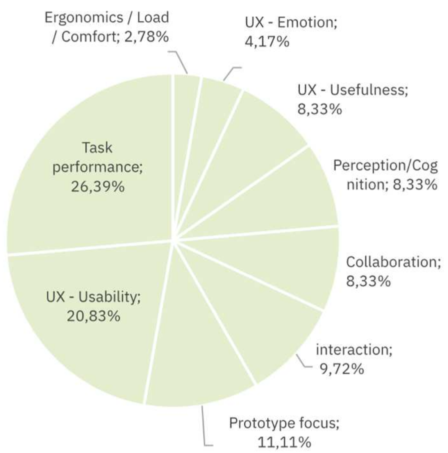
UX - Emotion	**5**	**6,94%**
Questionnaire		**4,17%**
Technology Acceptance Model (TAM)		
Unspecified	1	1,39%
7 Likert scale	1	1,39%
adapted from previous/similar research		
A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	1	1,39%
Interviews		
semi-structured	1	1,39%
Self-Reported / Diaries	**1**	**1,39%**
Self-reported data / Diaries	1	1,39%

UX - Meaning	**8**	**11,11%**
Questionnaire		
adapted from previous/similar research		
A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	2	2,78%
Technology Acceptance Model (TAM)		
Unspecified	1	1,39%
7 Likert scale	1	1,39%
custom-made		
1 to 5 scale	1	1,39%
Interviews		
structured	2	2,78%
Experts Review / Evaluation		
Heuristic evaluation	1	1,39%

UX - Usability	**28**	**38,89%**
Questionnaire		
Technology Acceptance Model (TAM)		
7 Likert scale	5	6,94%
Unspecified	2	2,78%
custom-made		
5 Likert scale	5	6,94%
adapted from previous/similar researches		
A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	4	5,56%
remote survey		
online survey	2	2,78%
Experts Review / Evaluation		
Heuristic evaluation	10	13,89%

UX - Usefulness	**4**	**5,56%**
Questionnaire		
Technology Acceptance Model (TAM)		
Unspecified	1	1,39%
7 Likert scale	1	1,39%
adapted from previous/similar researches		
A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	1	1,39%
remote survey		
online survey	1	1,39%

Section B - Correlation charts
Communication



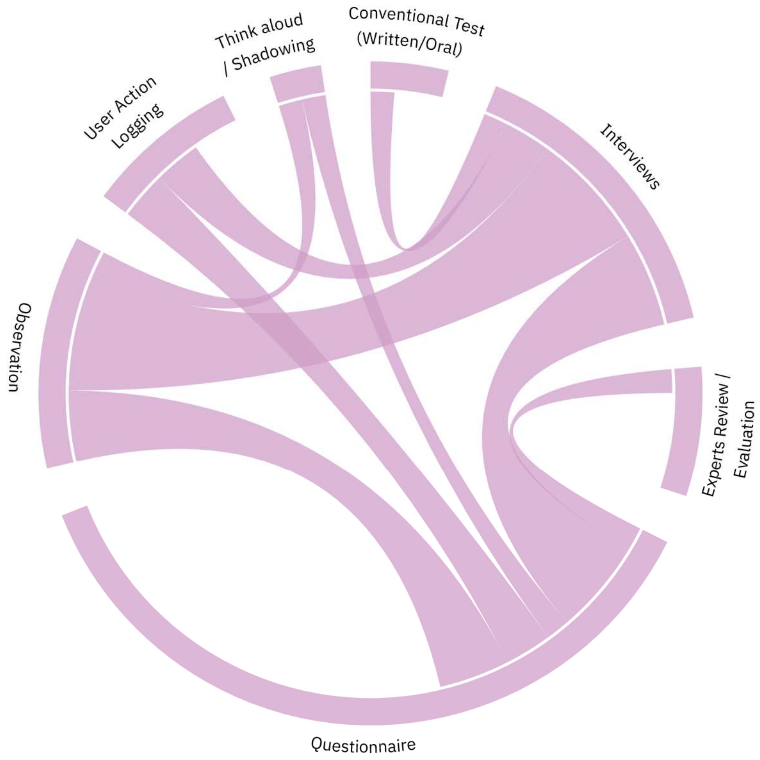
Section C - Method Used & Aspects Matrix
Communication

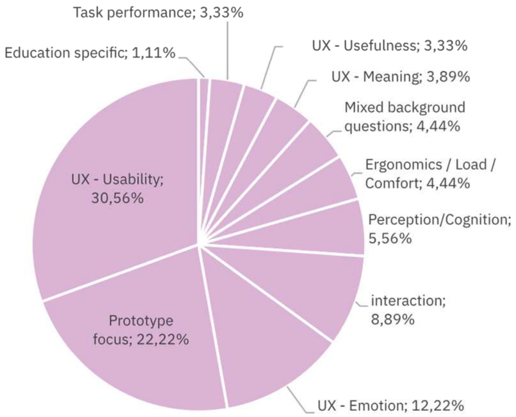
Section D – Lookup Table: Communication

Collaboration/Communication	**6**	**8,33%**
Questionnaire		
custom-made		
7 Likert scale	3	4,17%
1 to 7 scale bipolar scale	1	1,39%
User Action Logging		
tracking logs	2	2,78%
Ergonomics / Load / Comfort	**2**	**2,78%**
Interviews		
closed response (during evaluation)	1	1,39%
Questionnaire		
custom-made		
1 to 3 scale	1	1,39%
interaction	**7**	**9,72%**
Observation		
evaluators observations	5	6,94%
User Action Logging		
tracking logs	2	2,78%
Perception/Cognition	**6**	**8,33%**
User Action Logging		
evaluators count/measure	3	4,17%
tracking logs	1	1,39%
evaluators timing	1	1,39%
Questionnaire		
custom-made		
closed ended question/s	1	1,39%
Prototype focus	**8**	**11,11%**
Observation		
evaluators observations	4	5,56%
comments collection during test	1	1,39%
Questionnaire		
custom-made		
open ended question/s	2	2,78%
7 Likert scale	1	1,39%

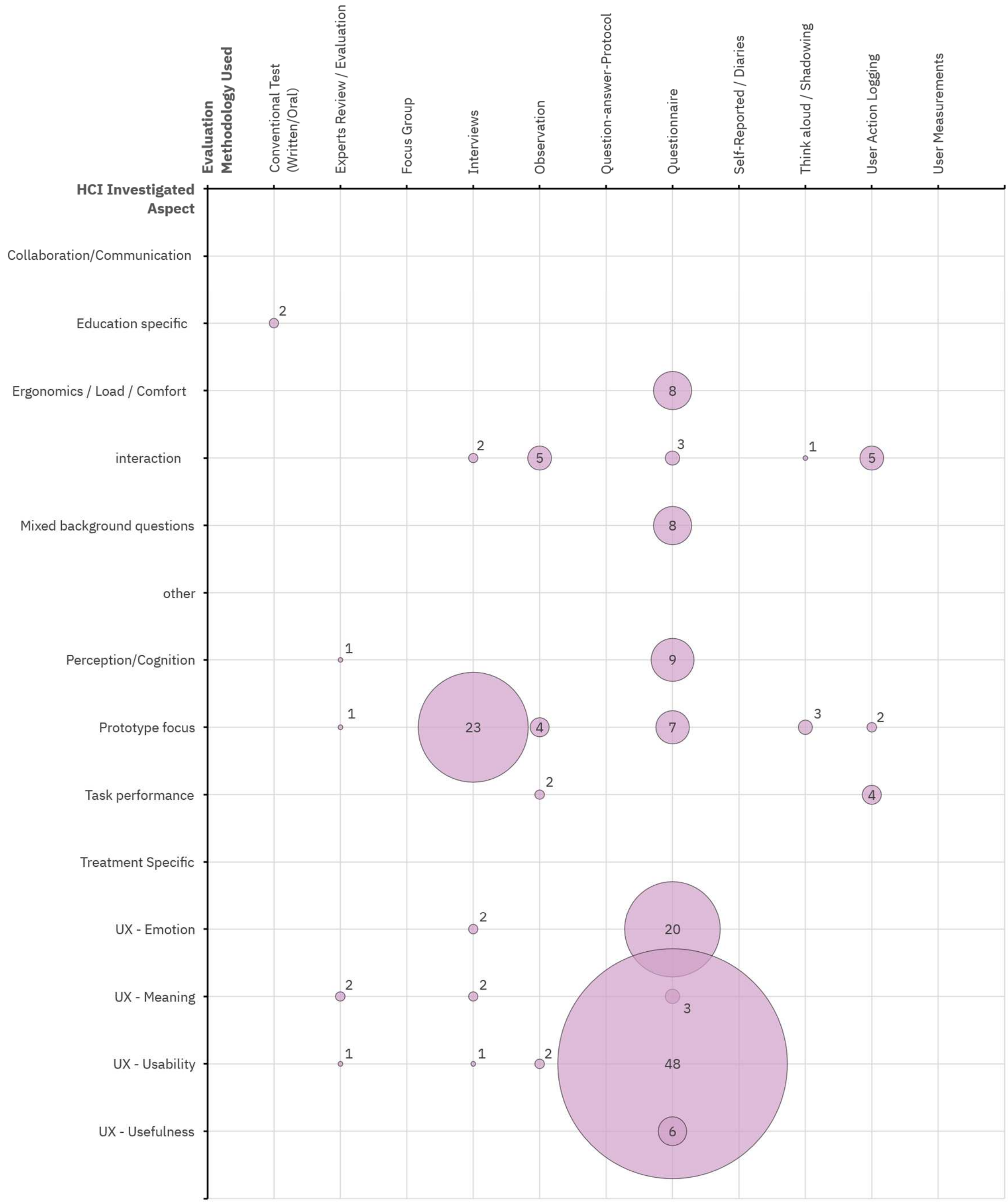
Task performance	**19**	**26,39%**
User Action Logging		
tracking logs	15	20,83%
evaluators count/measure	2	2,78%
evaluators timing	1	1,39%
Observation		
evaluators observations	1	1,39%
UX - Emotion	**3**	**4,17%**
Questionnaire		
custom-made		
7 Likert scale	2	2,78%
3 Separate Propositions (disagree/neutral/strongly agree)	1	1,39%
UX - Usability	**15**	**20,83%**
Questionnaire		
custom-made		
7 Likert scale	7	9,72%
order items	3	4,17%
1 to 5 scale	2	2,78%
3 Separate Propositions (disagree/neutral/strongly agree)	1	1,39%
open ended question/s	1	1,39%
Observation		
evaluators observations	1	1,39%
UX - Usefulness	**6**	**8,33%**
Questionnaire		
custom-made		
7 Likert scale	3	4,17%
open ended question/s	2	2,78%
3 Separate Propositions (disagree/neutral/strongly agree)	1	1,39%

Section B - Correlation charts
Cultural & Tourism





Section C - Method Used & Aspects Matrix
Cultural & Tourism



Section D – Lookup Table: Cultural & Tourism

Education specific	**2**	**1,11%**
Conventional Test (Written/Oral)		
test with evaluation given by teacher (PRE + Post -> Control + Experiment group)	1	0,56%
test with evaluation given by teacher	1	0,56%
Ergonomics / Load / Comfort	**8**	**4,44%**
Questionnaire		
NASA TLX		
7 Likert	5	2,78%
custom-made		
5 Likert scale	2	1,11%
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	1	0,56%
interaction	**16**	**8,89%**
User Action Logging		
system logs	5	2,78%
Observation		
evaluators observations	5	2,78%
Questionnaire		
Technology Acceptance Model (TAM)		
7 Likert scale	2	1,11%
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	1	0,56%
Interviews		
semi-structured	2	1,11%
Think aloud / Shadowing		
Think aloud on prototype	1	0,56%
Mixed background questions	**8**	**4,44%**
Questionnaire		
custom-made		
closed ended question/s	3	1,67%
1 to 5 scale	2	1,11%
opposite adjectives (1 to 4 scale)	1	0,56%
Technology Acceptance Model (TAM)		
7 Likert scale	1	0,56%
adapted from previous/similar research		
The Development and Evaluation of a Survey to Measure User Engagement - 5 Likert scale	1	0,56%

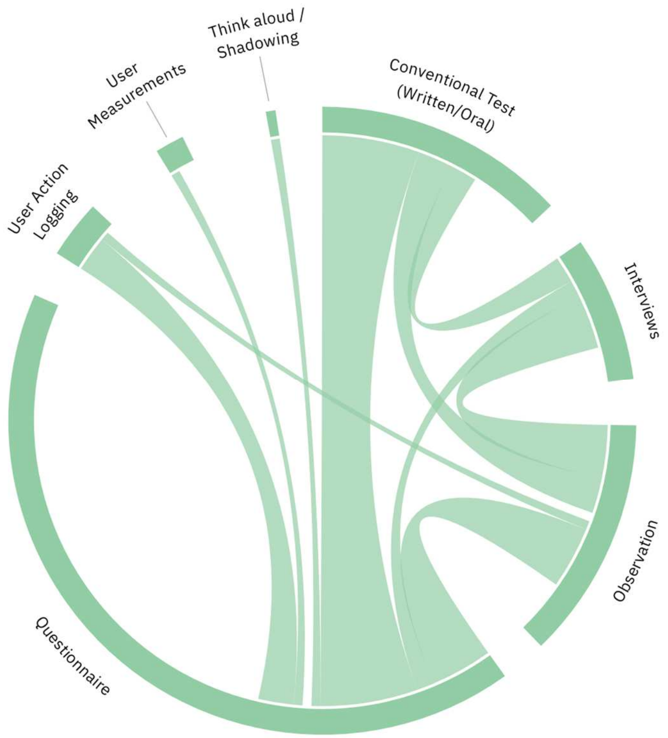
Perception/Cognition	**10**	**5,56%**
Questionnaire		
custom-made		
7 Likert scale	2	1,11%
opposite adjectives (1 to 4 scale)	1	0,56%
5 Likert scale	1	0,56%
presence questionnaire		
Regenbrecht and Schubert (2002) - 7 Likert scale	4	2,22%
Santa Barbara Sense of Direction (SBSOD)	1	0,56%
Experts Review / Evaluation		
Heuristic evaluation	1	0,56%
Prototype focus	**40**	**22,22%**
Interviews		
semi-structured		
open ended question/s	9	5,00%
unspecified	5	2,78%
recorded	2	1,11%
unstructured	5	2,78%
remote interview		
semi-structured phone interview	1	0,56%
structured		
Close-Ended Questions	1	0,56%
Questionnaire		
custom-made		
1 to 5 scale	4	2,22%
7 Likert scale	2	1,11%
5 Likert scale	1	0,56%
Observation		
evaluators observations		
unspecified	3	1,67%
on material recorded	1	0,56%
Think aloud / Shadowing		
Think aloud on task		
unspecified	2	1,11%
Think aloud on prototype		
unspecified	1	0,56%
User Action Logging		
system logs		
unspecified	2	1,11%

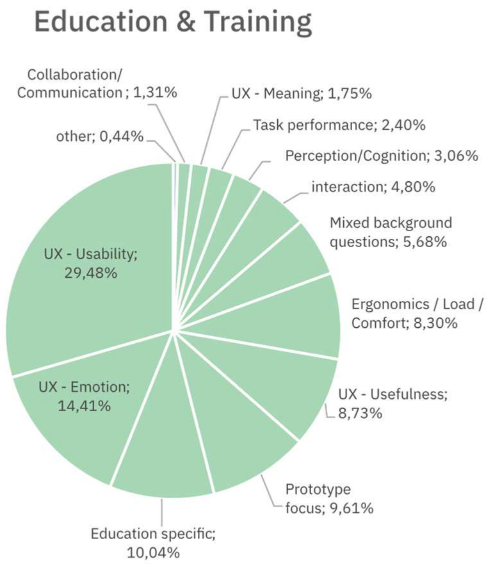
Experts Review / Evaluation		
Heuristic evaluation	1	0,56%
Task performance	**6**	**3,33%**
User Action Logging		
system logs	4	2,22%
Observation		
evaluators coded/structured observations		
on material recorded	2	1,11%
UX - Emotion	**22**	**12,22%**
Questionnaire		
custom-made		
1 to 5 scale	4	2,22%
5 Likert scale	4	2,22%
opposite adjectives (1 to 4 scale)	2	1,11%
7 Likert scale	2	1,11%
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	4	2,22%
adapted from previous/similar research		
The Development and Evaluation of a Survey to Measure User Engagement - 5 Likert scale	2	1,11%
Technology Acceptance Model (TAM)		
7 Likert scale	2	1,11%
Interviews		
semi-structured		
recorded	1	0,56%
open ended question/s	1	0,56%
UX - Meaning	**7**	**3,89%**
Questionnaire		
custom-made		
opposite adjectives (1 to 4 scale)	1	0,56%
5 Likert scale	1	0,56%
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	1	0,56%
Experts Review / Evaluation		
Experts Interview	2	1,11%
Interviews		
semi-structured		
open ended question/s	2	1,11%

UX - Usability	55	30,56%
Questionnaire		
custom-made		
5 Likert scale	18	10,00%
1 to 5 scale	5	2,78%
opposite adjectives (1 to 4 scale)	3	1,67%
7 Likert scale	3	1,67%
closed ended question/s	1	0,56%
Technology Acceptance Model (TAM)		
7 Likert scale	4	2,22%
Ben Schneiderman's acceptance test		
5 Likert scale	3	1,67%
System Usability Scale (SUS)		
5 Likert scale	3	1,67%
presence questionnaire		
Regenbrecht and Schubert (2002) - 7 Likert scale	3	1,67%
adapted from previous/similar research		
The Development and Evaluation of a Survey to Measure User Engagement - 5 Likert scale	3	1,67%
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	1	0,56%
NASA TLX		
7 Likert	1	0,56%
N/D		
N/D	3	1,67%
Observation		
evaluators observations	2	1,11%
Experts Review / Evaluation		
Heuristic evaluation	1	0,56%
Inter-views		
semi-structured	1	0,56%

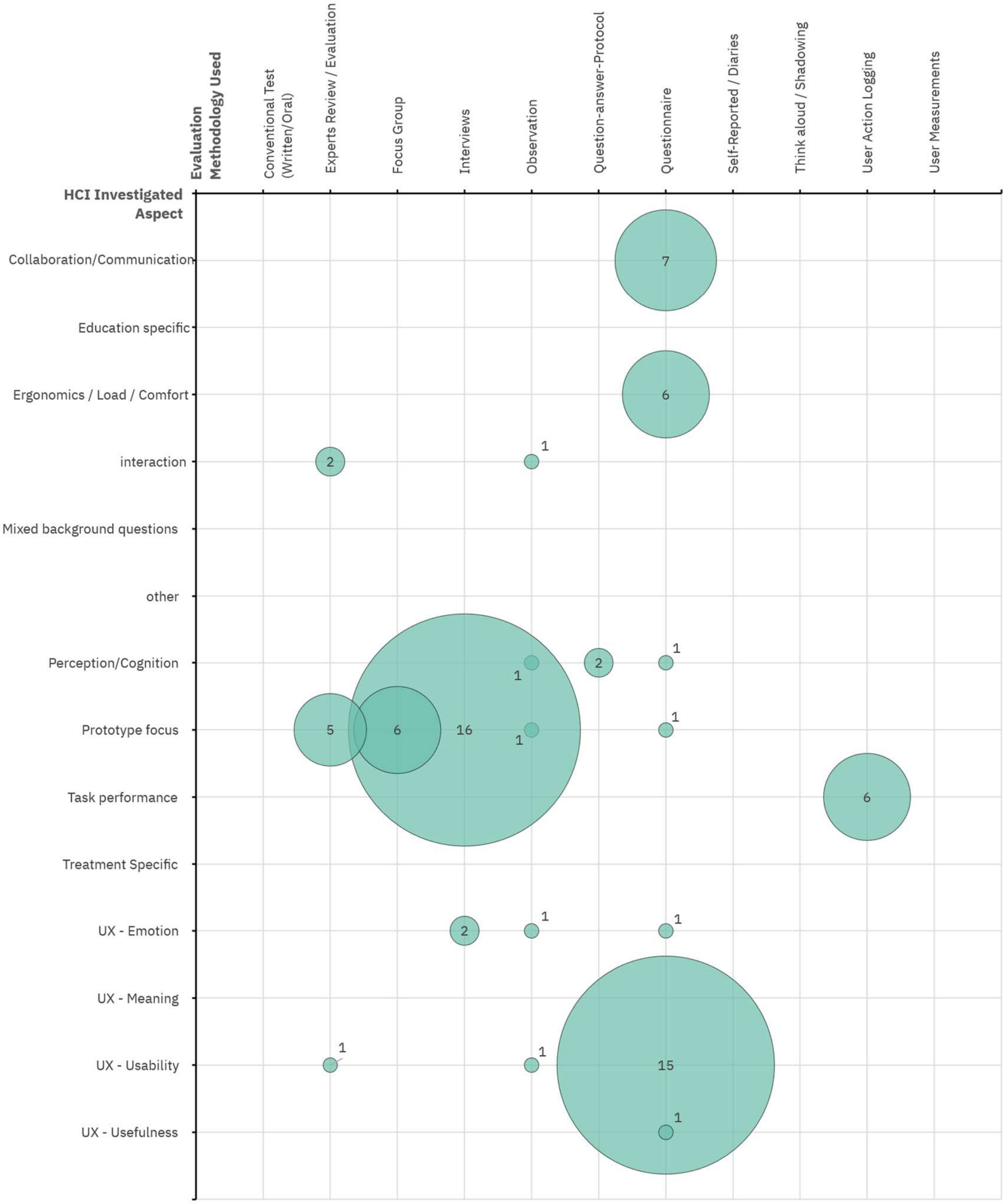
UX - Usefulness	6	3,33%
Questionnaire		
custom-made		
5 Likert scale	2	1,11%
1 to 5 scale	1	0,56%
Technology Acceptance Model (TAM)		
7 Likert scale	2	1,11%
System Usability Scale (SUS)		
5 Likert scale	1	0,56%

Section B - Correlation charts
Education & Training





Section C - Method Used & Aspects Matrix
Education & Training



Section D – Lookup Table: Education & Training

Collaboration/Communication	**6**	**1,31%**
Observation		
evaluators coded/structured observations	3	0,66%
Questionnaire		
Computer-Mediated Collaborative Learning: An Empirical Evaluation		
5 Likert scale	3	0,66%
Education specific	**46**	**10,04%**
Conventional Test (Written/Oral)		
test with evaluation given by teacher	8	1,75%
test with evaluation given by teacher (Control + Experiment groups)	7	1,53%
test with evaluation given by teacher (PRE + POST evaluation)	6	1,31%
test with evaluation given by teacher (PRE + Post -> Control + Experiment group)	3	0,66%
Questionnaire		
custom-made		
graded questions	10	2,18%
5 Likert scale	1	0,22%
6 Likert scale	1	0,22%
Flow experience questionnaire by Chang et al. (2012)		
5 Likert scale	2	0,44%
Education specific Questionnaire		
Pintrich's Motivated Strategies for Learning Questionnaire (MSLQ)	1	0,22%
Observation		
evaluators observations		
on material recorded	2	0,44%
unspecified	2	0,44%
evaluators coded/structured observations	2	0,44%
Interviews		
semi-structured	1	0,22%
Ergonomics / Load / Comfort	**38**	**8,30%**
Questionnaire		
Wearability Levels (WL) scale Knight et al.		
Visual Effects scales (VES) - 1 to 5 scale	6	1,31%
comfort rating scales (CRS) - 1 to 5 scale	6	1,31%
Borg RPE - 1 to 5 scale	1	0,22%
Borg-CR10 - 1 to 5 scale	1	0,22%
custom-made		
5 Likert scale	5	1,09%

6 Likert scale	1	0,22%
Intrinsic Motivation Inventory (IMI)		
5 Likert scale	1	0,22%
Likert 7 scale	1	0,22%
7 Likert polar terms scale	1	0,22%
QUIM (Quality In Use Integrated Measurement)	2	0,44%
Education specific Questionnaire		
Learning Attitude towards Ecosystems (LATE) - 5 Likert scale	1	0,22%
based on The ebb and flow of online learning by Pearce (10.1016/j.chb.2004.02.019) - 5 Likert scale	1	0,22%
Flow State Scale (FSS)		
5 Likert scale	2	0,44%
Questionnaire for User Interface and Satisfaction (QUIS)		
12 Likert scale	1	0,22%
Bipolar Laddering (BLA system)	1	0,22%
Interviews		
structured	5	1,09%
NASA TLX	5	1,09%
User Measurements		
Heart Rate Variability (HRV)	2	0,44%
interaction	**22**	**4,80%**
Observation	**11**	**2,40%**
evaluators observations	6	1,31%
evaluators coded/structured observations	5	1,09%
unspecified	4	0,87%
on material recorded	1	0,22%
Questionnaire		
custom-made		
5 Likert scale	3	0,66%
7 Likert scale	2	0,44%
Flow State Scale (FSS)		
5 Likert scale	1	0,22%
Technology Acceptance Model (TAM)		
Unspecified	1	0,22%
Education specific Questionnaire		
Keller's Instructional Materials Motivation Survey (IMMS)	1	0,22%
Think aloud / Shadowing		
Think aloud on prototype	2	0,44%

Interviews		
with proxy users		
semi-structured	1	0,22%
Mixed background questions	**26**	**5,68%**
Questionnaire		
custom-made		
closed ended question/s	10	2,18%
5 Likert scale	2	0,44%
7 Likert scale	2	0,44%
graded questions	1	0,22%
1 to 6 scale	1	0,22%
Intrinsic Motivation Inventory (IMI)		
5 Likert scale	1	0,22%
Computer-Mediated Collaborative Learning: An Empirical Evaluation		
5 Likert scale	1	0,22%
remote survey		
email survey - closed question/s	1	0,22%
System Usability Scale (SUS)		
5 Likert scale	1	0,22%
Bipolar Laddering (BLA system)	1	0,22%
Flow experience questionnaire by Chang et al. (2012)		
5 Likert scale	1	0,22%
Interviews		
later coded		
structured evaluation from evaluators with 1 to 5 scale	2	0,44%
Observation		
evaluators observations	2	0,44%
other	**2**	**0,44%**
Self-Reported / Diaries		
Participants artefacts (notebooks, emails, drawings, produced materials etc.)	2	0,44%
Perception/Cognition	**14**	**3,06%**
Questionnaire		
custom-made		
5 Likert scale	8	1,75%
presence questionnaire		
by Slater et al. (1994) - reduced version	2	0,44%
Flow State Scale (FSS)		
5 Likert scale	2	0,44%

Interviews		
with proxy users		
structured	1	0,22%
semi-structured	1	0,22%

Prototype focus	**44**	**9,61%**
Questionnaire		
custom-made		
open ended question/s	12	2,62%
closed ended question/s	3	0,66%
5 Likert scale	3	0,66%
7 Likert scale	1	0,22%
remote survey		
email survey - closed question/s	3	0,66%
Interviews		
with proxy users		
unstructured - unformal	3	0,66%
structured	3	0,66%
semi-structured	2	0,44%
un-structured	2	0,44%
semi-structured	4	0,87%
later coded		
unstructured interview later coded in topics	1	0,22%
Observation	**6**	**1,31%**
evaluators observations	3	0,66%
evaluators coded/structured observations	2	0,44%
on material recorded	1	0,22%
comments collection during test	1	0,22%
Think aloud / Shadowing	**1**	**0,22%**
Think aloud on prototype	1	0,22%

Task performance	**11**	**2,40%**
User Action Logging		
evaluators count/measure	5	1,09%
evaluators timing		
unspecified	2	0,44%
on material recorded	1	0,22%
system logs	2	0,44%
Observation		
evaluators coded/structured observations		

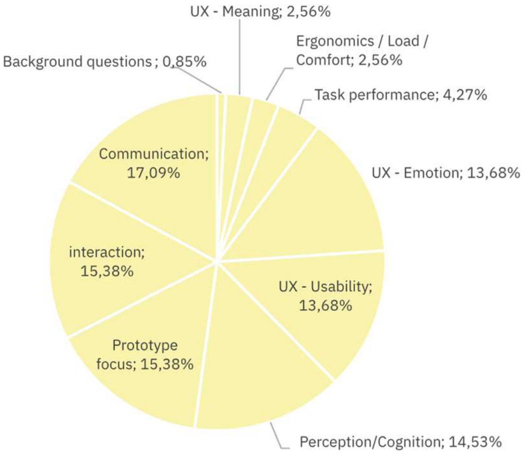
on material recorded	1	0,22%
UX - Emotion	**66**	**14,41%**
Questionnaire		
custom-made		
5 Likert scale	8	1,75%
7 Likert scale	6	1,31%
closed ended question/s	3	0,66%
open ended question/s	2	0,44%
Likert 4	1	0,22%
Education specific Questionnaire		
adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	4	0,87%
Keller's Instructional Materials Motivation Survey (IMMS)	2	0,44%
Learning Attitude towards Ecosystems (LATE) - 5 Likert scale	1	0,22%
Intrinsic Motivation Inventory (IMI)		
5 Likert scale	2	0,44%
Likert 7 scale	1	0,22%
7 Likert polar terms scale	1	0,22%
Bipolar Laddering (BLA system)	4	0,87%
Flow State Scale (FSS)		
5 Likert scale	3	0,66%
Technology Acceptance Model (TAM)		
Unspecified	3	0,66%
QUIM (Quality In Use Integrated Measurement)	2	0,44%
Questionnaire for User Interface and Satisfaction (QUIS)		
8 Likert scale	1	0,22%
10 Likert scale	1	0,22%
Post-Study System Usability Questionnaire (PSSUQ)	1	0,22%
System Usability Scale (SUS)	1	0,22%
remote survey		
email survey - closed question/s	1	0,22%
ISO 9241		
ISONORM part 10 - 5 Likert	1	0,22%
Interviews		
with proxy users		
semi-structured	3	0,66%
structured	1	0,22%
later coded		
unstructured interview later coded in topics	2	0,44%

structured	2	0,44%
Observation	**8**	**1,75%**
evaluators coded/structured observations	7	1,53%
on material recorded	4	0,87%
evaluators observations	1	0,22%
User Measurements		
Galvanic Skin Response (GSR)	1	0,22%
UX - Meaning	**8**	**1,75%**
Questionnaire		
custom-made		
7 Likert scale	6	1,31%
Technology Acceptance Model (TAM)		
Unspecified	1	0,22%
Interviews		
later coded		
unstructured interview later coded in topics	1	0,22%
UX - Usability	**135**	**29,48%**
Questionnaire		
custom-made		
5 Likert scale	22	4,80%
7 Likert scale	6	1,31%
open ended question/s	4	0,87%
1 to 10 scale	4	0,87%
Likert 4	2	0,44%
closed ended question/s	2	0,44%
6 Likert scale	2	0,44%
1 to 5 scale	1	0,22%
ISO 9241		
part 11	19	4,15%
ISONORM part 10 - 5 Likert	7	1,53%
Education specific Questionnaire		
adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	6	1,31%
Keller's Instructional Materials Motivation Survey (IMMS)	1	0,22%
Learning Attitude towards Ecosystems (LATE) - 5 Likert scale	1	0,22%
based on The ebb and flow of online learning by Pearce (10.1016/j.chb.2004.02.019) - 5 Likert scale	1	0,22%
Technology Acceptance Model (TAM)		
Unspecified	6	1,31%
7 Likert scale	1	0,22%

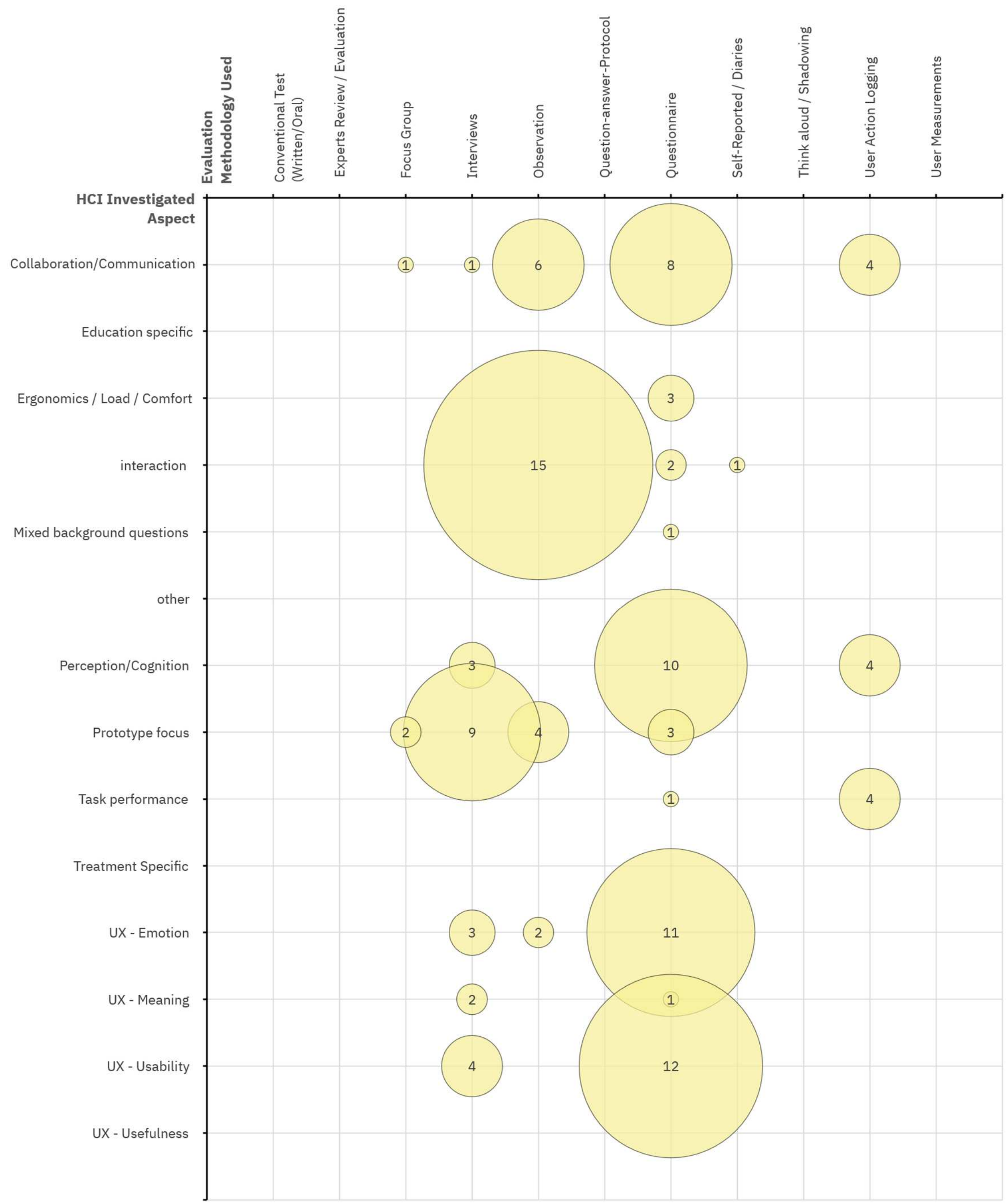
System Usability Scale (SUS)		
5 Likert scale	3	0,66%
Unspecified	2	0,44%
QUIM (Quality In Use Integrated Measurement)	5	1,09%
Post-Study System Usability Questionnaire (PSSUQ)		
Unspecified	3	0,66%
7 Likert scale	2	0,44%
Bipolar Laddering (BLA system)	4	0,87%
Intrinsic Motivation Inventory (IMI)		
5 Likert scale	2	0,44%
Likert 7 scale	1	0,22%
7 Likert polar terms scale	1	0,22%
Usability Satisfaction Questionnaires		
5 Likert scale	4	0,87%
Questionnaire for User Interface and Satisfaction (QUIS)		
6 Likert scale	1	0,22%
5 Likert scale	1	0,22%
11 Likert scale	1	0,22%
13 Likert scale	1	0,22%
Flow State Scale (FSS)		
5 Likert scale	3	0,66%
Computer-Mediated Collaborative Learning: An Empirical Evaluation		
5 Likert scale	2	0,44%
Interviews		
later coded		
unstructured interview later coded in topics	3	0,66%
with proxy users		
semi-structured	3	0,66%
structured		
Unspecified	2	0,44%
NASA TLX	1	0,22%
Observation		
evaluators coded/structured observations		
Unspecified	2	0,44%
on material recorded	1	0,22%
evaluators observations	1	0,22%
User Action Logging	**1**	**0,22%**
system logs	1	0,22%
UX - Usefulness	**40**	**8,73%**
Questionnaire		

custom-made		
5 Likert scale	9	1,97%
closed ended question/s	3	0,66%
open ended question/s	1	0,22%
Likert 4	1	0,22%
1 to 10 scale	1	0,22%
1 to 5 scale	1	0,22%
Technology Acceptance Model (TAM)		
Unspecified	3	0,66%
7 Likert scale	1	0,22%
Education specific Questionnaire		
adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	2	0,44%
Learning Attitude towards Ecosystems (LATE) - 5 Likert scale	1	0,22%
Intrinsic Motivation Inventory (IMI)		
Likert 7 scale	1	0,22%
7 Likert polar terms scale	1	0,22%
Usability Satisfaction Questionnaires		
5 Likert scale	2	0,44%
Questionnaire for User Interface and Satisfaction (QUIS)		
9 Likert scale	1	0,22%
7 Likert scale	1	0,22%
Post-Study System Usability Questionnaire (PSSUQ)		
7 Likert scale	1	0,22%
Unspecified	1	0,22%
ISO 9241		
part 11	1	0,22%
Bipolar Laddering (BLA system)	1	0,22%
QUIM (Quality In Use Integrated Measurement)	1	0,22%
System Usability Scale (SUS)		
5 Likert scale	1	0,22%
Interviews		
with proxy users		
semi-structured	2	0,44%
unstructured - unformal	1	0,22%
structured	1	0,22%
semi-structured	1	0,22%

Section B - Correlation charts
Entertainment



Section C - Method Used & Aspects Matrix
Entertainment



Section D – Lookup Table: Entertainment

Collaboration/Communication	**20**	**17,09%**
Questionnaire		
custom-made		
7 Likert scale	4	3,42%
5 Likert scale	4	3,42%
Observation		
evaluators observations		
on material recorded	2	1,71%
unspecified	2	1,71%
evaluators coded/structured observations	2	1,71%
User Action Logging		
system logs	4	3,42%
Focus Group		
Post-test focus group	1	0,85%
Interviews		
semi-structured	1	0,85%

Ergonomics / Load / Comfort	**3**	**2,56%**
Questionnaire		
custom-made		
5 Likert scale	2	1,71%
1 to 7 scale	1	0,85%

interaction	**18**	**15,38%**
Observation		
evaluators observations		
unspecified	7	5,98%
on material recorded	5	4,27%
evaluators coded/structured observations		
on material recorded	3	2,56%
Questionnaire		
GameFlow questionnaire		
Likert Ordinal scale	1	0,85%
custom-made		
5 Likert scale	1	0,85%
Self-Reported / Diaries		
Participants artefacts (notebooks, emails, drawings, produced materials etc.)	1	0,85%

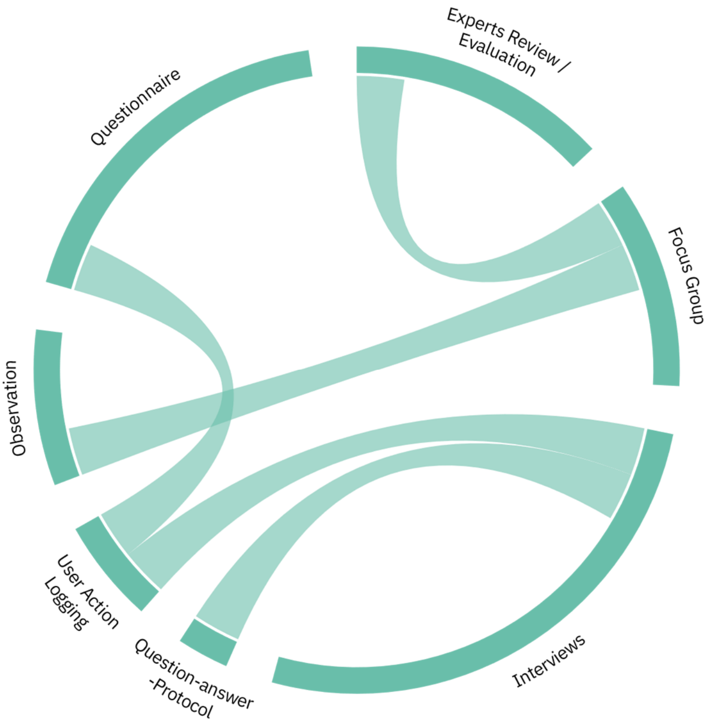
Mixed background questions	**1**	**0,85%**
Questionnaire		
custom-made		
closed ended question/s	1	0,85%
Perception/Cognition	**17**	**14,53%**
Questionnaire		
custom-made		
5 Likert scale	3	2,56%
open ended question/s	2	1,71%
1 to 7 scale	2	1,71%
closed response multi-item	1	0,85%
7 Likert scale	1	0,85%
presence questionnaire		
MEC-SPQ - Likert Ordinal	1	0,85%
User Action Logging		
system logs	4	3,42%
Interviews		
semi-structured	3	2,56%
Prototype focus	**18**	**15,38%**
Interviews		
unstructured	5	4,27%
semi-structured	2	1,71%
unstructured post-experiment discussion	1	0,85%
structured	1	0,85%
Observation		
evaluators observations	4	3,42%
Questionnaire		
custom-made		
open ended question/s	2	1,71%
5 Likert scale	1	0,85%
Focus Group		
Post-test focus group	2	1,71%
Task performance	**5**	**4,27%**
User Action Logging		
system logs	3	2,56%
evaluators timing	1	0,85%
Questionnaire		
custom-made		
graded questions	1	0,85%

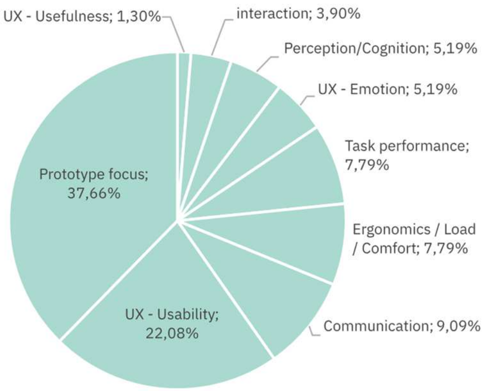
UX - Emotion	**16**	**13,68%**
Questionnaire		
custom-made		
7 Likert scale	5	4,27%
5 Likert scale	2	1,71%
1 to 7 scale	1	0,85%
System Usability Scale (SUS)	2	1,71%
Intrinsic Motivation Inventory (IMI)	1	0,85%
Likert Ordinal scale	1	0,85%
Interviews		
unstructured	2	1,71%
unstructured post-experiment discussion	1	0,85%
Observation		
evaluators observations		
on material recorded	1	0,85%
evaluators coded/structured observations		
on material recorded	1	0,85%

UX - Meaning	**3**	**2,56%**
Interviews		
semi-structured		
recorded	2	1,71%
Questionnaire		
custom-made		
7 Likert scale	1	0,85%

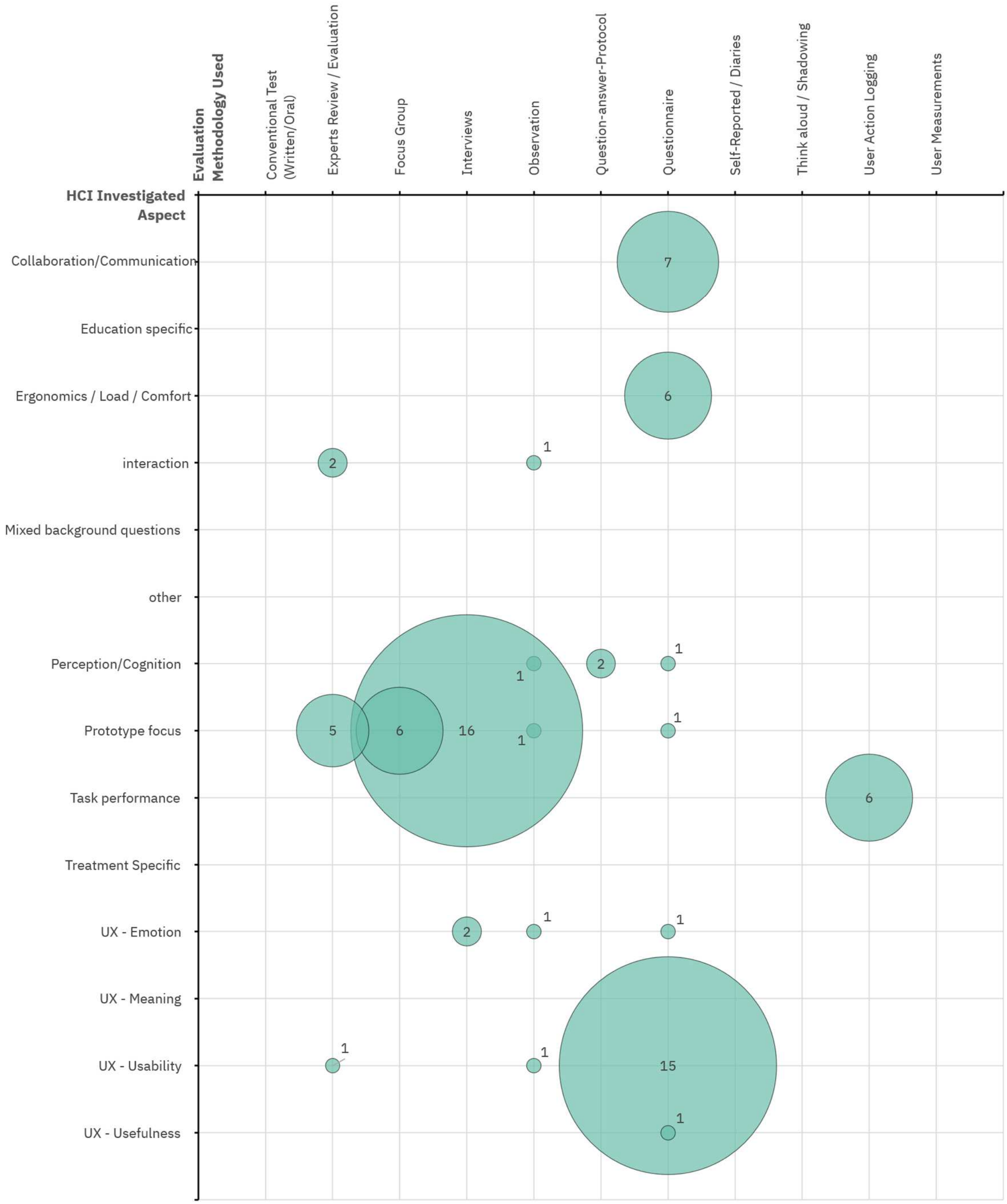
UX - Usability	**16**	**13,68%**
Questionnaire		
custom-made		
5 Likert scale	5	4,27%
7 Likert scale	2	1,71%
open ended question/s	1	0,85%
closed ended question/s	1	0,85%
System Usability Scale (SUS)	3	2,56%
Interviews		
unstructured post-experiment discussion	2	1,71%
semi-structured	2	1,71%

Section B - Correlation charts
Field Operations





Section C - Method Used & Aspects Matrix
Field Operations

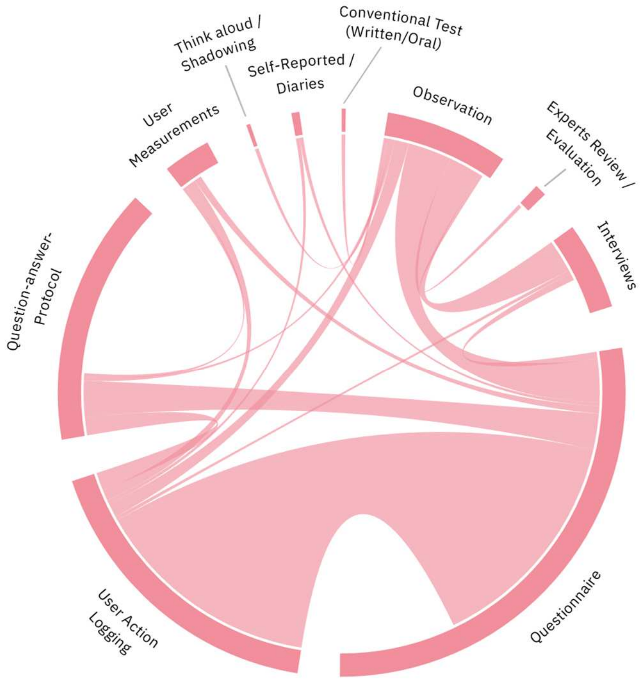


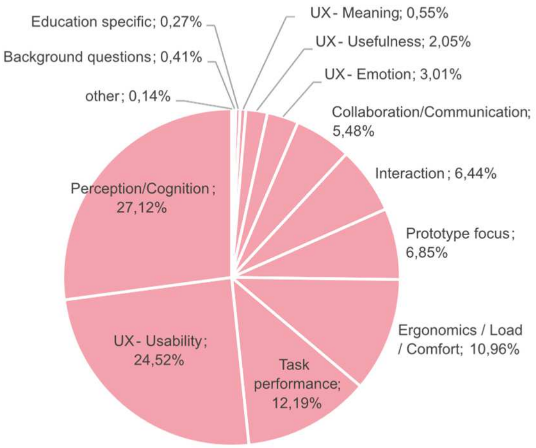
Section D – Lookup Table: Field Operations

Collaboration/Communication	**7**	**9,09%**
Questionnaire		
Education specific Questionnaire		
Evaluation method for computer supported collaborative learning (CSCL) by Spada et al.' - 5 Likert	7	9,09%
Ergonomics / Load / Comfort	**6**	**7,79%**
Questionnaire		
NASA TLX		
7 Likert	5	6,49%
Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)		
5 Likert scale	1	1,30%
interaction	**3**	**3,90%**
Experts Review / Evaluation		
Cognitive Walkthrough	2	2,60%
Observation		
evaluators observations	1	1,30%
Perception/Cognition	**4**	**5,19%**
Question-answer-Protocol		
open response (during evaluation)	1	1,30%
closed response (during evaluation)	1	1,30%
Observation		
evaluators observations		
on material recorded	1	1,30%
Questionnaire		
custom-made		
7 Likert scale	1	1,30%
Prototype focus	**29**	**37,66%**
Interviews		
unstructured post-experiment discussion	11	14,29%
unstructured	3	3,90%
structured	2	2,60%
Focus Group		
Post-test focus group	6	7,79%

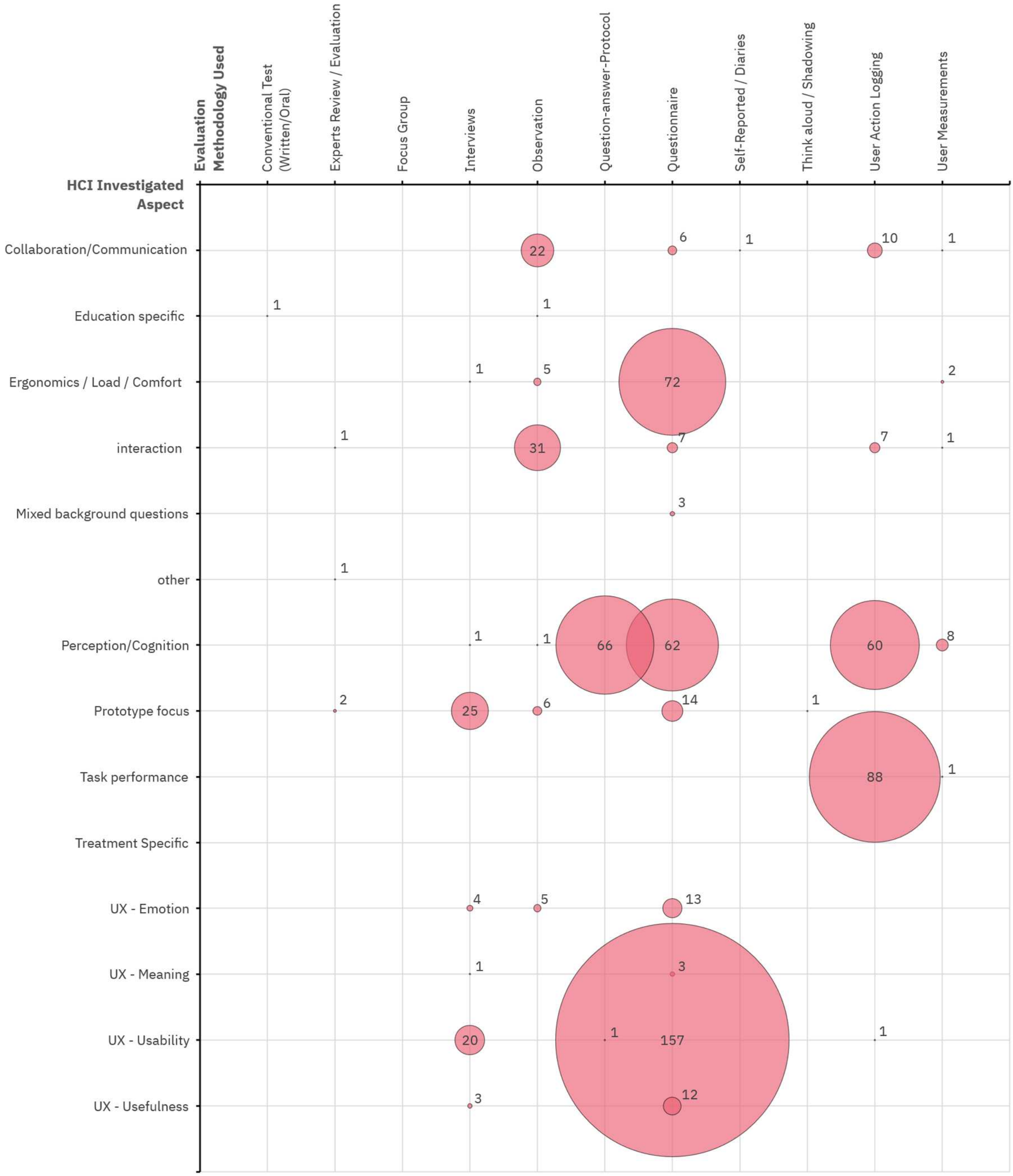
Experts Review / Evaluation		
Heuristic evaluation	3	3,90%
Tasks analysis	1	1,30%
Cognitive Walkthrough	1	1,30%
Observation		
evaluators observations	1	1,30%
Questionnaire		
custom-made		
7 Likert scale	1	1,30%
Task performance	**6**	**7,79%**
User Action Logging		
system logs	3	3,90%
tracking logs	1	1,30%
evaluators count/measure	1	1,30%
evaluators timing	1	1,30%
UX - Emotion	**4**	**5,19%**
Interviews		
unstructured post-experiment discussion	2	2,60%
Questionnaire		
custom-made		
7 Likert scale	1	1,30%
Observation		
evaluators observations	1	1,30%
UX - Usability	**17**	**22,08%**
Questionnaire	**15**	**19,48%**
Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)		
5 Likert scale	8	10,39%
custom-made	6	7,79%
7 Likert scale		
NASA TLX	1	1,30%
7 Likert		
Experts Review / Evaluation		
Heuristic evaluation	1	1,30%
Observation		
evaluators observations	1	1,30%
UX - Usefulness	**1**	**1,30%**
Questionnaire		
custom-made		
7 Likert scale	1	1,30%

Section B - Correlation charts
Generic Interface





Section C - Method Used & Aspects Matrix
Generic Interface



Section D – Lookup Table: Generic Interface

Collaboration/Communication	**40**	**5,49%**
Observation		
evaluators coded/structured observations	12	1,65%
on material recorded	7	0,96%
unspecified	5	0,69%
evaluators observations		
unspecified	7	0,96%
on material recorded	3	0,41%
User Action Logging		
tracking logs	5	0,69%
system logs	5	0,69%
Questionnaire		
custom-made		
10 Likert scale	2	0,27%
1 to 7 scale	1	0,14%
adapted from previous/similar research		
Rico and Brewster. Usable gestures for mobile interfaces: evaluating social accepta-bility	2	0,27%
Some Advantages of Video Conferencing Over High-quality Audio Conferencing: Fluency and Awareness of Attentional Focus. By Daly-Jones et al. (10.1006/ijhc.1998.0195) - 1 to 7 scale with polar terms	1	0,14%
User Measurements		
eye tracking	1	0,14%
Self-Reported / Diaries		
Participant’s artefacts (notebooks, emails, drawings, produced materials etc.)	1	0,14%
Education specific	**2**	**0,27%**
Conventional Test (Written/Oral)		
test with evaluation given by teacher	1	0,14%
Observation		
evaluators observations		
on material recorded	1	0,14%
Ergonomics / Load / Comfort	**80**	**10,97%**
Questionnaire		
custom-made		
7 Likert scale	19	2,61%
5 Likert scale	10	1,37%
closed response multi-item	3	0,41%
order items	3	0,41%
9 Likert scale	2	0,27%

open comments	1	0,14%
closed ended question/s	1	0,14%
NASA TLX		
100 scale	11	1,51%
RTLX version (Raw)- 100 scale	5	0,69%
Unspecified	5	0,69%
7 Likert	5	0,69%
modify Likert	4	0,55%
ISO 9241		
part 9 - 2000(E)	2	0,27%
Simulator Sickness Questionnaire (SSQ)		
5 Likert scale	1	0,14%
Observation		
evaluators observations		
unspecified	4	0,55%
on material recorded	1	0,14%
User Measurements		
Heart Rate Variability (HRV)	1	0,14%
Galvanic Skin Response (GSR)	1	0,14%
Interviews		
structured		
based on SIE's ease of use	1	0,14%
interaction	**47**	**6,45%**
Observation		
evaluators observations	19	2,61%
unspecified	13	1,78%
on material recorded	6	0,82%
evaluators coded/structured observations		
on material recorded	9	1,23%
unspecified	3	0,41%
User Action Logging		
evaluators count/measure		
on material recorded	4	0,55%
system logs	1	0,14%
tracking logs	1	0,14%
evaluators timing		
on material recorded	1	0,14%

Questionnaire		
custom-made		
7 Likert scale	2	0,27%
Unspecified	1	0,14%
adapted from previous/similar research		
Emotional intensity: Measurement and theoretical implications by Bachorowski & Braaten (1994) - 1 to 5 scale	2	0,27%
Questionnaire for User Interface and Satisfaction (QUIS)		
7 Likert	1	0,14%
presence questionnaire		
by Witmer and Singer (1998) - 7 Likert	1	0,14%
Experts Review / Evaluation		
Tasks analysis	1	0,14%
User Measurements	**1**	**0,14%**
eye tracking	1	0,14%
Mixed background questions	**3**	**0,41%**
Questionnaire		
custom-made		
closed ended question/s	2	0,27%
Unspecified	1	0,14%
N/D	**1**	**0,14%**
Questionnaire		
custom-made		
Unspecified	1	0,14%
other	**1**	**0,14%**
Experts Review / Evaluation		
Tasks analysis	1	0,14%
Perception/Cognition	**198**	**27,16%**
Question-answer-Protocol	**66**	**9,05%**
open response (during evaluation)	45	6,17%
closed response (during evaluation)	17	2,33%
Virtual element finding / matching	4	0,55%
Questionnaire	**62**	**8,50%**
custom-made		
7 Likert scale	14	1,92%
open ended question/s	7	0,96%
5 Likert scale	7	0,96%
-3 to +3 scale	5	0,69%
closed ended question/s	4	0,55%
1 to 5 scale	4	0,55%
10 Likert scale	3	0,41%

order items	1	0,14%
Unspecified	1	0,14%
11 Likert scale	1	0,14%
1 to 7 scale	1	0,14%
presence questionnaire		
IPQ version -3 to +3 scale	4	0,55%
by Witmer and Singer (1998) - 7 Likert	1	0,14%
Questionnaire for User Interface and Satisfaction (QUIS)		
7 Likert	3	0,41%
Simulator Sickness Questionnaire (SSQ)		
5 Likert scale	2	0,27%
illusion evaluation questionnaire by Pusch, Martin, and Coquillart		
1 to 7 scale	2	0,27%
adapted from previous/similar research		
Some Advantages of Video Conferencing Over High-quality Audio Conferencing: Fluency and Awareness of Attentional Focus. By Daly-Jones et al. (10.1006/ijhc.1998.0195) - 1 to 7 scale with polar terms	1	0,14%
ITU-R BT - Methodology for the Subjective Assessment of the Quality of Television Pictures		
1 to 5 scale	1	0,14%
User Action Logging		
evaluators count/measure		
unspecified	19	2,61%
on material recorded	1	0,14%
system logs	18	2,47%
evaluators timing	15	2,06%
tracking logs	7	0,96%
User Measurements		
eye accommodation	2	0,27%
gait tracking		
Force plate balance	1	0,14%
Electromyography (EMG)	1	0,14%
grasping / press force	1	0,14%
Heart Rate Variability (HRV)	1	0,14%
Electroencephalography (EEG)	1	0,14%
eye tracking	1	0,14%
Interviews	**1**	**0,14%**
structured	1	0,14%
Observation	**1**	**0,14%**
evaluators observations	1	0,14%

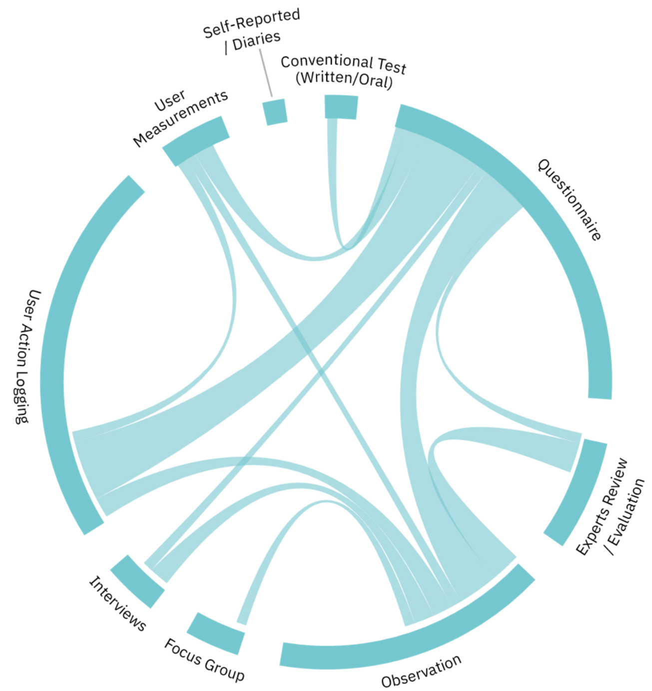
Prototype focus	**48**	**6,58%**
Interviews		
unstructured	12	1,65%
unstructured post-experiment discussion	4	0,55%
semi-structured	4	0,55%
structured		
open ended question/s	2	0,27%
based on SIE’s ease of use	1	0,14%
custom-made		
-3 to +3 scale	1	0,14%
Questionnaire		
custom-made		
open ended question/s	5	0,69%
7 Likert scale	3	0,41%
order items	2	0,27%
open comments	2	0,27%
1 to 10 scale	1	0,14%
5 Likert scale	1	0,14%
Observation		
evaluators observations	6	0,82%
Experts Review / Evaluation	**2**	**0,27%**
Tasks analysis	1	0,14%
Experts Interview	1	0,14%
Think aloud / Shadowing	**1**	**0,14%**
Think aloud on prototype	1	0,14%
Task performance	**89**	**12,21%**
User Action Logging		
system logs	39	5,35%
tracking logs	36	4,94%
evaluators timing	8	1,10%
unspecified	6	0,82%
on material recorded	2	0,27%
evaluators count/measure	5	0,69%
on material recorded	3	0,41%
unspecified	2	0,27%
User Measurements	**1**	**0,14%**
Electroencephalography (EEG)	1	0,14%

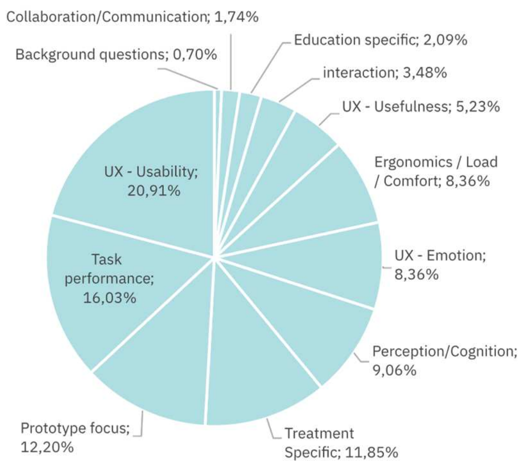
UX - Emotion	**22**	**3,02%**
Questionnaire		
custom-made		
7 Likert scale	7	0,96%
opposed adjective Likert 5 scale	3	0,41%
5 Likert scale	1	0,14%
9 Likert scale	1	0,14%
Simulator Sickness Questionnaire (SSQ)		
5 Likert scale	1	0,14%
Observation		
evaluators coded/structured observations		
on material recorded	2	0,27%
unspecified	1	0,14%
evaluators observations		
unspecified	2	0,27%
Interviews		
structured		
based on SIE’s ease of use	1	0,14%
7 Likert scale	1	0,14%
unstructured post-experiment discussion	1	0,14%
semi-structured	1	0,14%
UX - Meaning		
Questionnaire		
custom-made		
5 Likert scale	1	0,14%
opposed adjective Likert 5 scale	1	0,14%
7 Likert scale	1	0,14%
Interviews		
unstructured post-experiment discussion	1	0,14%
UX - Usability		
Questionnaire		
custom-made		
7 Likert scale	63	8,64%
5 Likert scale	20	2,74%
order items	19	2,61%
1 to 5 scale	7	0,96%
1 to 7 scale	6	0,82%
closed response multi-item	4	0,55%
Unspecified	4	0,55%
10 Likert scale	3	0,41%
9 Likert scale	3	0,41%

-3 to +3 scale	3	0,41%
1 to 10 scale	2	0,27%
balanced scale: -2 -1 +1 +2	2	0,27%
open comments	1	0,14%
opposed adjective Likert 5 scale	1	0,14%
3 Separate Propositions (Not Acceptable/Acceptable/Excellent)	1	0,14%
closed ended question/s	1	0,14%
10 Likert scale polar terms	1	0,14%
7 Likert polar terms scale	1	0,14%
adapted from previous/similar research		
Assessing dimensions of perceived visual aesthetics of web sites by Lavie and Tractinsky (2004) - 1 to 5 scale	4	0,55%
Some Advantages of Video Conferencing Over High-quality Audio Conferencing: Fluency and Awareness of Attentional Focus. By Daly-Jones et al. (10.1006/ijhc.1998.0195) - 1 to 7 scale with polar terms	3	0,41%
ISO 9241	4	0,55%
part 9 - 2000(E)		
NASA TLX		
100 scale	1	0,14%
RTLX version (Raw)- 100 scale	1	0,14%
7 Likert	1	0,14%
Simulator Sickness Questionnaire (SSQ)		
5 Likert scale	1	0,14%
Interviews		
structured	11	1,51%
7 Likert scale	4	0,55%
based on SIE’s ease of use	3	0,41%
rank items	2	0,27%
unspecified	2	0,27%
unstructured	5	0,69%
unstructured post-experiment discussion	2	0,27%
semi-structured	2	0,27%
User Action Logging		
system logs	1	0,14%
Question-answer-Protocol		
open response (during evaluation)	1	0,14%

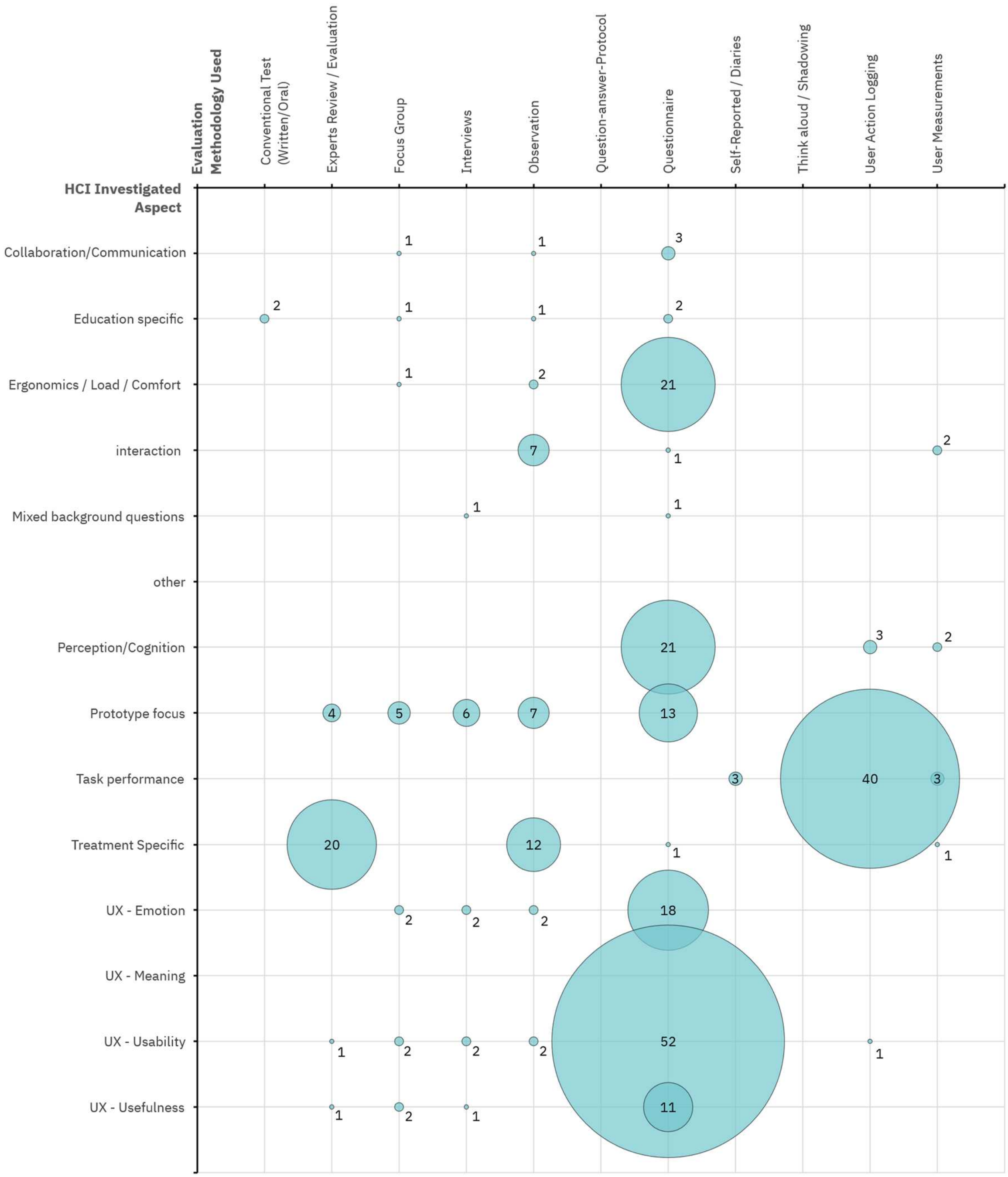
UX - Usefulness	**15**	**2,06%**
Questionnaire		
custom-made		
7 Likert scale	6	0,82%
closed response multi-item	2	0,27%
5 Likert scale	2	0,27%
9 Likert scale	1	0,14%
1 to 7 scale	1	0,14%
Interviews		
semi-structured	1	0,14%
unstructured	1	0,14%
structured		
7 Likert scale	1	0,14%

Section B - Correlation charts
Health Care & Medicine





Section C - Method Used & Aspects Matrix
Health Care & Medicine



Section D – Lookup Table: Health Care & Medicine

Collaboration/Communication	**5**	**1,74%**
Questionnaire		
custom-made		
6 Likert	2	0,70%
5 Likert with proxy users	1	0,35%
Focus Group		
Pre focus group	1	0,35%
Observation		
evaluators coded/structured observations		
on material recorded	1	0,35%
Education specific	**6**	**2,09%**
Conventional Test (Written/Oral)		
test with evaluation given by teacher (PRE + POST evaluation)	2	0,70%
Questionnaire		
custom-made		
graded questions	2	0,70%
Focus Group		
Pre focus group	1	0,35%
Observation		
evaluators observations	1	0,35%
Ergonomics / Load / Comfort	**24**	**8,36%**
Questionnaire		
NASA TLX		
7 Likert	5	1,74%
100 scale	4	1,39%
custom-made		
1 to 10 scale	2	0,70%
open ended question/s	1	0,35%
6 Likert	1	0,35%
Profile of Mood States questionnaire (POMS)	4	1,39%
Intrinsic Motivation Inventory (IMI)	2	0,70%
5 Likert scale		
Usability Satisfaction Questionnaires		
7 Likert	1	0,35%
System Usability Scale (SUS)		
5 Likert scale	1	0,35%

Observation		
evaluators observations	2	0,70%
Focus Group	**1**	**0,35%**
Pre focus group	1	0,35%
interaction	**10**	**3,48%**
Observation	**7**	**2,44%**
evaluators observations		
on material recorded	2	0,70%
evaluators coded/structured observations		
on material recorded	3	1,05%
User Measurements		
eye tracking	2	0,70%
Questionnaire		
custom-made		
5 Likert scale	1	0,35%
Mixed background questions	**2**	**0,70%**
Interviews		
with proxy users		
semi-structured	1	0,35%
Questionnaire		
custom-made		
closed ended question/s	1	0,35%
Perception/Cognition	**26**	**9,06%**
Questionnaire		
custom-made		
5 Likert scale	10	3,48%
6 Likert	2	0,70%
1 to 100 scale	1	0,35%
presence questionnaire		
by Slater et al. (1994) - 1 to 7 scale	6	2,09%
Treatment / Rehabilitation specific Questionnaire		
base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	2	0,70%
User Action Logging		
tracking logs	2	0,70%
system logs	1	0,35%
User Measurements	**2**	**0,70%**
grasping / press force	1	0,35%
eye tracking	1	0,35%

Prototype focus	**35**	**12,20%**
Questionnaire		
custom-made		
open ended question/s	5	1,74%
1 to 10 scale	3	1,05%
5 Likert with proxy users	2	0,70%
5 Likert scale	1	0,35%
6 Likert	1	0,35%
AttrakDiff		
Second Version	1	0,35%
Observation		
evaluators observations	6	2,09%
evaluators coded/structured observations		
on material recorded	1	0,35%
Interviews		
semi-structured	3	1,05%
unstructured post-experiment discussion	2	0,70%
with proxy users		
semi-structured	1	0,35%
Focus Group		
Post-test focus group	3	1,05%
workshop with students	1	0,35%
Pre focus group	1	0,35%
Experts Review / Evaluation		
Experts Interview	3	1,05%
Cognitive Walkthrough	1	0,35%

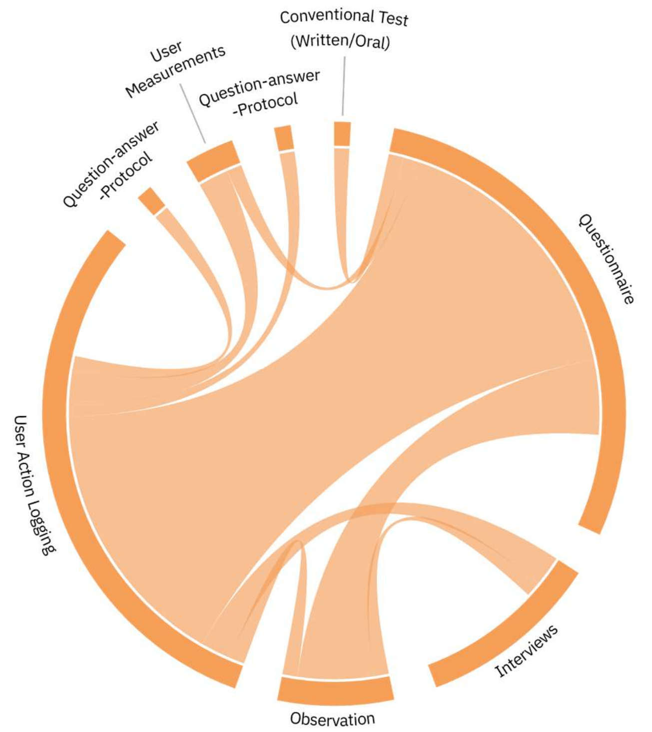
Task performance	**46**	**16,03%**
User Action Logging		
tracking logs	34	11,85%
system logs	6	2,09%
Self-Reported / Diaries	**3**	**1,05%**
Self-reported data / Diaries	3	1,05%
User Measurements	**3**	**1,05%**
Electromyography (EMG)	2	0,70%
eye tracking	1	0,35%

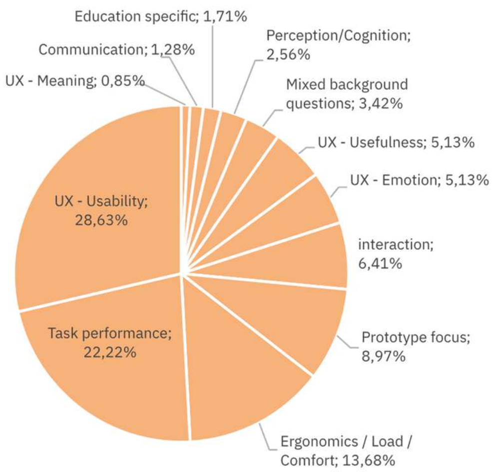
Treatment Specific	**34**	**11,85%**
Experts Review / Evaluation		
Treatment / Rehabilitation specific tests Experts Evaluation		
Anxiety Disorders Interview Schedule (ADIS-IV)	4	1,39%
Subjective units of discomfort scale (SUDS) (1 to 10 scale) (pre and post therapy)	4	1,39%
modified The Fear of Spiders Questionnaire (8 Likert) (pre and post therapy)	2	0,70%
Presence and reality judgment (open ended) (pre and post therapy)	2	0,70%
Spider Phobia Beliefs Questionnaire (SPBQ) (1 to 100 scale) (pre and post therapy)	2	0,70%
Target Behaviors (adapted from Marks & Mathew 1979) (1 to 10 scale) (pre and post therapy)	2	0,70%
Measures regarding expectations and-satisfaction with the treatment (1 to 7 scale) (pre and post therapy)	1	0,35%
Degree of belief in catastrophic thoughts (1 to 100 scale) (pre and post therapy)	1	0,35%
unspecified	1	0,35%
Fear and avoidance scales (1 to 10 scale) (pre and post therapy)	1	0,35%
Observation		
Treatment / Rehabilitation specific tests Experts Evaluation		
Behavior Avoidance Test (Bat) (pre and post therapy)	4	1,39%
Standard functional tests (box & blocks, Rancho)	1	0,35%
Wolf Motor Arm Test (pre/post-test)	1	0,35%
Berg Balance Scale (BBS)	1	0,35%
The Fugl-Meyer Upper Extremity Motor Performance Section Test (pre/post-test)	1	0,35%
clinical measurements on motor rehabilitation	1	0,35%
Working Alliance Inventory (WAI)	1	0,35%
Objective Structured Assessment Technical Skills (OSATS) (1 to 5 scale)	1	0,35%
short Falls Efficacy Scale-International (FES-I)	1	0,35%
User Measurements		
gait tracking		
GAITRite system	1	0,35%
Questionnaire		
Treatment / Rehabilitation specific Questionnaire		
DASH questionnaire (pre/post-test)	1	0,35%
UX - Emotion	**24**	**8,36%**
Questionnaire		
custom-made		
6 Likert	6	2,09%
5 Likert with proxy users	3	1,05%
1 to 10 scale	1	0,35%
5 Likert scale	1	0,35%
Treatment / Rehabilitation specific Questionnaire		
base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	4	1,39%

AttrakDiff		
Second Version	2	0,70%
Intrinsic Motivation Inventory (IMI)		
5 Likert scale	1	0,35%
Interviews		
unstructured post-experiment discussion	1	0,35%
structured		
7 Likert scale	1	0,35%
Focus Group		
Post test focus group	2	0,70%
Observation		
evaluators observations	1	0,35%
evaluators coded/structured observations		
on material recorded	1	0,35%
UX - Usability	**60**	**20,91%**
Questionnaire		
custom-made		
5 Likert scale	12	4,18%
6 Likert	9	3,14%
1 to 5 scale	6	2,09%
open ended question/s	3	1,05%
1 to 10 scale	2	0,70%
Usability Satisfaction Questionnaires		
7 Likert	6	2,09%
Treatment / Rehabilitation specific Questionnaire		
base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	6	2,09%
System Usability Scale (SUS)		
5 Likert scale	4	1,39%
NASA TLX		
7 Likert	1	0,35%
100 scale	1	0,35%
Intrinsic Motivation Inventory (IMI)		
5 Likert scale	1	0,35%
AttrakDiff		
Second Version	1	0,35%
Interviews		
with proxy users		
semi-structured	1	0,35%

structured		
7 Likert scale	1	0,35%
Focus Group		
Pre focus group	1	0,35%
Post test focus group	1	0,35%
Observation		
evaluators observations	2	0,70%
Experts Review / Evaluation		
Experts Interview	1	0,35%
User Action Logging		
system logs	1	0,35%
UX - Usefulness	**15**	**5,23%**
Questionnaire		
custom-made		
5 Likert scale	6	2,09%
6 Likert	2	0,70%
5 Likert with proxy users	1	0,35%
System Usability Scale (SUS)		
5 Likert scale	2	0,70%
Focus Group		
Pre focus group	1	0,35%
Post test focus group	1	0,35%
Experts Review / Evaluation		
Experts Interview	1	0,35%
Interviews		
with proxy users		
semi-structured	1	0,35%

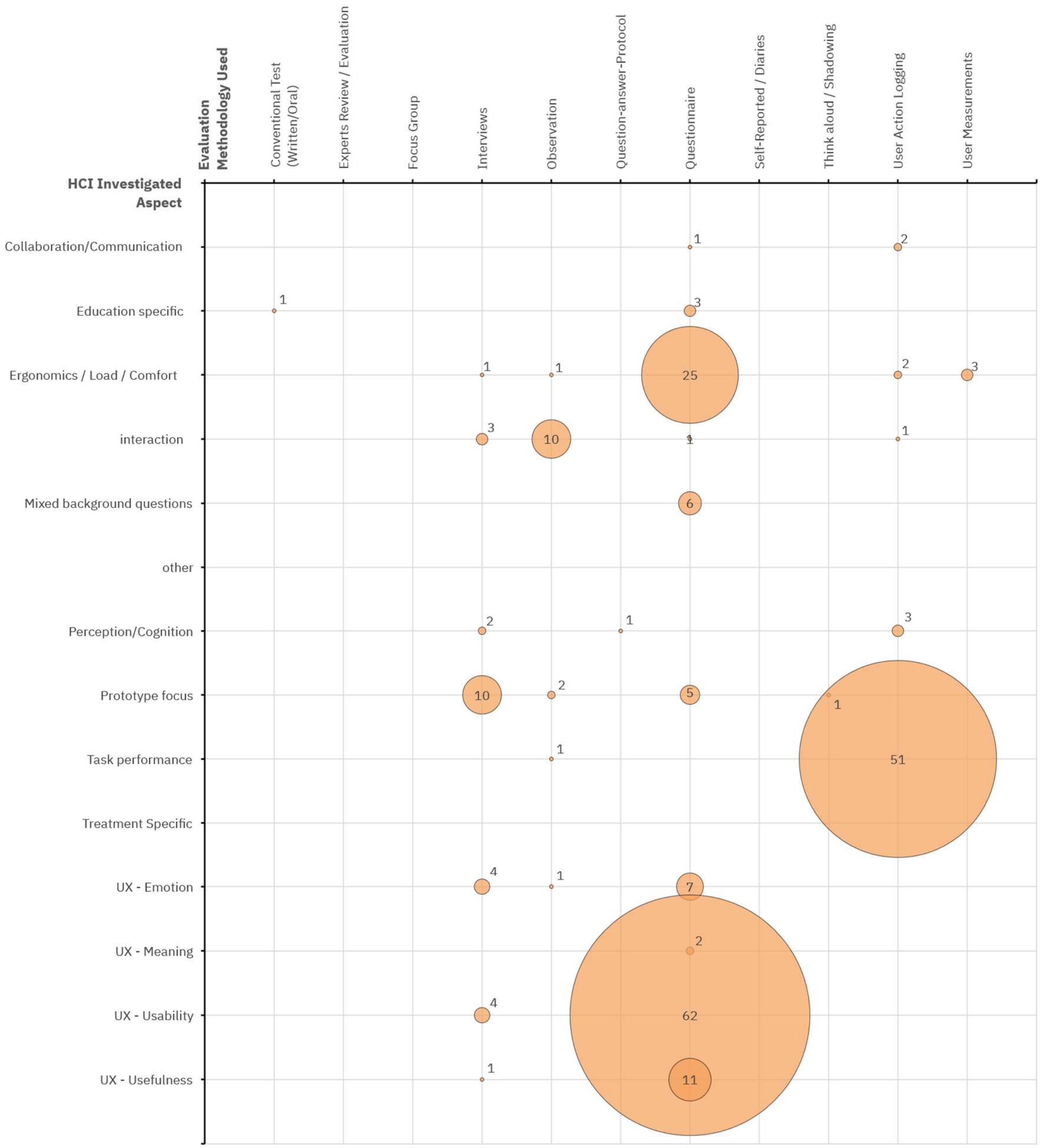
Section B - Correlation charts
Industry





Section C - Method Used & Aspects Matrix Industry

Section D – Lookup Table: Industry



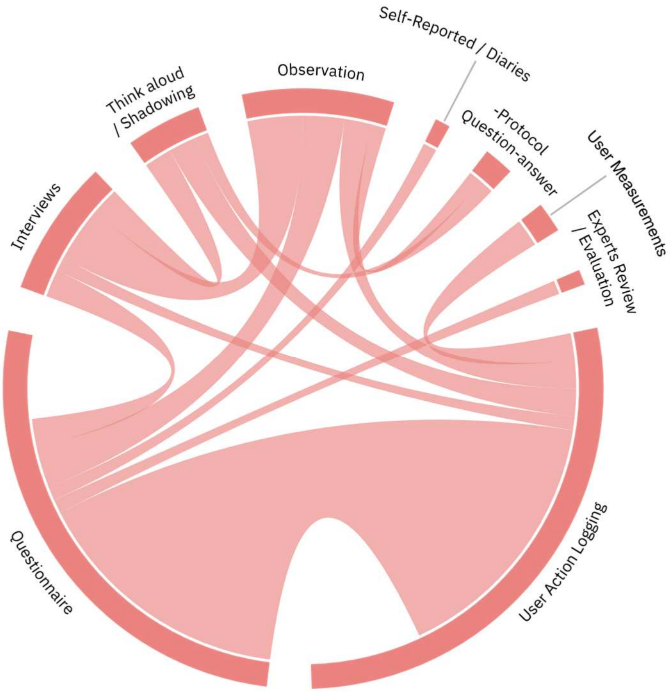
Collaboration/Communication	**3**	**1,28%**
User Action Logging		
evaluators count/measure	2	0,85%
Questionnaire		
custom-made		
1 to 7 scale	1	0,43%
Education specific	**4**	**1,71%**
Questionnaire		
custom-made		
graded questions	2	0,85%
5 Likert scale	1	0,43%
Conventional Test (Written/Oral)		
test with evaluation give by teacher (Control + Experiment groups)	1	0,43%
Ergonomics / Load / Comfort	**32**	**13,68%**
Questionnaire		
custom-made		
7 Likert scale	6	2,56%
order items	1	0,43%
9 Likert scale	1	0,43%
10 Likert scale polar terms	1	0,43%
1 to 5 scale	1	0,43%
5 Likert scale	1	0,43%
NASA TLX		
100 scale	7	2,99%
Cornell Musculoskeletal Discomfort Questionnaires (CMDQ)	3	1,28%
Sensitivity scale questionnaire by Detlev von Zerssen	2	0,85%
EZ-Scale	2	0,85%
User Measurements		
Heart Rate Variability (HRV)	3	1,28%
User Action Logging		
tracking logs	2	0,85%
Interviews		
structured		
8 Likert scale	1	0,43%
Observation		
evaluators observations	1	0,43%
interaction	**15**	**6,41%**
Observation		
evaluators observations		

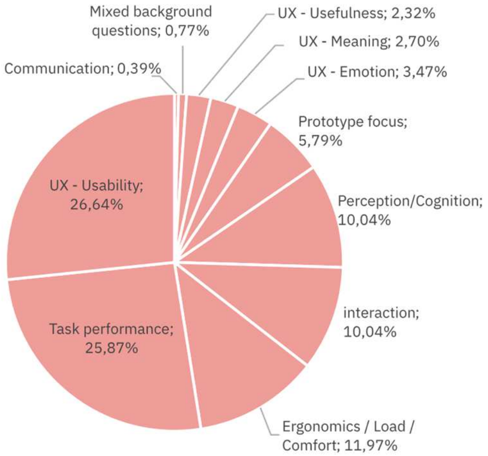
unspecified	8	3,42%
on material recorded	2	0,85%
Interviews		
semi-structured	1	0,43%
unstructured	1	0,43%
structured		
6 Likert scale	1	0,43%
User Action Logging		
tracking logs	1	0,43%
Questionnaire		
custom-made		
9 Likert scale	1	0,43%
Mixed background questions	**6**	**3,42%**
Questionnaire		
custom-made		
5 Likert scale	2	0,85%
1 to 7 scale	2	0,85%
closed ended question/s	1	0,43%
1 to 5 scale	1	0,43%
Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	2	0,85%
Perception/Cognition		
User Action Logging		
evaluators count/measure	1	0,43%
tracking logs	1	0,43%
evaluators timing	1	0,43%
Interviews		
structured		
9 Likert scale	1	0,43%
7 Likert scale	1	0,43%
Question-answer-Protocol		
closed response (during evaluation)	1	0,43%
Prototype focus		
Interviews		
semi-structured		
open ended question/s	2	0,85%
unstructured post-experiment discussion	3	1,28%
unstructured	2	0,85%
structured		

6 Likert scale	1	0,43%
Questionnaire		
custom-made		
open ended question/s	4	1,71%
open comments	1	0,43%
Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	3	1,28%
Observation		
comments collection during test	2	0,85%
Think aloud / Shadowing		
Think aloud on task	1	0,43%
Task performance	**52**	**22,22%**
User Action Logging	**51**	**21,79%**
tracking logs	16	6,84%
evaluators count/measure		
unspecified	11	4,70%
on material recorded	2	0,85%
evaluators timing		
unspecified	10	4,27%
on material recorded	2	0,85%
system logs	10	4,27%
Observation		
evaluators observations		
on material recorded	1	0,43%
UX - Emotion	**12**	**5,13%**
Questionnaire		
custom-made		
10 Likert scale polar terms	3	1,28%
open ended question/s	1	0,43%
7 Likert scale	1	0,43%
1 to 5 scale	1	0,43%
5 Likert scale	1	0,43%
Interviews		
unstructured post-experiment discussion	4	1,71%
Observation	**1**	**0,43%**
evaluators observations	1	0,43%
UX - Meaning	**2**	**0,85%**
Questionnaire		
custom-made		

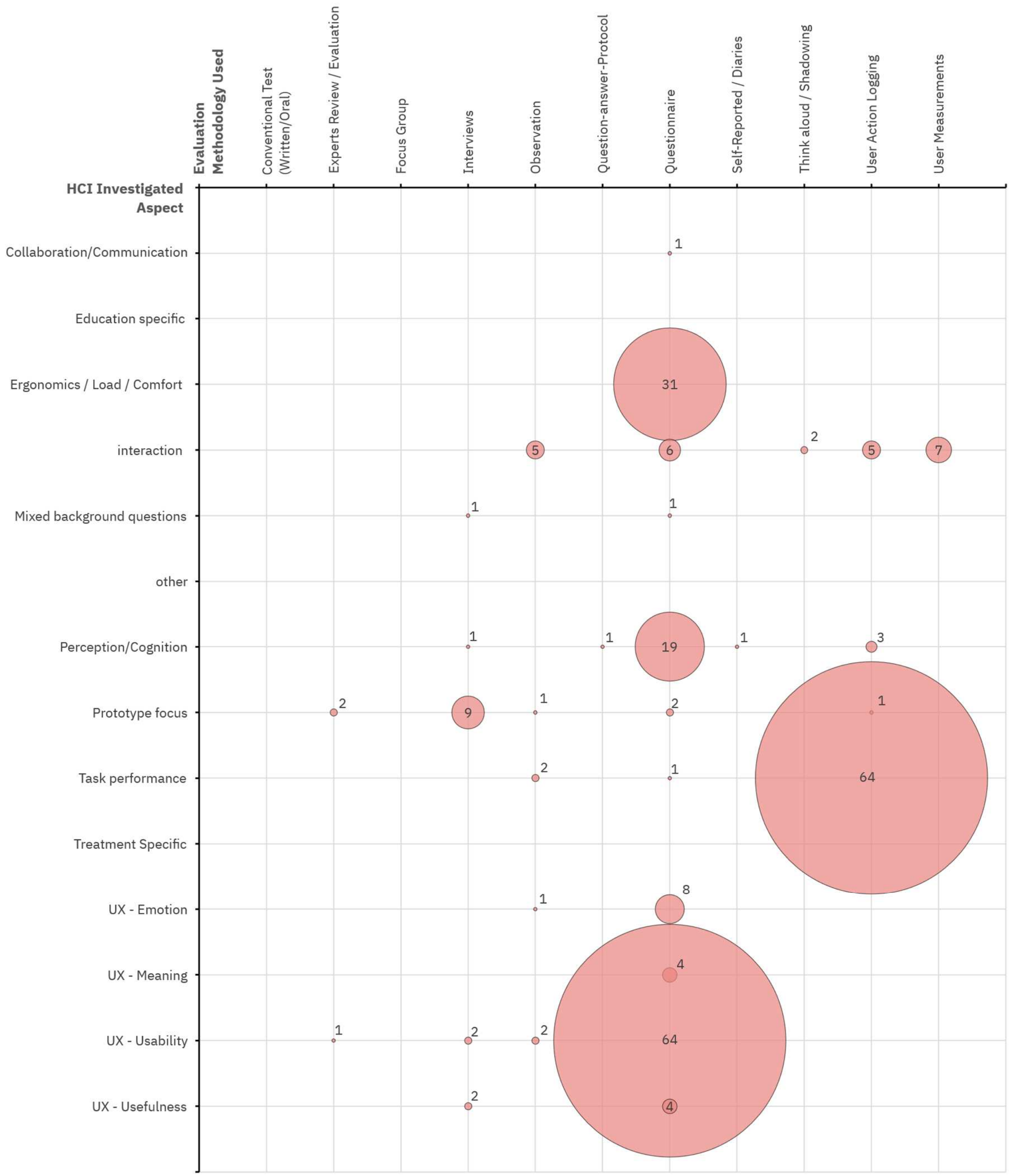
5 Likert scale	2	0,85%
UX - Usability	**66**	**28,63%**
Questionnaire		
custom-made		
5 Likert scale	27	11,54%
7 Likert scale	7	2,99%
9 Likert scale	6	2,56%
order items	4	1,71%
open ended question/s	3	1,28%
10 Likert scale polar terms	2	0,85%
1 to 5 scale	2	0,85%
1 to 7 scale	1	0,43%
6 Likert scale	1	0,43%
Perceived Usefulness Perceive Ease of Use (PUEU)	5	2,14%
Post-Study System Usability Questionnaire (PSSUQ)		
7 Likert scale	2	0,85%
Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	1	0,43%
After-Scenario Questionnaire (ASQ)		
7 Likert scale	1	0,43%
NASA TLX		
100 scale	1	0,43%
Interviews		
structured		
5 Likert scale	1	0,43%
10 Likert scale	1	0,43%
unstructured post-experiment discussion	1	0,43%
semi-structured	1	0,43%
UX - Usefulness	**12**	**5,13%**
Questionnaire		
custom-made		
5 Likert scale	4	1,71%
7 Likert scale	2	0,85%
1 to 5 scale	2	0,85%
1 to 7 scale	2	0,85%
Perceived Usefulness Perceive Ease of Use (PUEU)	1	0,43%
Interviews	**1**	**0,43%**
semi-structured	1	0,43%
-	1	0,43%

Section B - Correlation charts
Navigation & Driving





Section C - Method Used & Aspects Matrix
Navigation & Driving



Section D – Lookup Table: Navigation & Driving

Collaboration/Communication	**1**	**0,39%**
Questionnaire		
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	1	0,39%
Ergonomics / Load / Comfort	**31**	**11,97%**
Questionnaire		
NASA TLX		
100 scale	11	4,25%
unweighted	3	1,16%
custom-made		
5 Likert scale	5	1,93%
1 to 5 scale	1	0,39%
1 to 6 scale	1	0,39%
ISO 9241		
part 9 - with only one Fatigue category (7 Likert)	5	1,93%
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	2	0,77%
System Usability Scale (SUS)		
7 Likert scale	1	0,39%
Short Feedback Questionnaire (SFQ)		
5 Likert scale	1	0,39%
Rating Scale for Mental Effort (RSME)		
-	1	0,39%
interaction	**25**	**10,04%**
Questionnaire		
custom-made		
-3 to +3 scale	4	1,54%
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	2	0,77%
Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	1	0,39%
User Measurements	**7**	**2,70%**
eye tracking	7	2,70%
Observation		
evaluators observations	4	1,54%

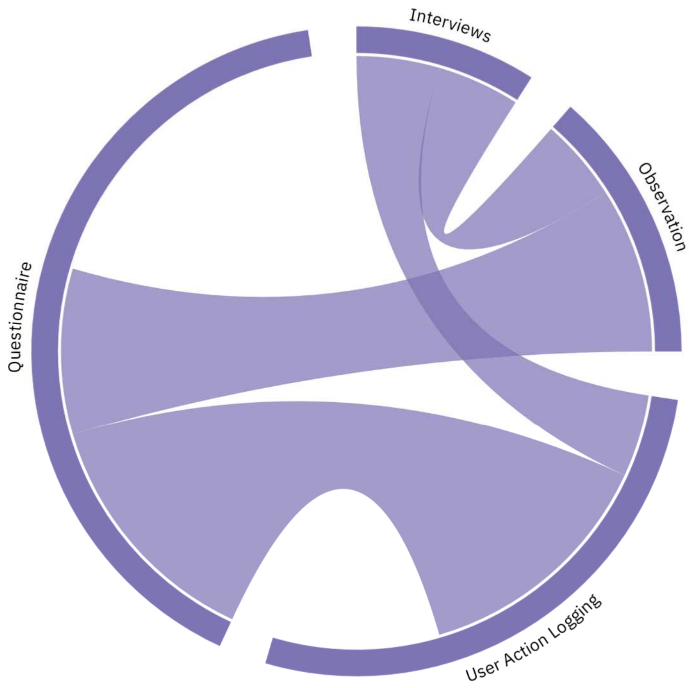
evaluators coded/structured observations		
on material recorded	1	0,39%
User Action Logging		
tracking logs	5	1,93%
Think aloud / Shadowing		
Think aloud on prototype	1	0,39%
Shadowing	1	0,39%
Mixed background questions	**2**	**0,77%**
Interviews	**1**	**0,39%**
semi-structured	1	0,39%
Questionnaire		
Technical self-efficacy (TSE) Questionnaire	1	0,39%
Perception/Cognition	**25**	**10,04%**
Questionnaire		
custom-made		
5 Likert scale	5	1,93%
closed ended question/s	3	1,16%
7 Likert scale	2	0,77%
-3 to +3 scale	2	0,77%
6 Likert	1	0,39%
presence questionnaire		
by Witmer and Singer (1998) - 7 Likert	6	2,32%
Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	1	0,39%
User Action Logging		
tracking logs	3	1,16%
Self-Reported / Diaries		
Factor-Referenced Cognitive Tests (Paperfolding test)	1	0,39%
Interviews		
structured		
1 to 6 scale	1	0,39%
Question-answer-Protocol		
closed response (during evaluation)	1	0,39%

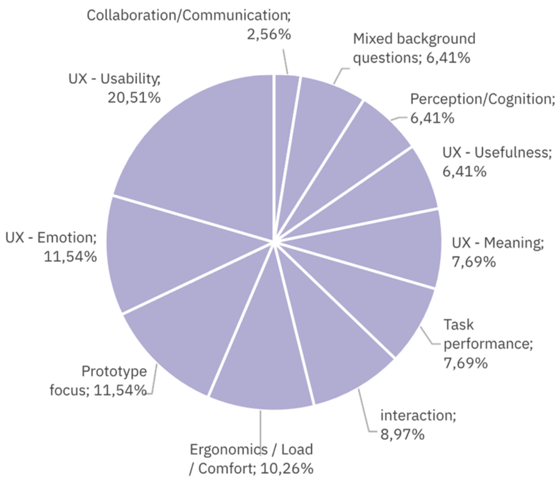
Prototype focus	**15**	**5,79%**
Interviews		
semi-structured		
open ended question/s	3	1,16%
unspecified	2	0,77%
unstructured	3	1,16%
unstructured post-experiment discussion	1	0,39%
Experts Review / Evaluation		
Experts Interview	2	0,77%
Questionnaire		
custom-made		
open ended question/s	1	0,39%
closed ended question/s	1	0,39%
User Action Logging		
tracking logs	1	0,39%
Observation		
evaluators observations	1	0,39%
Task performance	**67**	**25,87%**
User Action Logging		
system logs	39	15,06%
tracking logs	24	9,27%
evaluators count/measure		
on material recorded	1	0,39%
Observation		
evaluators observations	1	0,39%
evaluators coded/structured observations	1	0,39%
Questionnaire		
custom-made		
-3 to +3 scale	1	0,39%
UX - Emotion	**9**	**3,47%**
Questionnaire		
custom-made		
1 to 6 scale	2	0,77%
6 Likert	1	0,39%
order items	1	0,39%
5 Likert scale	1	0,39%
Software Usability Measurement Inventory (SUMI)		
1 to 3 scale	2	0,77%

Short Feedback Questionnaire (SFQ)		
5 Likert scale	1	0,39%
Observation		
evaluators observations	1	0,39%
UX - Meaning	**4**	**2,70%**
Questionnaire	**4**	**2,70%**
Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	2	1,16%
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	2	0,77%
custom-made		
6 Likert	2	0,77%
UX - Usability	**69**	**26,64%**
Questionnaire		
custom-made		
5 Likert scale	9	3,47%
7 Likert scale	6	2,32%
-3 to +3 scale	5	1,93%
6 Likert	5	1,93%
1 to 5 scale	4	1,54%
1 to 6 scale	4	1,54%
order items	3	1,16%
closed response multi-item	3	1,16%
Software Usability Measurement Inventory (SUMI)		
1 to 3 scale	10	3,86%
System Usability Scale (SUS)		
7 Likert scale	4	1,54%
Short Feedback Questionnaire (SFQ)		
5 Likert scale	3	1,16%
ISO 9241		
part 9 - with only one Fatigue category (7 Likert)	3	1,16%
NASA TLX		
100 scale	2	0,77%
presence questionnaire		
by Witmer and Singer (1998) - 7 Likert	2	0,77%
Unified Theory of Acceptance and Use of Technology (UTAUT2)		
7 Likert scale	1	0,39%

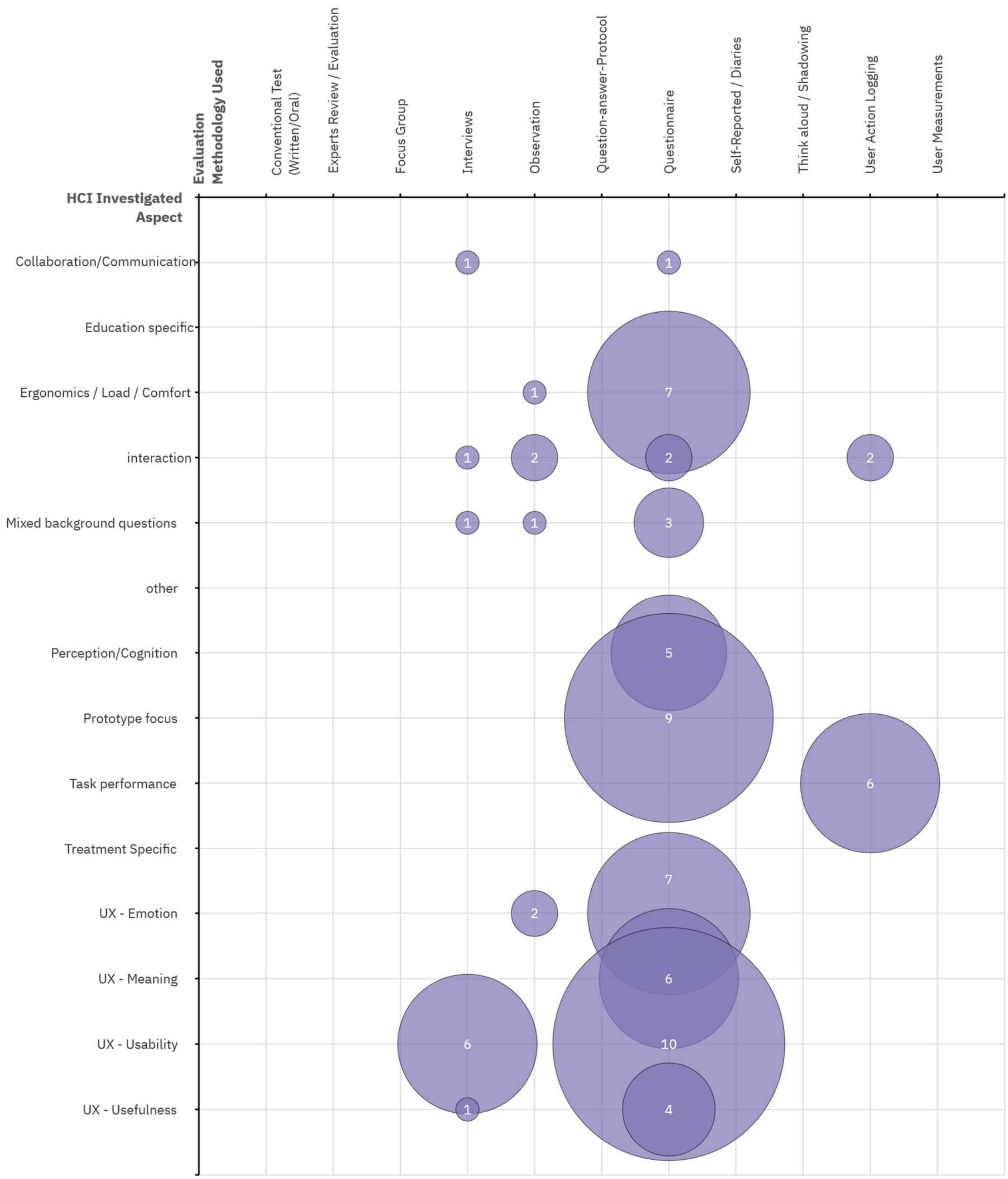
Interviews		
unstructured	1	0,39%
structured		
2 to 6 scale	1	0,39%
Observation		
evaluators observations	2	0,77%
Experts Review / Evaluation		
Experts Interview	1	0,39%
UX - Usefulness	**6**	**2,32%**
Questionnaire		
custom-made		
6 Likert	2	0,77%
-3 to +3 scale	1	0,39%
System Usability Scale (SUS)		
7 Likert scale	1	0,39%
Interviews		
unstructured	2	0,77%

Section B - Correlation charts
Other





Section C - Method Used & Aspects Matrix
Other



Section D – Lookup Table: Other

Collaboration/Communication	**2**	**2,56%**
Interviews		
semi-structured	1	1,28%
Questionnaire		
remote survey		
online survey - Likert 7 scale	1	1,28%
Ergonomics / Load / Comfort	**8**	**10,26%**
Questionnaire		
NASA TLX		
modify Likert	5	6,41%
custom-made		
7 Likert scale	2	2,56%
Observation		
evaluators observations	1	1,28%
interaction	**7**	**8,97%**
User Action Logging		
tracking logs	2	2,56%
Observation		
evaluators observations	2	2,56%
on material recorded	1	1,28%
Questionnaire		
remote survey		
online survey - polar choice	1	1,28%
custom-made		
7 Likert scale	1	1,28%
Interviews		
semi-structured	1	1,28%
Mixed background questions	**5**	**6,41%**
Questionnaire		
remote survey		
online survey - closed ended question/s	2	2,56%
online survey - 7 Likert scale	1	1,28%
Interviews		
semi-structured	1	1,28%
Observation		
evaluators observations	1	1,28%

Perception/Cognition	**5**	**6,41%**
Questionnaire		
custom-made		
7 Likert scale	4	5,13%
remote survey		
online survey - Likert 7 scale	1	1,28%
Prototype focus	**9**	**11,54%**
Questionnaire		
remote survey		
online survey - 7 Likert scale	3	3,85%
online survey - Likert 7 scale	3	3,85%
online survey - open ended question/s	2	2,56%
online survey - open / closed ended question/s	1	1,28%
Task performance	**6**	**7,69%**
User Action Logging	**6**	**7,69%**
tracking logs	4	5,13%
evaluators count/measure		
on material recorded	2	2,56%
UX - Emotion	**9**	**11,54%**
Questionnaire	**7**	**8,97%**
remote survey		
online survey - Likert 7 scale	3	3,85%
online survey - open / closed ended question/s	1	1,28%
custom-made		
Unspecified	1	1,28%
7 Likert scale	1	1,28%
Intrinsic Motivation Inventory (IMI)		
5 Likert scale	1	1,28%
Observation		
evaluators observations	1	1,28%
evaluators coded/structured observations	1	1,28%
UX - Meaning	**6**	**7,69%**
Questionnaire		
AttrakDiff		
First Version - 5 item bipolar scale	3	3,85%
remote survey		
online survey - Likert 7 scale	1	1,28%
online survey - 7 Likert scale	1	1,28%
custom-made: un-specificized	1	1,28%

UX - Usability	**16**	**20,51%**
Questionnaire		
custom-made		
1 to 5 scale	3	3,85%
7 Likert scale	2	2,56%
Unspecified	1	1,28%
remote survey		
online survey - 7 Likert scale	1	1,28%
online survey - open / closed ended question/s	1	1,28%
online survey - Likert 7 scale	1	1,28%
NASA TLX		
modify Likert	1	1,28%
Interviews		
semi-structured	6	7,69%
UX - Usefulness	**5**	**6,41%**
Questionnaire	**4**	**5,13%**
remote survey		
online survey - Likert 7 scale	2	2,56%
online survey - 7 Likert scale	1	1,28%
Intrinsic Motivation Inventory (IMI)		
5 Likert scale	1	1,28%
Interviews		
semi-structured	1	1,28%

APPENDIX - **B**

Table of papers analysis

Table Of Contents Appendix – B

Papers reference index ____ 2
Technologies used in studies____ 30
Domain/Field focus and Studies Design____ 19
Evaluation methodologies and main HCI aspects investigated ______________________________ 25

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
1	10.1109/ISMAR.2005.31	Experimental Evaluation of an Augmented Reality Visualization for Directing a Car Driver's Attention.	Tönnis, Sando, Lange, Bubb	Bai_and_Blackwell_ (2012)	2005	
2	10.1109/ISMAR.2007.4538831	Visual Longitudinal and Lateral Driving Assistance in the Head-Up Display of Cars	Tönnis, Lange, Klinker	Bai_and_Blackwell_ (2012)	2007	
3	10.1109/ISMAR.2006.297789	Effective Control of a Car Driver's Attention for Visual and Acoustic Guidance Towards the Direction of Imminent Dangers	Tönnis, Klinker	Bai_and_Blackwell_ (2012)	2006	
4	10.1109/ISMAR.2009.5336486	Evaluating the benefits of augmented reality for task localization in maintenance of an armored personnel carrier turret	Feiner, Henderson	Bai_and_Blackwell_ (2012)	2009	
5	10.1109/ISMAR.2009.5336484	Pick-by-Vision: A First Stress Test	Bjoern et all	Bai_and_Blackwell_ (2012)	2009	
6	10.1109/ISMAR.2006.297803	Interactive laser-projection for programming industrial robots	Michael, ZähWolfgang	Bai_and_Blackwell_ (2012)	2006	
7	10.1109/ISMAR.2008.4637331	Supporting order picking with Augmented Reality	Björn, Klinker	Bai_and_Blackwell_ (2012)	2008	
8	10.1109/ISMAR.2007.4538836	Laparoscopic Virtual Mirror for Understanding Vessel Structure Evaluation Study by Twelve Surgeons	Bichlmeier, Heining, Rustaee, Nassir	Bai_and_Blackwell_ (2012)	2007	
9	10.1109/ISMAR.2010.5643555	Evaluation of the Virtual Mirror as a Navigational Aid for Augmented Reality Driven Minimally Invasive Procedures	Bichlmeier, Euler, Blum, Nassir	Bai_and_Blackwell_ (2012)	2010	
10	10.1109/ISMAR.2008.4637335	Collocated AAR: Augmenting After Action Review with Mixed Reality	Quarles, Samsun, Fischler et al.	Bai_and_Blackwell_ (2012)	2008	
11	10.1109/ISMAR.2004.34	Immersive Authoring of Tangible Augmented Reality Applications	Lee, Nelles, Kim	Bai_and_Blackwell_ (2012)	2004	
12	10.1109/ISMAR.2006.297790	User evaluations on form factors of tangible magic lenses	Oh, Hua	Bai_and_Blackwell_ (2012)	2004	
13	10.1109/ISMAR.2002.1115085	Alternative tools for tangible interaction: a usability evaluation	Fjeld, Schar, Signorello, Krueger	Bai_and_Blackwell_ (2012)	2002	
14	10.1109/ISMAR.2009.5336500	Interaction and Presentation Techniques for Shake Menus in Tangible Augmented Reality	White, Feng, Feiner	Bai_and_Blackwell_ (2012)	2009	
15	10.1109/ISMAR.2006.297807	Visualizing and navigating complex situated hypermedia in augmented and virtual reality	Guven, Feiner	Bai_and_Blackwell_ (2012)	2006	
16	10.1109/ISMAR.2010.5643554	Task support system by displaying instructional video onto AR workspace	Michihiko, Uematsu, Saito, Senda, Iketani	Bai_and_Blackwell_ (2012)	2010	
17	10.1109/ISMAR.2009.5336502	Continuous Natural User Interface: Reducing the Gap Between Real and Digital World	Nils, Stricker	Bai_and_Blackwell_ (2012)	2009	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
18	10.1109/ISMAR.2006.297791	Evaluation of three input techniques for selection and annotation of physical objects through an augmented reality view	Thomas et al.	Bai_and_Blackwell_ (2012)	2006	
19	10.1109/ISMAR.2003.1240699	Evaluation of calibration procedures for optical see-through head-mounted displays	Tang, Zhou, Owen	Bai_and_Blackwell_ (2012)	2003	
20	10.1109/ISMAR.2007.4538843	Hear-Through and Mic-Through Augmented Reality: Using Bone Conduction to Display Spatialized Audio	Lindeman, Noma, Gonçalves	Bai_and_Blackwell_ (2012)	2007	
21	10.1109/ISMAR.2007.4538847	A Two-by-Two Mixed Reality System That Merges Real and Virtual Worlds in Both Audio and Visual Senses	Higa, Nishiura, Kimura, Shibata, Tamura	Bai_and_Blackwell_ (2012)	2007	
22	10.1109/ISMAR.2008.4637321	An optical see-through head mounted display with addressable focal planes	Liu, Cheng, Hua	Bai_and_Blackwell_ (2012)	2008	
23	10.1109/ISMAR.2003.1240688	Resolving multiple occluded layers in augmented reality	Livingston, Swan, Gabbard, Brown, et all.	Bai_and_Blackwell_ (2012)	2003	
24	10.1109/ISMAR.2010.5643561	Effects of a retroreflective screen on depth perception in a head-mounted projection display	Zhang, Hua	Bai_and_Blackwell_ (2012)	2010	
25	10.1109/ISMAR.2002.1115091	Augmented-reality visualizations guided by cognition: Perceptual heuristics for combining visible and obscured information	Furmanski, Azuma, Daily	Bai_and_Blackwell_ (2012)	2002	
26	10.1109/ISMAR.2008.4637327	User evaluation of see-through vision for mobile outdoor augmented reality	Avery, Thomas, Piekarski	Bai_and_Blackwell_ (2012)	2008	
27	10.1109/ISMAR.2010.5643547	An Augmented Reality X-Ray system based on visual saliency	Sandor, Cunningham, Dey, Mattila	Bai_and_Blackwell_ (2012)	2010	
28	10.1109/ISMAR.2006.297788	Quantification of visual capabilities using augmented reality displays	Livingston	Bai_and_Blackwell_ (2012)	2006	
29	10.1109/ISMAR.2007.4538832	Evaluating Display Types for AR Selection and Annotation	Wither, DiVerdi, Hollerer	Bai_and_Blackwell_ (2012)	2007	
30	10.1109/ISMAR.2006.297810	A 2D-3D integrated interface for mobile robot control using omnidirectional images and 3D geometric	Saitoh, Machida, Kiyokawa, Takemura	Bai_and_Blackwell_ (2012)	2006	
31	10.1109/ISMAR.2007.4538844	Human-Centered Development of an AR Handheld Display	Grasset, Duenser, Billinghurst	Bai_and_Blackwell_ (2012)	2007	
32	10.1109/ISMAR.2010.5643544	The Effect of Out-of-focus Blur on Visual Discomfort When Using Stereo Displays	Blum, Wieczorek, Aichert, et all.	Bai_and_Blackwell_ (2012)	2010	
33	10.1109/ISMAR.2009.5336496	A user study towards understanding stereo perception in head-worn augmented reality displays	Livingston, Ai, Decker	Bai_and_Blackwell_ (2012)	2009	
34	10.1109/ISMAR.2003.1240696	An occlusion capable optical see-through head mount display for supporting co-located collaboration	Kiyokawa, Billinghurst, Campbell, Woods	Bai_and_Blackwell_ (2012)	2003	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
35	10.1109/ISMAR.2008.4637340	An information layout method for an optical see-through head mounted display focusing on the viewability	Tanaka, Kishino, Miyamae et all.	Bai_and_Blackwell_ (2012)	2008	
36	10.1109/ISMAR.2008.4637341	Label segregation by remapping stereoscopic depth in far-field augmented reality	Peterson, Axholt, Ellis	Bai_and_Blackwell_ (2012)	2008	
37	10.1109/ISMAR.2003.1240689	Evaluating label placement for augmented reality view management	Azuma, Furmanski	Bai_and_Blackwell_ (2012)	2003	
38	10.1109/ISMAR.2008.4637328	An Evaluation of Graphical Context when the Graphics are Outside of the task area	Robertson, Macintyre, Walker	Bai_and_Blackwell_ (2012)	2008	
39	10.1109/ISMAR.2007.4538833	An Evaluation of Graphical Context as a Means for Ameliorating the Effects of Registration Error	Robertson, MacIntyre	Bai_and_Blackwell_ (2012)	2007	
40	10.1109/ISMAR.2008.4637329	The effect of registration error on tracking distant augmented objects	Livingston, Ai	Bai_and_Blackwell_ (2012)	2008	
41	10.1109/ISMAR.2007.4538845	Dynamic Adaptation of Projected Imperceptible Codes	Grundhofer, Seeger, Hantsch, Bimber	Bai_and_Blackwell_ (2012)	2007	
42	10.1109/ISMAR.2003.1240691	Using augmented reality for visualizing complex graphs in three dimensions	Belcher, Billinghurst, Hayes, Stiles	Bai_and_Blackwell_ (2012)	2003	
43	10.1109/ISMAR.2003.1240690	The effects of shadow representation of virtual objects in augmented reality	Sugano, Kato, Tachibana	Bai_and_Blackwell_ (2012)	2003	
44	10.1109/ISMAR.2009.5336501	Influence of Visual and Haptic Delays on Stiffness Perception in Augmented Reality	Knoerlein, Di_Luca, Harders	Bai_and_Blackwell_ (2012)	2009	
45	10.1109/ISMAR.2010.5643560	Experiences with an AR evaluation test bed: Presence, performance, and physiological measurement	Gandy, Catrambone, Macintyre, et all.	Bai_and_Blackwell_ (2012)	2010	
46	10.1109/ISMAR.2005.30	Evaluation of mixed-space collaboration	Grasset, Lamb, Billinghurst	Bai_and_Blackwell_ (2012)	2005	
47	10.1109/ISMAR.2002.1115083	Communication Behaviors of Co-Located Users in Collaborative AR Interfaces	Kiyokawa, Billinghurst, Hayes, Gupta, Sannohe, Kato	Bai_and_Blackwell_ (2012)	2002	
48	10.1109/ISMAR.2005.29	Enhanced Eyes for Better Gaze-Awareness in Collaborative Mixed Reali	Tateno, Takemura, Ohta	Bai_and_Blackwell_ (2012)	2005	
49	10.1109/ISMAR.2006.297804	Photometric inconsistency on a mixed-reality face, Photometric inconsistency on a mixed-reality face	Takemura, Kitahara, Ohta	Bai_and_Blackwell_ (2012)	2006	
50	10.1109/ISMAR.2005.32	Face to face collaborative AR on mobile phones	Henrysson, Billinghurst, Ollila	Bai_and_Blackwell_ (2012)	2005	
51	10.1109/ISMAR.2009.5336522	Using AR to Support Cross-Organisational Collaboration in Dynamic Tasks	Nilsson, Johansson, Jönsson	Bai_and_Blackwell_ (2012)	2009	
52	10.1109/ISMAR.2010.5643559	The importance of eye-contact for collaboration in AR system	Prytz, Nilsson, Jönsson	Bai_and_Blackwell_ (2012)	2010	Same setting and experiment of 10.1109/ISMAR.2009.5336522 (ID 50)

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
53	10.1109/ISMAR.2004.23	Collaborative mixed reality visualization of an archaeological excavation	Benko, Ishak, Feiner	Bai_and_Blackwell_ (2012)	2004	
54	10.1109/ISMAR.2009.5336507	Interference Avoidance in Multi-User Hand-Held Augmented Reality	Oda, Feiner	Bai_and_Blackwell_ (2012)	2009	
55	\	\	\	Bai_and_Blackwell_ (2012)	\	Dupplicate in Bai and Blackwell survey (2012): A 2D-3D integrated interface for mobile robot control using omnidirectional images and 3D geometric models - Saitoh, Machida, Kiyokawa, Takemura (2006)
56	10.1109/ISMAR.2008.4637330	Mobile Augmented Reality in industrial applications: Approaches for solution of user-related issues	Tumler, Mecke, Schenk, Huckauf, Roggentin	Bai_and_Blackwell_ (2012)	2008	
57	10.1109/ISMAR.2007.4538826	AR-Jig: A Handheld Tangible User Interface for Modification of 3D Digital Form via 2D Physical Curve	Anabuki, Ishii	Bai_and_Blackwell_ (2012)	2007	
58	10.1109/ISMAR.2007.4538824	Visual Hints for Tangible Gestures in Augmented Reality	White, Lister, Feiner	Bai_and_Blackwell_ (2012)	2007	
59	10.1109/ISMAR.2008.4637322	Vesp'R: design and evaluation of a handheld AR device	Veas, Kruijff	Bai_and_Blackwell_ (2012)	2008	
60	10.1109/ISMAR.2010.5643566	Build your world and play in it: Interacting with surface particles on complex objects	Jones, Sodhi, Campbell, Garnett, Bailey	Bai_and_Blackwell_ (2012)	2010	
61	10.1109/ISMAR.2002.1115076	Fata Morgana - a presentation system for product design	Klinker, Dutoit, Bauer, Bayer, Novak, Matzke	Bai_and_Blackwell_ (2012)	2002	
62	10.1109/ISMAR.2005.5	A pipeline for rapidly incorporating real objects into a mixed environment	Wang, Kotranza, Quarles, Lok, Allen	Bai_and_Blackwell_ (2012)	2005	
63	10.1109/ISMAR.2009.5336485	Real-Time In-Situ Visual Feedback of Task Performance in Mixed Environments for Learning Joint Psychomotor-Cognitive Tasks	Kotranza, Lind, Pugh, Lok	Bai_and_Blackwell_ (2012)	2009	
64	10.1109/ISAR.2001.970539	Dynamic shader lamps : painting on movable objects	Bandyopadhyay, Raskar, Fuchs	Bai_and_Blackwell_ (2012)	2001	
65	10.1109/ISMAR.2008.4637332	Virtual redlining for civil engineering in real environments	Schall, Mendez, Schmalstieg	Bai_and_Blackwell_ (2012)	2008	
66	10.1109/ISMAR.2006.297800	A mobile markerless AR system for maintenance and repair	Platonov, Heibel, Meier, Grollmann	Bai_and_Blackwell_ (2012)	2006	
67	10.5555/850976.854986	The Use of Dense Stereo Range Data in Augmented Reality	Gordon, Billinghurst, Bell, Woodfill, Kowalik	Bai_and_Blackwell_ (2012)	2002	
68	10.1109/ISMAR.2008.4637334	An Augmented Reality museum guide	Miyashita, Meier, Tachikawa, Orlic, Eble, Scholz, Gapel, Gerl, Arnaudov, Lieberknecht	Bai_and_Blackwell_ (2012)	2008	
69	10.1109/ISMAR.2005.14	ARVino - Outdoor Augmented Reality Visualisation of Viticulture GIS Data	King, Piekarski, Thomas	Bai_and_Blackwell_ (2012)	2005	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
70	10.1109/ISMAR.2005.11	AR Karaoke: acting in your favorite scenes	Gandy, Macintyre, Presti, Dow, Bolter, Yarbrough, O'Rear	Bai_and_Blackwell_ (2012)	2005	
71	10.1109/ISMAR.2003.1240695	Herding Sheep: Live System Development for Distributed Augmented Reality	Macwilliams, Sandor, Wagner, Bauer, Klinker, Bruegge	Bai_and_Blackwell_ (2012)	2003	
72	10.1111/j.1365-2729.2009.00329.x	A context-aware ubiquitous learning environment for language listening and speaking	Liu	Lim_et_all_(2019)	2009	
73	10.1111/j.1467-8535.2012.01302.x	Using augmented-reality-based mobile learning material in EFL English composition: An exploratory case study	Liu, Tsai	Lim_et_all_(2019)	2012	
74	10.2196/jmir.2497	Effects of Mobile Augmented Reality Learning Compared to Textbook Learning on Medical Students: Randomized Controlled Pilot Study	Albrecht, Folta-Schoofs, nat, Behrends, hum, Jan	Lim_et_all_(2019)	2013	
75	10.1108/00220411311295342	Does place affect user engagement and understanding? Mobile learner perceptions on the streets of New York	Cocciolo, Rabina	Lim_et_all_(2019)	2013	
76	10.1007/s00779-011-0494-x	Expected user experience of mobile augmented reality services: a user study in the context of shopping centres	Olsson, Lagerstam, Kärkkäinen, Väänänen	Lim_et_all_(2019)	2011	
77	10.1109/TLT.2014.2312719	Augmenting Reality and Formality of Informal and Non-Formal Settings to Enhance Blended Learning	Pérez-Sanagustín, Hernández-Leo, Santos, Kloos, Blat	Lim_et_all_(2019)	2014	
78	10.1016/j.chb.2013.03.006	Relationship between student profile, tool use, participation, and academic performance with the use of Augmented Reality technology for visualized architecture models	Fonseca, Martí, Redondo, Navarro, Sánchez	Lim_et_all_(2019)	2013	
79	10.1016/j.eswa.2014.02.018	REENACT: A step forward in immersive learning about Human Historyby augmented reality, role playing and social networking	Blanco-Fernández, López-Nores, Pazos-Arias, Gil-Solla, Ramos-Cabrer, García-Duque	Lim_et_all_(2019)	2014	
80	10.1016/j.eswa.2013.09.016	Mobile augmented reality based context-aware library management system	Shatte, Holdsworth, Lee	Lim_et_all_(2019)	2014	
81	10.1109/MPRV.2014.19	Using Augmented Reality to Help Children with Autism Stay Focused	Escobedo, Tentori, Quintana, Favela, Garcia-Rosas	Lim_et_all_(2019)	2014	
82	10.1007/s10209-014-0362-3	Geo-located teaching using handheld augmented reality: good practices to improve the motivation and qualifications of architecture students	Riera, Redondo, Fonseca	Lim_et_all_(2019)	2014	
83	10.1109/TLT.2014.2370634	Supporting Teacher Orchestration in Ubiquitous Learning Environments: A Study in Primary Education	Muñoz-Cristóbal, Jorrín-Abellán, Asensio-Pérez, Martínez-Monés, Prieto	Lim_et_all_(2019)	2014	
84	10.1109/TE.2014.2379712	Augmented Reality-Based Simulators as Discovery Learning Tools: An Empirical Study	Ibáñez, Di-Serio, Villarán-Molina, Delgado-Kloos	Lim_et_all_(2019)	2015	
85	10.3916/C45-2015-07	Tecnología asistencial móvil, con realidad aumentada, para las personas mayores	Saracchini, Catalina-Ortega, Bordoni	Lim_et_all_(2019)	2015	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
85	10.3916/C45-2015-07	Tecnología asistencial móvil, con realidad aumentada, para las	Saracchini, Catalina-Ortega, Bordoni	Lim_et_all_(2019)		
86	10.1016/j.chb.2014.11.093	Augmented reality to promote collaborative and autonomous learning in higher education	Martín-Gutiérrez, Fabiani, Benesova, Meneses, Mora	Lim_et_all_(2019)	2015	
87	10.1016/j.pmcj.2014.08.009	Tourists responses to mobile augmented reality travel guides: The role of emotions on adoption behavior	Kourouthanassis, Boletsis, Bardaki, Chasanidou	Lim_et_all_(2019)	2015	
88	10.1109/TBME.2016.2560761	See It With Your Own Eyes: Markerless Mobile Augmented Reality for Radiation Awareness in the Hybrid Room	Rodas, Barrera, Padoy	Lim_et_all_(2019)	2016	
89	10.1109/TVCG.2015.2498612	Efficient Verification of Holograms Using Mobile Augmented Reality	Hartl, Arth, Grubert, Schmalstieg	Lim_et_all_(2019)	2015	
90	10.1109/RITA.2016.2518460	Virtual Heritage of the Territory: Design and Implementation of Educational Resources in Augmented Reality and Mobile Pedestrian Navigation	Nagata, Giner, Abad	Lim_et_all_(2019)	2016	
91	10.1109/TMM.2016.2639380	Privacy Preserving Cloth Try-On Using Mobile Augmented Reality	Sekhavat	Lim_et_all_(2019)	2017	
92	10.1016/j.jretconser.2017.05.011	Enhancing the online decision-making process by using augmented reality: A two country comparison of youth markets	Pantano, Rese, Baier	Lim_et_all_(2019)	2017	
93	10.1016/j.compedu.2017.02.009	Mixed-reality learning environments: Integrating mobile interfaces with laboratory test-beds	Frank, Kapila	Lim_et_all_(2019)	2017	
94	10.1016/j.techfore.2016.10.010	How augmented reality apps are accepted by consumers: A comparative analysis using scales and opinions	Resea, Baier, Geyer-Schulz, Schreiber	Lim_et_all_(2019)	2016	
95	10.1016/j.techfore.2016.09.032	Enabling smart retail settings via mobile augmented reality shopping apps	Dacko	Lim_et_all_(2019)	2016	
96	10.1016/j.eswa.2017.03.060	Markerless tracking system for augmented reality in the automotive industry	Lima, Roberto, Simões, Almeida, Figueiredo, Teixeira, Teichrieb	Lim_et_all_(2019)	2017	
97	10.1016/j.aei.2017.09.005	Mobile augmented reality for teaching structural analysis	Turkan, Radkowski, Karabulut-Ilgu, Behzadan, Chen	Lim_et_all_(2019)	2017	
98	10.1016/j.entcom.2017.05.001	LAGARTO: A LocAtion based Games AuthoRing TOol enhanced with augmented reality features	Maia, Nolêto, Lima, Ferreira, Marinho, Viana, Trinta	Lim_et_all_(2019)	2017	
99	10.1007/s11042-017-4810-y	The effect of tracking technique on the quality of user experience for augmented reality mobile navigation	Sekhavat, Parsons	Lim_et_all_(2019)	2018	
100	10.1007/s00542-017-3333-9	System satisfaction survey for the App to integrate search and augmented reality with geographical information technology	Chiu, Lee	Lim_et_all_(2019)	2018	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
101	10.1016/j.cag.2017.09.001	Combining traditional and indirect augmented reality for indoor crowded environments. A case study on the Casa Batlló museum	Cristina,Portalés, Coma, Fernández, Martínez	Lim_et_all_(2019)	2017	
102	10.1080/10447318.2017.1393974	Marker versus Markerless Augmented Reality. Which Has More Impact on Users?	Brito, Stoyanova	Lim_et_all_(2019)	2017	
103	10.1109/RITA.2017.2655179	Evaluation of the Use of Technology to Improve Safety in the Teaching Laboratory	Rogado, Quintana, Mayo	Lim_et_all_(2019)	2017	
104	10.1007/s10055-017-0319-y.pdf	Real-time adjustment of contrast saliency for improved information visibility in mobile augmented reality	Ahn, Lee, Kim	Lim_et_all_(2019)	2018	
105	10.1049/htl.2017.0064	Quantifying attention shifts in augmented reality image-guided neurosurgery	Léger, Drouin, Collins, Popa, Kersten-Oertel	Lim_et_all_(2019)	2017	
106	10.1016/j.autcon.2017.10.032	Integrating mobile Building Information Modelling and Augmented Reality systems: An experimental study	Chua, Matthews, Love	Lim_et_all_(2019)	2017	
107	10.1016/j.autcon.2018.02.020	Precision study on augmented reality-based visual guidance for facility management tasks	Liu, Seipel	Lim_et_all_(2019)	2018	
108	10.1016/j.chb.2017.12.003	The effects of aging on the use of handheld augmented reality in a route planning task	Peleg-Adler, Lanir, Korman	Lim_et_all_(2019)	2017	
109	10.1016/j.chb.2017.12.043	Determining visitor engagement through augmented reality at science festivals: An experience economy perspective	Diecka, Jung, Rauschnabelb	Lim_et_all_(2019)	2018	
110	10.1016/j.jretconser.2018.05.004	We ARe at home: How augmented reality reshapes mobile marketing and consumer-brand relationships	Scholz, Duffy	Lim_et_all_(2019)	2018	
111	10.1016/j.compenvurbsys.2018.05.003	The Urban CoBuilder – A mobile augmented reality tool for crowd-sourced simulation of emergent urban development patterns: Requirements, prototyping and assessment	Imottesjo, Kain	Lim_et_all_(2019)	2018	
112	10.1109/TVCG.2017.2676777	A Context-Aware Method for Authentically Simulating Outdoors Shadows for Mobile Augmented Reality	Barreira, Bessa, Barbosa, Magalhães	Lim_et_all_(2019)	2018	
113	10.1016/j.ijhcs.2018.01.009	Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum	Fenu, Pittarello	Lim_et_all_(2019)	2018	
114	10.1016/j.ijhcs.2018.01.010	Empirical study of the usability and interactivity of an augmented-reality dressing mirror	Chiu, Lee	Lim_et_all_(2019)	2018	
115	10.1016/j.pmcj.2018.03.004	Attitude estimation for indoor navigation and augmented reality with smartphones	Michel, Genevès, Fourati, Layaïdaa	Lim_et_all_(2019)	2018	
116	10.1109/RITA.2018.2831738	Experiences Using QR Codes for Improving the Teaching-Learning Process in Industrial Engineering Subjects	Torres-Jiménez, Rus-Casas, Dorado, Jiménez-Torres	Lim_et_all_(2019)	2018	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
117	10.1007/978-3-642-12349-8_3	QR Code and Augmented Reality-Supported Mobile English Learning System	Liu, Tan, Chu	Lim_et_all_(2019)	2008	
118	978-84-939814-7-1	Using augmented reality and education platform in architectural visualization: Evaluation of usability and student's level of sastisfaction	Fonseca, Martí, Redondo, Navarro, Sánchez	Lim_et_all_(2019)	2012	
119	10.1145/2390895.2390905	Developing an augmented reality application in the framework of architecture degree	Sánchez, Redondo, Fonseca	Lim_et_all_(2019)	2012	
120	10.1016/j.procs.2012.06.092	Service Oriented Architecture to Support Mexican Secondary Education through Mobile Augmented Reality	Santana-Mancilla, Garc'a-Ruiz, Acosta-Diaz, Juáreza	Lim_et_all_(2019)	2012	
121	10.5555/2675983.2676363	Technology-enhanced learning in construction education using mobile context-aware augmented reality visual simulation	Shirazi, Behzadan	Lim_et_all_(2019)	2013	
122	978-989-98434-0-0	Development of an interactive book with Augmented Reality for mobile learning	Tahira, Ribeir, Kitamura, Inoue, Ficheman	Lim_et_all_(2019)	2013	
123	10.1109/VS-GAMES.2013.6624233	How Does Usability Impact Motivation in Augmented Reality Serious Games for Education?	Perdomo, Rashed-Ali, Quarles	Lim_et_all_(2019)	2013	
124	10.1016/j.procs.2013.11.007	New Strategies Using Handheld Augmented Reality and Mobile Learning-teaching Methodologies, in Architecture and Building Engineering Degrees	Redondo, Fonseca, Sánchez, Navarro	Lim_et_all_(2019)	2013	
125	10.1109/SIIE.2014.7017714	Motivation assessment in engineering students using hybrid technologies for 3D visualization	Fonseca, Falip, Valls, Redondo, Climent, Vicent	Lim_et_all_(2019)	2014	
126	10.1109/FIE.2014.7044238	Academic performance assessment using Augmented Reality in engineering degree course	Sánchez, Redondo, Fonseca, Navarro	Lim_et_all_(2019)	2014	
127	10.1109/FIE.2014.7044209	Engineering teaching methods using hybrid technologies based on the motivation and assessment of student's profiles	Fonseca. Villagrasa. Vail, Redondo, Climent, Vicent	Lim_et_all_(2019)	2014	
128	10.1109/FIE.2014.7044138	Desktop vs. Mobile: A Comparative Study of Augmented Reality Systems for Engineering Visualizations in Education	Contero, Camba, Salvador-Herranz	Lim_et_all_(2019)	2014	
129	10.1016/j.procs.2014.08.180	Historical Oslo on a Handheld Device – A Mobile Augmented Reality Application	Chen	Lim_et_all_(2019)	2014	
130	10.1109/ICALT.2014.129	Mobile-Based AR Application Helps to Promote EFL Children's Vocabulary Study	He, Ren, Zhu, Cai, Chen	Lim_et_all_(2019)	2014	
131	10.1109/ICEBE.2015.55	Applying Augmented Reality Technology to Book Publication Business	Lai, Wong, Lo	Lim_et_all_(2019)	2015	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
132	10.1109/IE.2015.37	Mobile Augmented Reality as an Orientation Aid: A Scavenger Hunt Prototype	Roger, Frommel, Breier, Celik, Kramer, Kreidel, Brich, Riemer, Schrader	Lim_et_all_(2019)	2015	
133	10.1016/j.sbspro.2015.07.054	Utilising Mobile-Augmented Reality for Learning Human Anatomy	Jamali, Fairuz, Shiratuddin, Wong, Oskam	Lim_et_all_(2019)	2015	
134	10.1016/j.sbspro.2015.01.450	Students' Perception of Mobile Augmented Reality Applications in Learning Computer Organization	Majid, Mohammed, Sulaiman	Lim_et_all_(2019)	2015	
135	10.1109/LT.2016.7562858	The use of augmented reality enhanced flashcards for arabic vocabulary acquisition	Zainuddin, Idrus	Lim_et_all_(2019)	2016	
136	10.1109/EDUCON.2016.7474591	Impact of smart immersive mobile learning in language literacy education	Bazzaza, Alzubaidi, Zemerly, Weruga, Ng	Lim_et_all_(2019)	2016	
137	10.1109/EDUCON.2016.7474650	AIR-EDUTECH: Augmented Immersive Reality (AIR) Technology for High School Chemistry Education	Qassem, Hawai, AlShehhi, Zemerly, Ng	Lim_et_all_(2019)	2016	
138	10.1109/ISCMI.2017.8279616	Fruitify: Nutritionally augmenting fruits through markerless-based augmented reality	Kulpy, Bekaroo	Lim_et_all_(2019)	2017	
139	10.1109/ISMAR-Adjunct.2017.51	[POSTER] Walking in Augmented Reality: An Experimental Evaluation by Playing with a Virtual Hopscotch	Chessa, Solari	Lim_et_all_(2019)	2017	
140	10.1109/ICALT.2017.64	Science Education and Augmented Reality Content: The Case of the Water Circle	Bratitsis, Bardanika, Ioannou	Lim_et_all_(2019)	2017	
141	10.1109/ICOT.2017.8336106	User Interface Model for Indonesian Animal Apps to Kid using Augmented Reality	Selviany, Kaburuan, Junaedi	Lim_et_all_(2019)	2017	
142	10.1007/978-3-319-03161-3_11	GuideMe: A Mobile Augmented Reality System to Display User Manuals for Home Appliances	Müller, Aslan, Krüßen	Lim_et_all_(2019)	2013	
143	10.1007/978-3-319-40244-4_19	Design of a Mobile Augmented Reality Application: An Example of Demonstrated Usability	Tsai, Chang, Yu, Chen, Kuo, Wu	Lim_et_all_(2019)	2016	
144	10.1109/SVR.2012.4	AR-based Video-Mediated Communication: A Social Presence Enhancing Experience	Almeida, Oikawa, Carres, Miyazaki, Kato, Billinghurst	Billinghurst_et_all_(2018)	2012	
145	10.1145/1268517.1268552	Understanding the design space of referencing in collaborative augmented reality environments	Chastine, Nagel, Zhu, Yearsovich	Billinghurst_et_all_(2018)	2007	
146	10.1145/2371574.2371610	Integrating the physical environment into mobile remote collaboration	Gauglitz, Lee, Turk, Höllerer	Billinghurst_et_all_(2018)	2012	
147	10.1145/2459236.2459249	SEMarbeta: Mobile Sketch-Gesture-Video Remote Support for Car Drivers	Chen, Chen, Kunz, Yantac, Bergmark, Sundin, Fjeld	Billinghurst_et_all_(2018)	2013	
148	10.1145/2671015.2671016	In touch with the remote world: remote collaboration with augmented reality drawings and virtual navigation	Gauglitz, Nuernberger, Turk, Höllerer	Billinghurst_et_all_(2018)	2014	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
149	10.1145/2642918.2647372	World-stabilized annotations and virtual scene navigation for remote collaboration	Gauglitz, Nuernberger, Turk, Höllerer	Billinghurst_et_all_(2018)	2015	
150	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Evaluation of mixed-space collaboration - Grasset, Lamb, Billinghurst (2005)
151	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): “Face to face collaborative AR on mobile phones - Henrysson, Billinghurst, Ollila (2005)
152	10.1145/2582051.2582097	JackIn: integrating first-person view with out-of-body vision generation for human-human augmentation	Kasahara, Rekimoto	Billinghurst_et_all_(2018)	2014	
153	10.1145/2145204.2145394	As if being there: mediated reality for crime scene investigation	Poelman, Akman, Lukosch, Jonker	Billinghurst_et_all_(2018)	2012	
154	10.1145/2470654.2470679	BeThere: 3D mobile collaboration with spatial input	Sodhi, Jones, Forsyth, Bailey, Maciocci	Billinghurst_et_all_(2018)	2013	
155	10.1109/ICSMC.2009.5346691	Comparative effectiveness of Mixed Reality based virtual environments in collaborative design	Wang, Dunston	Billinghurst_et_all_(2018)	2009	
156	10.1515/ijdhd-2014-0327	Augmented reality improves myoelectric prosthesis training	Anderson, Bischof	Billinghurst_et_all_(2018)	2014	
157	10.1007/s00779-007-0187-7	Human factors and qualitative pedagogical evaluation of a mobile augmented reality system for science education used by learners with physical disabilities	Arvanitis, Petrou, Knight, Savas, Sotiriou, Gargalakos, Gialouri	Billinghurst_et_all_(2018)	2007	
158	10.1109/ICALT.2005.71	Augmented instructions - a fusion of augmented reality and printed learning materials	Asai, Kobayashi, Kondo	Billinghurst_et_all_(2018)	2005	
159	0949-149X/91	Using the Augmented Reality 3D Technique for a Convex Imaging Experiment in a Physics Course	Cai, Chiang, Wang	Billinghurst_et_all_(2018)	2013	
160	0949-149X/92	A case study of Augmented Reality simulation system application in a chemistry course	Cai, Wang, Chiang	Billinghurst_et_all_(2018)	2014	
161	10.1016/j.ridd.2013.06.026	An augmented reality (AR)-based vocational task prompting system for people with cognitive impairments	Chang, Kang, Huang	Billinghurst_et_all_(2018)	2013	
162	10.1016/j.compedu.2014.05.004	Students' online interactive patterns in augmented reality-based inquiry activities	Chiang, Yang, Hwang	Billinghurst_et_all_(2018)	2014	
163	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Lim et all (2019): Does place affect user engagement and understanding?: Mobile learner perceptions on the streets of New York - Cocciolo, Rabina (2013)

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
164	10.1145/2414536.2414554	Creating interactive physics education books with augmented reality	Duenser, Walker, Horner, Bentall	Billinghurst_et_all_(2018)	2012	
165	10.1007/s10209-014-0361-4	Mixed-methods research: a new approach to evaluating the motivation and satisfaction of university students using advanced visual technologies	Fonseca, Redondo, Falip	Billinghurst_et_all_(2018)	2014	
166	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Lim et all (2019): Relationship between student profile, tool use, participation, and academic performance with the use of Augmented Reality technology for visualized architecture models - Fonseca et. all (2014)
167	10.5555/1531826.1531834	SMART: a SysteM of Augmented Reality for Teaching 2nd grade students	Freitas, Campos	Billinghurst_et_all_(2018)	2008	
168	10.1016/j.compedu.2012.12.001	Evaluation of learning outcomes using an educational iPhone game vs. traditional game	Furió, González-Gancedo, Juan, Seguí, Rando	Billinghurst_et_all_(2018)	2013	
169	10.1109/SVR.2012.15	Guidance and Movement Correction Based on Therapeutics Movements for Motor Rehabilitation Support Systems	Gama, Chaves, Teichrieb	Billinghurst_et_all_(2018)	2012	
170	10.1016/j.websem.2005.05.004	Rules and ontologies in support of real-time ubiquitous application	Hatala, Wakkary, Kalantari	Billinghurst_et_all_(2018)	2005	
171	10.1016/j.autcon.2012.12.007	A study on the benefits of augmented reality in retaining working memory in assembly tasks: A focus on differences in gender	Hou, Wang	Billinghurst_et_all_(2018)	2013	
172	1SSN: 2152-2715	Can we combine learning with augmented reality physical activity?	Hsiao	Billinghurst_et_all_(2018)	2010	
173	10.1080/10494820.2010.486682	Learning while exercising for science education in augmented reality among adolescents	Hsiao, Chen, Huang	Billinghurst_et_all_(2018)	2010	
174	10.1145/1810543.1810572	Make a Riddle and TeleStory: Designing children's applications for the Siftables platform	Hunter, Kalanithi, Merrill	Billinghurst_et_all_(2018)	2010	
175	10.1016/j.compedu.2013.09.004	Experimenting with electromagnetism using augmented reality: Impact on flow student experience and educational effectiveness	Ibáñez, Di Serio,Villarán, Kloos	Billinghurst_et_all_(2018)	2013	
176	10.1109/RTCSA.2011.43	Augmented Reality Go: Extending Traditional Game Play with Interactive Self-Learning Support	Iwata, Yamabe, Nakajima	Billinghurst_et_all_(2018)	2011	
177	WSCG_2011	ARGreenet and BasicGreenet: Two mobile games for learning how to recycle	Juan, Furió, Alem, Ashworth, D 'estiu	Billinghurst_et_all_(2018)	2011	
178	978-80-86943-82-4	Using an Augmented Reality game to find matching pairs	Juan, Carrizo, Abad, Giménez	Billinghurst_et_all_(2018)	2011	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
179	Teachers College Record 112(10):2565-2602	From information to experience: Place-based augmented reality games as a model for learning in a globally networked society	Kurt	Billinghurst_et_all_(2018)	2010	
180	10.1109/ICALT.2011.100	Influences of AR-Supported Simulation on Learning Effectiveness in Face-to-face Collaborative Learning for Physics	Li, Gu, Chang, Duh	Billinghurst_et_all_(2018)	2011	
181	10.2312/LocalChapterEvents/TPCG/TPCGUK05/163-170	Augmented Reality Scenarios for Guitar Learning	Liarokapis	Billinghurst_et_all_(2018)	2005	
182	10.1016/j.compedu.2013.05.011	An investigation of learners' collaborative knowledge construction performances and behavior patterns in an augmented reality simulation system	Lin, Duh, Wang, Tsai	Billinghurst_et_all_(2018)	2013	
183	10.1504/IJTEL.2011.042102	Limitless or pointless? An evaluation of augmented reality technology in the school and home	Luckin, Fraser	Billinghurst_et_all_(2018)	2011	
184	10.22260/ISARC2011/0263	Generic user manual for maintenance of mountain bike brakes based on augmented reality	Martín-Gutierrez	Billinghurst_et_all_(2018)	2012	
185	10.1109/ICIS.2012.106	The Design and Implementation of Augmented Reality Learning Systems	Oh, Byun	Billinghurst_et_all_(2018)	2012	
186	10.1109/HICSS.2013.390	Manipulating Virtual Objects with Your Hands: A Case Study on Applying Desktop Augmented Reality at the Primary School	Salvador-Herran, Pérez-López, Ortega, Soto, Alcañiz, Contero	Billinghurst_et_all_(2018)	2013	
187	10.1109/ICALT.2013.45	Augmented Reality X-Ray Interaction in K-12 Education: Theory, Student Perception and Teacher Evaluation	Santos, Chen, Taketomi, Yamamoto, Miyazaki, Kato	Billinghurst_et_all_(2018)	2013	
188	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Lim_et_all_(2019): Mobile augmented reality based context-aware library managementsystem - Shatte, Holdsworth, Lee (2014)
189	10.1016/j.compedu.2014.07.013	Augmented reality in informal learning environments: A field experiment in a mathematics exhibition	Sommerauer, Müller	Billinghurst_et_all_(2018)	2014	
190	10.1109/ICCEA.2010.239	Preliminary Evaluation on User Acceptance of the Augmented Reality use for Education	Sumadio, Rohaya, Rambli	Billinghurst_et_all_(2018)	2010	
191	10.1145/2371574.2371627	A real-world study of an audio-tactile tourist guide	Szymczak, Rassmus-Gröhn, Magnusson, Hedvall	Billinghurst_et_all_(2018)	2012	
192	10.1109/ICDAR.2013.15	Wearable Reading Assist System: Augmented Reality Document Combining Document Retrieval and Eye Tracking	Toyama, Dengel, Suzuki, Kise	Billinghurst_et_all_(2018)	2013	
193	10.1145/2494091.2494113	P.I.A.N.O.: enhancing instrument learning via interactive projected augmentation	Weing, Röhlig, Rogers, Gugenheimer, Schaub, Könings, Rukzio, Weber	Billinghurst_et_all_(2018)	2013	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
194	10.1016/j.compedu.2013.02.014	Evaluation of learners' attitude toward learning in ARIES augmented reality environments	Wojciechowski, Cellary	Billinghurst_et_all_(2018)	2013	
195	10.1007/s11042-011-0979-7	Playful training with augmented reality games: case studies towards reality-oriented system design	Yamabe, Nakajima	Billinghurst_et_all_(2018)	2012	
196	10.1016/j.compedu.2014.01.002	The development and evaluation of an augmented reality-based armillary sphere for astronomical observation instruction	Zhang, Sung, Hou, Chang	Billinghurst_et_all_(2018)	2014	
197	10.1145/2501988.2502012	Imaginary reality gaming: ball games without a ball	Baudisch, Pohl, Reinicke, Wittmers, Lühne, Knaust, Köhler, Schmidt , Schmidt, Holz	Billinghurst_et_all_(2018)	2013	
198	10.1145/1240624.1240847	Presence and engagement in an interactive drama.	Dow, Mehta, Harmon, MacIntyre, Mateas	Billinghurst_et_all_(2018)	2007	
199	10.1145/2371574.2371609	Playing it Real: Magic Lens and Static Peephole Interfaces for Games in a Public Space	Grubert, Morrison, Munz, Reitmayr	Billinghurst_et_all_(2018)	2012	
200	10.1109/ISMAR.2012.6402563	Mobile augmented reality for cultural heritage: A technology acceptance study	Haugstvedt, Krogstie	Billinghurst_et_all_(2018)	2012	
201	10.1145/1753846.1754089	Designing a CD augmentation for mobile phones	Henze. Boll	Billinghurst_et_all_(2018)	2010	
202	10.1109/WETICE.2006.27	Curball--A Prototype Tangible Game for Inter-Generational Play	Kern, Stringer, Fitzpatrick, Schmidt	Billinghurst_et_all_(2018)	2006	
203	10.1145/1413634.1413718	Mobility and social interaction as core gameplay elements in multi-player augmented reality	Mulloni, Wagner, Schmalstieg	Billinghurst_et_all_(2018)	2008	
204	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Interference Avoidance in Multi-User Hand-Held Augmented Reality - Oda, Feiner (2009)
205	10.1145/1851600.1851654	Visualization of off-screen objects in mobile augmented reality	Schinke, Henze, Boll	Billinghurst_et_all_(2018)	2010	
206	10.1007/s00779-011-0459-0	Auditory display design for exploration in mobile audio-augmented	Vazquez-AlvarezI, Oakley, Brewster	Billinghurst_et_all_(2018)	2011	
207	10.1109/ISMAR-AMH.2010.5643295	The Westwood Experience: Connecting story to locations via Mixed Reality	Wither, Allen, Samanta, Hemanus, Tsai, Azuma, Carter, Hinman, Korah	Billinghurst_et_all_(2018)	2010	
208	10.1145/1501750.1501816	BragFish: Exploring physical and social interaction in co-located handheld augmented reality games	Xu, Gandy, Deen, Schrank, Spreen	Billinghurst_et_all_(2018)	2008	
209	ISSN 2342-9666	Chores Are Fun: Understanding Social Play in Board Games for Digital Tabletop Game Design	Xu, Barba, Radu, Gandy, Macintyre	Billinghurst_et_all_(2018)	2012	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
209	ISSN 2342-9666	Chores Are Fun: Understanding Social Play in Board Games for	Xu, Barba, Radu, Gandy, Macintyre	Billinghurst_et_all_(2018)		
210	10.1109/TSMCA.2006.886376	The Role of 3-D Sound in Human Reaction and Performance in Augmented Reality Environments	Zhou, Cheok, Qiu, Yang	Billinghurst_et_all_(2018)	2007	
211	10.1145/2071536.2071538	Smart-phone augmented reality for public participation in urban planning	Allen, Regenbrecht, Abbott	Billinghurst_et_all_(2018)	2011	
212	10.1016/j.compind.2012.11.010	Mixed prototyping with configurable physical archetype for usability evaluation of product interfaces	Barbieri, Angilica, Bruno, Muzzupappa	Billinghurst_et_all_(2018)	2013	
213	10.1007/s10055-011-0206-x	In-Situ interactive image-based model building for Augmented Reality from a handheld device	Bunnun, Subramanian, Mayol-Cuevas	Billinghurst_et_all_(2018)	2013	
214	10.1162/PRES_a_00146	Augmented Reality Text Style Readability with See-Through Head-Mounted Displays in Industrial Context	Fiorentino, Debernardis , E. Uva , Monno	Billinghurst_et_all_(2018)	2013	
215	10.1016/j.compind.2013.11.004	Augmented reality on large screen for interactive maintenance instructions	Fiorentino, Debernardis , E. Uva , Monno	Billinghurst_et_all_(2018)	2014	
216	10.1080/10494820.2013.815221	Evaluating virtual reality and augmented reality training for industrial maintenance and assembly tasks	Gavish,Gutiérrez, Webel, Rodríguez, Peveri, Bockholt, Tecchia	Billinghurst_et_all_(2018)	2013	
217	10.1145/1543137.1543153	Augmented assembly using a mobile phone	Billinghurst, Hakkarainen, Woodward	Billinghurst_et_all_(2018)	2008	
218	978-1-4799-2869-9	Mobile interactive hologram verification	Hartl, Grubert, Schmalstieg, Reitmayr	Billinghurst_et_all_(2018)	2013	
219	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Evaluating the Benefits of Augmented Reality for Task Localization in Maintenance of an Armored Personnel Carrier Turret - Henderson, Feiner (2009)
220	10.1109/TVCG.2009.91	Opportunistic Tangible User Interfaces for Augmented Reality	Henderson, Feiner	Billinghurst_et_all_(2018)	2010	
221	10.1109/TVCG.2010.245	Exploring the benefits of augmented reality documentation for maintenance and repair	Henderson, Feiner	Billinghurst_et_all_(2018)	2011	
222	10.1109/ISMAR.2011.6092386	Augmented reality in the psychomotor phase of a procedural task	S. Henderson; Feiner	Billinghurst_et_all_(2018)	2011	
223	10.1016/j.autcon.2012.09.002	InfoSPOT: A mobile Augmented Reality method for accessing building information through a situation awareness approach	Irizarry, Gheisari, Williams, Walker	Billinghurst_et_all_(2018)	2012	
224	10.1145/2148131.2148190	Situated modeling: a shape-stamping interface with tangible primitives	Lau, Hirose, Ohgawara, Mitani, Igarashi	Billinghurst_et_all_(2018)	2012	
225	10.1145/1868914.1869017	Pointing for non-visual orientation and navigation	Magnusson, Molina, Rassmus-Gröhn, Szymczak	Billinghurst_et_all_(2018)	2010	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
226	10.1145/2407516.2407583	Evaluation of 3D selection tasks in parabolic flight conditions: pointing task in augmented reality user interfaces	Markov-Vetter, Moll, Staadt	Billinghurst_et_all_(2018)	2012	
227	10.1109/ISMAR.2013.6671762	Improving procedural task performance with Augmented Reality annotations	Marner, Irlitti, Thomas	Billinghurst_et_all_(2018)	2013	
228	10.5555/1690508.1690533	User expectations for mobile mixed reality services: an initial user study	Olsson, Ihamäki, Lagerstam, Ventä-Olkkonen, Väänänen	Billinghurst_et_all_(2018)	2009	
229	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Continuous Natural User Interface: Reducing the Gap Between Real and Digital World - Didier, Stricker (2009)
230	10.1145/1152215.1152245	A novel interface to sensor networks using handheld augmented reality	Rauhala, Gunnarsson, Henrysson	Billinghurst_et_all_(2018)	2006	
231	10.1007/s00371-009-0348-y	Pick-by-vision: augmented reality supported order picking	Reif, Günthner	Billinghurst_et_all_(2018)	2009	
232	10.1145/1864349.1864391	Augmenting on-screen instructions with micro-projected guides: when it works, and when it fails	Rosenthal, Kane, Wobbrock, Avrahami	Billinghurst_et_all_(2018)	2010	
233	10.1007/s00779-012-0599-x	Smart Vidente: advances in mobile augmented reality for interactive visualization of underground infrastructure	Schall, Zollmann, Reitmayr	Billinghurst_et_all_(2018)	2012	
234	10.1109/VR.2008.4480755	Augmented Reality for Industrial Building Acceptance	Schönfelder, Schmalstieg	Billinghurst_et_all_(2018)	2008	
235	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Pick-by-Vision: A First Stress Test - Bjoern et al. (2009)
236	10.1007/10055-011-0187-9	Pick-by-vision: there is something to pick at the end of the augmented tunnel	Schwerdtfeger, Reif, Günthner, Klinker	Billinghurst_et_all_(2018)	2011	
237	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Mobile Augmented Reality in Industrial Applications: Approaches for Solution of User-Related Issues - Tumler (2008)
238	10.1016/j.apergo.2012.11.008	Innovative system for real-time ergonomic feedback in industrial manufacturing	Vignais, Miezal, Bleser, Mura, Gorecky, Marin	Billinghurst_et_all_(2018)	2013	
239	10.1061/(ASCE)CP.1943-5487.0000156.	On-Site Building Information Retrieval by Using Projection-Based Augmented Reality	Yeh, Tsai, Kang	Billinghurst_et_all_(2018)	2012	
240	10.1080/00207540600972935	Augmented reality for assembly guidance using a virtual interactive tool	Yuan, Ong, Nee	Billinghurst_et_all_(2018)	2006	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
241	10.1007/s10055-010-0183-5	An augmented reality interface to contextual information	Ajanki, Billinghurst, Gamper, Järvenpää, Kandemir, Kaski, Koskela, Kurimo, Laaksonen, Puolamäki, Ruokolainen, Tossavainen	Billinghurst_et_all_(2018)	2010	
242	10.1109/VR.2011.5759432	Parameter estimation variance of the single point active alignment method in optical see-through head mounted display calibration	Axholt, Cooper, Skoglund, Ellis, O'Connell, Ynnerman	Billinghurst_et_all_(2018)	2011	
243	10.1145/2425836.2425864	Freeze view touch and finger gesture based interaction methods for handheld augmented reality interfaces	Bai, Lee, Billinghurst	Billinghurst_et_all_(2018)	2012	
244	10.1145/2543651.2543678	Markerless 3D gesture-based interaction for handheld augmented reality interfaces	Bai, Gao, El-Sana, Billinghurst	Billinghurst_et_all_(2018)	2013	
245	10.1145/2559206.2581371	Using 3D hand gestures and touch input for wearable AR interaction	Bai, Lee, Billinghurst	Billinghurst_et_all_(2018)	2014	
246	10.1109/ISMAR.2012.6402557	A hand-held AR magic lens with user-perspective rendering	Baričević, Lee, Turk, Höllerer, Bowman	Billinghurst_et_all_(2018)	2012	
247	10.1109/3DUI.2007.340778	Balloon Selection: A Multi-Finger Technique for Accurate Low-Fatigue 3D Selection	Benko, Feiner	Billinghurst_et_all_(2018)	2007	
248	10.1145/2642918.2647402	Dyadic projected spatial augmented reality	Benko, Wilson, Zannier	Billinghurst_et_all_(2018)	2014	
249	10.1145/1753326.1753671	Touch projector: Mobile interaction through video	Boring, Baur, Butz, Gustafson, Baudisch	Billinghurst_et_all_(2018)	2010	
250	10.1007/s00779-011-0502-1	Usability of one-handed interaction methods for handheld projection-based augmented reality	Choi, Kim	Billinghurst_et_all_(2018)	2012	
251	10.1145/1978942.1979342	Multi-user interaction on media facades through live video on mobile devices	Boring, Gehring, Wiethoff, Blöckner, Schöning, Butz	Billinghurst_et_all_(2018)	2011	
252	10.1145/2449396.2449435	Real-time hand interaction for augmented reality on mobile phones	Chun, Höllerer	Billinghurst_et_all_(2018)	2013	
253	10.1145/2491367.2491370	Free-hands interaction in augmented reality	Datc, Lukosch	Billinghurst_et_all_(2018)	2013	
254	10.1145/2556288.2557352	In situ with bystanders of augmented reality glasses: perspectives on recording and privacy-mediating technologies	Denning, Dehlawi, Kohno	Billinghurst_et_all_(2018)	2014	
255	10.1145/1647314.1647368	Mediated attention with multimodal augmented reality	Dierker, Mertes, Hermann, Hanheide, Sagerer	Billinghurst_et_all_(2018)	2009	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
256	10.1145/1851600.1851629	Zooming interfaces for augmented reality browsers	Mulloni, Dünser, Schmalstieg	Billinghurst_et_all_(2018)	2010	
257	10.1109/ISMAR.2012.6402555	Image-driven view management for augmented reality browsers	Grasset, Langlotz, Kalkofen, Tatzgern, Salzburg, Schmalstieg	Billinghurst_et_all_(2018)	2012	
258	10.1145/2380116.2380167	DuploTrack: a real-time system for authoring and guiding duplo block assembly	Gupta, Fox, Curless, Cohen	Billinghurst_et_all_(2018)	2012	
259	10.1007/s11042-011-0983-y.pdf	Gesture-based interaction via finger tracking for mobile augmented reality	Hürst, Wezel	Billinghurst_et_all_(2018)	2013	
260	10.1109/3DUI.2010.5444713	An empirical evaluation of virtual hand techniques for 3D object manipulation in a tangible augmented reality environment	Ha, Woo	Billinghurst_et_all_(2018)	2010	
261	10.1145/1450579.1450625	Opportunistic controls: leveraging natural affordances as tangible user interfaces for augmented reality	Henderso, Feiner	Billinghurst_et_all_(2018)	2008	
262	10.1145/1152399.1152430	Virtual object manipulation using a mobile phone	Henrysson, Billinghurst, Ollila	Billinghurst_et_all_(2018)	2005	
263	10.1145/1321261.1321295	Experiments in 3D interaction for mobile phone AR	Henrysson, Marshall, Billinghurst	Billinghurst_et_all_(2018)	2007	
264	10.1145/1851600.1851632	Evaluation of an off-screen visualization for magic lens and dynamic peephole interfaces	Henze, Boll	Billinghurst_et_all_(2018)	2010	
265	10.1109/ISWC.2010.5665865	Augmented Viewport: An action at a distance technique for outdoor AR using distant and zoom lens cameras	Hoang, Thomas	Billinghurst_et_all_(2018)	2010	
266	10.1016/j.cag.2011.04.005	Aroundplot: Focus+context interface for off-screen objects in 3D environments	Jo, Hwang, Park, Ryu	Billinghurst_et_all_(2018)	2011	
267	10.1145/2503368.2503375	IllumiRoom: peripheral projected illusions for interactive experiences	Jones, Benko, Ofek, Wilson	Billinghurst_et_all_(2018)	2013	
268	10.1145/2087756.2087786	Wearable mobile augmented reality: evaluating outdoor user experience	Kerr, Rice, Teo, Wan, Cheong, Ng, Ng-Thamrin, Thura-Myo, Wren	Billinghurst_et_all_(2018)	2011	
269	10.1080/10447318.2012.722466	Usability Principles for Augmented Reality Applications in a Smartphone Environment	Ko, Chang, Ji	Billinghurst_et_all_(2018)	2013	
270	10.1109/ISIE.2005.1529155	Haptic Telepresent Control Technology Applied to Disposal of Explosive Ordnances: Principles and Experimental Results	Kron, Schmidt	Billinghurst_et_all_(2018)	2005	
271	10.1145/2541016.2541022	Audio stickies: visually-guided spatial audio annotations on a mobile augmented reality platform	Langlotz, Regenbrecht, Zollmann, Schmalstieg	Billinghurst_et_all_(2018)	2013	
272	10.1145/1452392.1452444	A Wizard of Oz study for an AR multimodal interface	Lee, Billinghurst	Billinghurst_et_all_(2018)	2008	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
272	10.1145/1452392.1452444	A Wizard of Oz study for an AR multimodal interface	Lee, Billinghurst	Billinghurst_et_all_(2018)		
273	10.1109/ISMAR.2009.5336464	A Replication Study Testing the Validity of AR Simulation in VR for Controlled Experiments	Lee, Bonebrake Höllerer, Bowman	Billinghurst_et_all_(2018)	2009	
274	10.1109/VR.2010.5444820	The Role of Latency in the Validity of AR Simulation	Lee, Bonebrake Höllerer, Bowman	Billinghurst_et_all_(2018)	2010	
275	10.1109/ISMAR.2011.6092398	A user study on the Snap-To-Feature interaction method	Lee, Billinghurst	Billinghurst_et_all_(2018)	2011	
276	10.1007/s10055-013-0230-0	A usability study of multimodal input in an augmented reality environment	Lee, Billinghurst, Baek, Green, Woo	Billinghurst_et_all_(2018)	2013	
277	10.1145/2470654.2470680	SpaceTop: integrating 2D and spatial 3D interactions in a see-through desktop environment	Lee, Olwal, Ishii, Boulanger	Billinghurst_et_all_(2018)	2013	
278	10.1109/3DUI.2012.6184177	Integrating spatial sensing to an interactive mobile 3D map	Lehtinen, Nurminen, Oulasvirta	Billinghurst_et_all_(2018)	2012	
279	10.1145/2470654.2466191	Sublimate: State-Changing Virtual and Physical Rendering to Augment Interaction with Shape Displays	Leithinger, Follmer, Olwal, Ishii, Lee, Hogge; Luescher	Billinghurst_et_all_(2018)	2013	
280	10.1145/1321261.1321297	An evaluation of virtual lenses for object selection in augmented reality	Looser, Billinghurst, Grasset, Cockburn	Billinghurst_et_all_(2018)	2007	
281	10.1109/ICCVW.2013.64	Wearable Smartphone: Wearable Hybrid Framework for Hand and Foot Gesture Interaction on Smartphone	Lv	Billinghurst_et_all_(2018)	2013	
282	10.1109/ISMAR.2011.6143895	An empiric evaluation of confirmation methods for optical see-through head-mounted display calibration	Maier, Dey, Waechter, Sandor, Tönnis, Klinker	Billinghurst_et_all_(2018)	2011	
283	10.1145/2466816.2466827	DrillSample: precise selection in dense handheld augmented reality environments	Mosse, Venditti, Kaufmann	Billinghurst_et_all_(2018)	2013	
284	10.1145/2466816.2466829	3DTouch and HOMER-S: Intuitive Manipulation Techniques for One-Handed Handheld Augmented Reality	Mosse, Venditti, Kaufmann	Billinghurst_et_all_(2018)	2013	
285	10.1109/ISMAR.2013.6671775	User friendly SLAM initialization	Mulloni, Ramachandran, Reitmayr, Wagner, Grasset, Diaz	Billinghurst_et_all_(2018)	2013	
286	10.1145/2470654.2466425	Reducing Disruption from Subtle Information Delivery during a Conversation: Mode and Bandwidth Investigation	Ofek, Iqbal, Strauss	Billinghurst_et_all_(2018)	2013	
287	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): User Evaluations on Form Factors of Tangible Magic Lenses - Oh et al. (2006)
288	10.1109/ISMAR.2011.6092372	Online user survey on current mobile augmented reality	Olsson, Salo	Billinghurst_et_all_(2018)	2011	
289	10.1145/2207676.2208677	Narratives of satisfying and unsatisfying experiences of current mobile augmented reality applications	Olsson, Salo	Billinghurst_et_all_(2018)	2012	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
290	10.1109/ISMAR.2010.5643599	Validating Spatial Augmented Reality for interactive rapid prototyping	Porter, Marner, Smith, Zucco, Thomas	Billinghurst_et_all_(2018)	2010	
291	10.1109/3DUI.2008.4476593	Hemp-hand-displacement-based pseudo-haptics: a study of a force field application	Pusch, Martin, Coquillart	Billinghurst_et_all_(2018)	2008	
292	10.1016/j.ijhcs.2008.09.015	HEMP—hand-displacement-based pseudo-haptics: A study of a force field application and a behavioural analysis	Pusch, Martin, Coquillart	Billinghurst_et_all_(2018)	2009	
293	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): An Evaluation of Graphical Context as a Means for Ameliorating the Effects of Registration Error - Robertson and MacIntyre (2007)
294	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): An evaluation of graphical context when the graphics are outside of the task area - Robertson, MacIntyre and Walker (2008)
295	10.1145/1613858.1613907	Impact of item density on magic lens interactions	Rohs, Schöning, Naumann, Schleicher, Krüger	Billinghurst_et_all_(2018)	2009	
296	10.1145/1978942.1979343	Interaction with magic lenses: real-world validation of a Fitts' Law model	Rohs, Oulasvirta, Suomalainen	Billinghurst_et_all_(2018)	2011	
297	10.1145/2207676.2207702	LightGuide: projected visualizations for hand movement guidance	Sodhi, Benko, Wilson	Billinghurst_et_all_(2018)	2012	
298	10.1109/ISMAR.2012.6402560	Quick viewpoint switching for manipulating virtual objects in hand-held augmented reality using stored snapshots	Sukan, Feiner, Tversky, Energin	Billinghurst_et_all_(2018)	2012	
299	10.3389/fnins.2011.00060	Towards intelligent environments: an augmented reality–brain–machine interface operated with a see-through head-mount display	Takano, Hata, Kansaku	Billinghurst_et_all_(2018)	2011	
300	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Evaluation of three input techniques for selection and annotation of physical objects through an augmented reality view - Thomas (2006)
301	10.1145/2557500.2557528	A mixed reality head-mounted text translation system using eye gaze input	Toyama, Sonntag, Dengel, Matsuda, Iwamura, Kise	Billinghurst_et_all_(2018)	2014	
302	10.1145/2598153.2598154	A natural interface for multi-focal plane head mounted displays using 3D gaze	ToyamJ, Orlosky, Sonntag, Kiyokawa	Billinghurst_et_all_(2018)	2014	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
303	10.1145/1054972.1055056	A study on the manipulation of 2D objects in a projector/camera-based augmented reality environment	Voida, Podlaseck, Kjeldsen, Pinhanez	Billinghurst_et_all_(2018)	2005	
304	10.1145/2556288.2557090	MixFab: a mixed-reality environment for personal fabrication	Weichel, Lau, Kim, Villar, Gellersen	Billinghurst_et_all_(2018)	2014	
305	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Evaluating Display Types for AR Selection and Annotation - Wither, DiVerdi and Tobias Hollerer (2007)
306	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Visual Hints for Tangible Gestures in Augmented Reality - White et al. (2007)
307	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Interaction and Presentation Techniques for Shake Menus in Tangible Augmented Reality - White et al. (2009)
308	10.1109/IEMBS.2006.259707	Dynamic Augmented Reality for Sensory Substitution in Robot-Assisted Surgical Systems	Akinbiyi, Reiley, Saha, Burschka, Hasser, Yuh, Okamura	Billinghurst_et_all_(2018)	2006	
309	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Lim et al. (2019): Effects of Mobile Augmented Reality Learning Compared to Textbook Learning on Medical Students: Randomized Controlled Pilot Study - Albrecht et al. (2013)
310	10.1145/2501988.2502045	YouMove: enhancing movement training with an augmented reality mirror	Anderson, Grossman, Matejka, Fitzmaurice	Billinghurst_et_all_(2018)	2013	
311	10.1016/j.neuroimage.2006.11.060	Non-rigid alignment of pre-operative MRI, fMRI, and DT-MRI with intra-operative MRI for enhanced visualization and navigation in image-guided neurosurgery	Archip, Clatz, Whalen, Kacher, Fedorov, Kot, Chrisochoides, Jolesz Golby, Black, Warfield	Billinghurst_et_all_(2018)	2007	
312	10.1109/ISMAR.2013.6671763	Through the looking glass: Pretend play for children with autism	Bai, Blackwell, Coulouris	Billinghurst_et_all_(2018)	2013	
313	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Laparoscopic Virtual Mirror for Understanding Vessel Structure Evaluation Study by Twelve Surgeons - Bichlmeier et al. (2007)
314	10.1007/s00268-006-0724-y	Augmented versus Virtual Reality Laparoscopic Simulation: What Is the Difference?	Botden, Buzink, Marlies, Schijven, Jakimowicz	Billinghurst_et_all_(2018)	2007	
315	10.1097/SIH.0b013e3181659e91	ProMIS Augmented Reality Training of Laparoscopic Procedures Face Validity	Botden, Buzink, Marlies, Schijven, Jakimowicz	Billinghurst_et_all_(2018)	2008	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
316	10.1089/cpb.2005.8.162	Mixing Realities? An Application of Augmented Reality for the Treatment of Cockroach Phobia	Botella, Juan, Baños, Alcañiz, Guillén, Rey	Billinghurst_et_all_(2018)	2005	
317	10.1016/j.beth.2009.07.002	Treating Cockroach Phobia With Augmented Reality	Botella, Bretón-López Quero, Baño, García-Palacios	Billinghurst_et_all_(2018)	2009	
318	10.1016/j.chb.2010.07.043	Treating cockroach phobia using a serious game on a mobile phone and augmented reality exposure: A single case study	Botella, Breton-López, Quero, Baños, García-Palacios, Zaragoza, Alcaniz	Billinghurst_et_all_(2018)	2011	
319	10.1089/cyber.2009.0170	An Augmented Reality System Validation for the Treatment of Cockroach Phobia	Bretón-López, Quero, Botella, García-Palacios, Maria, Alcañiz	Billinghurst_et_all_(2018)	2010	
320	10.1007/s00464-012-2184-9	Single versus multimodality training basic laparoscopic skills	Brinkman, Havermans, Buzink, Botden, Jakimowicz, Schoot	Billinghurst_et_all_(2018)	2012	
321	10.1109/TSMCA.2009.2030166	Improved Telemanipulator Navigation During Display-Control Misalignments Using Augmented Reality Cues	Chintamani, Cao, Ellis, Pandya	Billinghurst_et_all_(2018)	2009	
322	10.1002/lary.22153	Augmented image guidance improves skull base navigation and reduces task workload in trainees: A preclinical trial	Dixon, Daly, Chan, Vescan, Witterick, Irish	Billinghurst_et_all_(2018)	2011	
323	10.1682/JRRD.2009.10.0165	At-home training with closed-loop augmented-reality cueing device for improving gait in patients with Parkinson disease	Espay, Baram, Dwivedi, Shukla, Gartner, Gaines, Duker, Revilla	Billinghurst_et_all_(2018)	2010	
324	10.1109/TBME.2005.851493	Image overlay guidance for needle insertion in CT scanner	Fichtinger, Deguet, Masamune, Balogh, Fischer, Mathieu, Taylor, Zinreich, Fayad	Billinghurst_et_all_(2018)	2005	
325	10.3109/10929080500230486	Image overlay for CT-guided needle insertions	Fichtinger, Deguet, Fischer, Iordachita, Balogh, Masamune, Taylor, Fayad, De Oliveira & S. James Zinreich	Billinghurst_et_all_(2018)	2005	
326	10.1007/s11548-013-0816-8	Percutaneous lung biopsy: comparison between an augmented reality CT navigation system and standard CT-guided technique	Grasso, Faiella, Luppi, Schena, Giurazza, Del_Vescovo, D'Agostino, Cazzato, Zobel	Billinghurst_et_all_(2018)	2013	
327	10.1007/s00464-011-1861-4	Visual force feedback in laparoscopic training	Horeman, Rodrigues, Dobbelsteen, Jansen, Dankelman	Billinghurst_et_all_(2018)	2012	
328	10.1007/s00464-014-3425-x	Learning from visual force feedback in box trainers: tissue manipulation in laparoscopic surgery	Horeman, Delft, Blikkendaal, Dankelman, Dobbelsteen, Jansen	Billinghurst_et_all_(2018)	2014	
329	10.1109/TOH.2011.40	Rendering Virtual Tumors in Real Tissue Mock-Ups Using Haptic Augmented Reality	Jeon, Choi, Harders	Billinghurst_et_all_(2018)	2011	
330	10.1016/j.cag.2010.08.001	Using augmented and virtual reality for the development of acrophobic scenarios. Comparison of the levels of presence and anxiety	Juan, Pérez	Billinghurst_et_all_(2018)	2010	
331	10.1016/j.ijhcs.2011.03.002	A comparative study of the sense of presence and anxiety in an invisible marker versus a marker augmented reality system for the treatment of phobia towards small animals	Juan, Joele	Billinghurst_et_all_(2018)	2011	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
331	10.1016/j.ijhcs.2011.03.002	A comparative study of the sense of presence and anxiety in	Juan, Joele	Billinghurst_et_all_(2018)		
332	10.3109/17483101003718161	An affordable, computerised, table-based exercise system for stroke survivors	King, Hale, Pekkari, Persson, Gregorsson, Nilsson	Billinghurst_et_all_(2018)	2010	
333	10.1016/j.jsurg.2010.06.004	Hand-Assisted Laparoscopic Sigmoid Colectomy Skills Acquisition: Augmented Reality Simulator Versus Human Cadaver Training Models	Leblanc, Senagore, Ellis, Champagne, Augestad, Neary, Delaney, Colorectal Surgery Training Group	Billinghurst_et_all_(2018)	2010	
334	10.1016/j.tvjl.2012.09.015	Augmented reality intravenous injection simulator based 3D medical imaging for veterinary medicine	S._Lee, J._Lee, A._Lee, Park, S._Lee, Song, Seo, H_Lee, Kim, Eom	Billinghurst_et_all_(2018)	2013	
335	10.1109/ICORR.2005.1501112	An augmented reality training environment for post-stroke finger extension rehabilitation	Luo, Kenyon, Kline, Fischer, Kamper	Billinghurst_et_all_(2018)	2005	
336	10.1109/IEMBS.2005.1616080	Integration of Augmented Reality and Assistive Devices for Post-Stroke Hand Opening Rehabilitation	Luo, Kenyon, Kline, Fischer, Kamper	Billinghurst_et_all_(2018)	2006	
337	10.1088/1741-2560/11/4/046001	Stereovision and augmented reality for closed-loop control of grasping in hand prostheses	Markovic, Dosen, Cipriani, Popovic, Farina	Billinghurst_et_all_(2018)	2014	
338	10.1002/cav.52	An augmented reality system to guide radio-frequency tumour ablation	Nicolau, Garcia, Pennec, Soler, Ayache	Billinghurst_et_all_(2018)	2005	
339	10.1145/1324892.1324915	Fun and usable: augmented reality instructions in a hospital setting	Nilsson, Johansson	Billinghurst_et_all_(2018)	2007	
340	10.1109/ISMAR.2011.6092389	Out of reach? - A novel AR interface approach for motor rehabilitation	Regenbrecht, McGregor, Ott, Hoermann, Schubert, Hale, Otago, Hoermann, Dixon, Franz	Billinghurst_et_all_(2018)	2011	
341	10.1016/j.cag.2012.04.012	Augmented Reality: Visual manipulations for motor rehabilitation	Regenbrecht, Hoermann, Mcgregor, Dixon, Franz, Ott, Hale, Schubert, Hoermann	Billinghurst_et_all_(2018)	2012	
342	10.1109/JPROC.2013.2294178	Manipulating the Experience of Reality for Rehabilitation Applications	Regenbrecht, Hoermann, Ott, Müller, Franz	Billinghurst_et_all_(2018)	2014	
343	10.1007/s00464-007-9261-5	Concurrent validity of augmented reality metrics applied to the fundamentals of laparoscopic surgery (FLS)	Ritter, Kindelan, Michael, Pimentel, Bowyer	Billinghurst_et_all_(2018)	2007	
344	10.1016/j.eururo.2009.05.017	Augmented Reality: A New Tool To Improve Surgical Accuracy during Laparoscopic Partial Nephrectomy? Preliminary In Vitro and In Vivo Results	Teber, Guven, Simpfendörfer, Baumhauer, Güven, Yencilek, Gözen, Rassweiler	Billinghurst_et_all_(2018)	2009	
345	10.3109/17453050903557359	Augmented Reality for Anatomical Education	Thomas, John, Delieu	Billinghurst_et_all_(2018)	2010	
346	10.1148/radiol.2382041441	An Augmented Reality System for MR Image–guided Needle Biopsy: Initial Results in a Swine Model	Wacker, Vogt, Khamene, Jesberger, Nour, Elgort, Sauer, Duerk, Lewin	Billinghurst_et_all_(2018)	2006	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
347	10.7205/MILMED-D-13-00074	Using Augmented Reality as a Clinical Support Tool to Assist Combat Medics in the Treatment of Tension Pneumothoraces	Wilson, Doswell, Fashola, Debeatham, Darko, Walker, Danner, Matthews, Weaver	Billinghurst_et_all_(2018)	2013	
348	10.1017/S1352465813000088	How Technology Influences the Therapeutic Process: Evaluation of the Patient-Therapist Relationship in Augmented Reality Exposure Therapy and In Vivo Exposure Therapy	Wrzesien, Bretón-López, Botella, Burkhardt, Alcañiz, Pérez-Ara, Amo	Billinghurst_et_all_(2018)	2013	
349	10.1589/jpts.25.797	The Effects of Augmented Reality-based Otago Exercise on Balance, Gait, and Falls Efficacy of Elderly Women	Yoo, Chung, Lee	Billinghurst_et_all_(2018)	2013	
350	10.1097/SIH.0b013e3182662c69	Practice on an Augmented Reality/Haptic Simulator and Library of Virtual Brains Improves Residents' Ability to Perform a Ventriculostomy	Yudkowsky, Luciano, Banerjee, Schwartz, Alaraj, Lemole, Charbel, Smith, Rizzi, Byrne, Bendok, Frim	Billinghurst_et_all_(2018)	2013	
351	10.1145/2406367.2406417	Insights into user experiences and acceptance of mobile indoor navigation devices	Arning, Ziefle, Li, Kobbelt	Billinghurst_et_all_(2018)	2012	
352	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): User evaluation of see-through vision for mobile outdoor augmented reality - Avery, Thomas, Piekarski (2008)
353	10.1007/s00779-010-0343-3	Organizing and presenting geospatial tags in location-based augmented reality	Choi, Jang, Kim	Billinghurst_et_all_(2018)	2011	
354	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Lim et al. (2019): Creating interactive physics education books with augmented reality - Duenser et al. (2012)
355	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Lim et al. (2019): Zooming Interfaces for Augmented Reality Browsers - Mulloni et al. (2010)
356	10.1016/j.cag.2011.04.006	A topometric system for wide area augmented reality	Gee, Webb, Escamilla-Ambrosioc, Mayol-Cuevas, Calway	Billinghurst_et_all_(2018)	2011	
357	10.1109/TSMCC.2007.900665	Effects of Augmented Reality Display Settings on Human Wayfinding Performance	Goldiez, Ahmad, Hancock	Billinghurst_et_all_(2018)	2007	
358	10.1016/j.intcom.2011.06.006	An interactive 3D movement path manipulation method in an augmented reality environment	Ha, Billinghurst, Woo	Billinghurst_et_all_(2018)	2012	
359	10.1145/2556288.2557021	Simplifying orientation measurement for mobile audio augmented reality applications	Heller, Krämer, Borchers	Billinghurst_et_all_(2018)	2014	
360	10.1016/j.pmcj.2012.05.002	Digital urban ambience: Mediating context on mobile devices in a city	Kjeldskov, Skov, Nielsen, Thorup, Vestergaard	Billinghurst_et_all_(2018)	2012	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
360	10.1016/j.pmcj.2012.05.002	Digital urban ambience: Mediating context on mobile devices	Kjeldskov, Skov, Nielsen, Thorup,	Billinghurst_et_all_(2018)		
361	10.1145/2406367.2406372	A mobile indoor navigation system interface adapted to vision-based localization	Möller, Kranz, Huitl, Diewald, Roalter	Billinghurst_et_all_(2018)	2012	
362	10.1145/2556288.2557003	Experimental evaluation of user interfaces for visual indoor navigation	Möller, Kranz, Diewald, Roalter, Huitl, Stockinger, Koelle, Lindemann	Billinghurst_et_all_(2018)	2014	
363	10.1145/1518701.1518991	Like Bees Around the Hive: A Comparative Study of a Mobile Augmented Reality Map	Morrison, Oulasvirta, Peltonen, Lemmelä, Jacucci, Reitmayr, Näsänen, Juustila	Billinghurst_et_all_(2018)	2009	
364	10.1016/j.trc.2011.08.005	Augmented Reality Vehicle system: Left-turn maneuver study	Moussa, Radwan, Hussain	Billinghurst_et_all_(2018)	2012	
365	10.1145/2037373.2037406	Handheld augmented reality indoor navigation with activity-based instructions	Mulloni, Seichter, Schmalstieg	Billinghurst_et_all_(2018)	2011	
366	10.1109/ISMAR.2011.6092390	User experiences with augmented reality aided navigation on phones	Mulloni, Seichter, Schmalstieg	Billinghurst_et_all_(2018)	2012	
367	10.1109/ISMAR-AMH.2013.6671262	User-centered perspectives for automotive augmented reality	Ng, Bark, Beckwith, Tran, Bhandari, Sridhar	Billinghurst_et_all_(2018)	2013	
368	10.1145/1322192.1322219	Map navigation with mobile devices: Virtual versus physical movement with and without visual context	Rohs, Schöning, Martin, Krüger, Essl	Billinghurst_et_all_(2018)	2007	
369	10.1007/s00779-009-0247-2	Impact of item density on the utility of visual context in magic lens interactions	Rohs, Schleicher, Schöning, Essl, Naumann, Krüger	Billinghurst_et_all_(2018)	2009	
370	10.1016/j.trf.2012.08.007	Directing driver attention with augmented reality cues	Rusch, Schall, Gavin, Lee, Dawson, Vecer, Rizzo	Billinghurst_et_all_(2018)	2012	
371	10.1177/0018720812462029	Augmented Reality Cues and Elderly Driver Hazard Perception	Schall, Rusch, Lee, Dawson, Thomas, Nazan, Rizzo	Billinghurst_et_all_(2018)	2012	
372	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Experimental Evaluation of an Augmented Reality Visualization for Directing a Car Driver’s Attention - Tonnis et al. (2005)
373	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Effective Control of a Car Driver's Attention for Visual and Acoustic Guidance Towards the Direction of Imminent Dangers - Tönnis and Klinker (2006)
374	10.1109/SEANES.2012.6299572	Effects of guided arrows on head-up display towards the vehicle windshield	Tangmanee, Teeravarunyou	Billinghurst_et_all_(2018)	2012	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
375	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): The Effect of Out-of-focus Blur on Visual Discomfort When Using Stereo Displays - Blum et all. (2010)
376	10.1109/3DUI.2010.5444706	Evaluating depth perception of photorealistic mixed reality visualizations for occluded objects in outdoor environments	Dey, Cunningham, Sandor	Billinghurst_et_all_(2018)	2010	
377	10.1109/ISMAR.2012.6402556	Tablet versus Phone: Depth Perception in Handheld Augmented Reality	Dey, Cunningham, Sandor	Billinghurst_et_all_(2018)	2012	
378	10.1109/VR.2005.1492748	An empirical user-based study of text drawing styles and outdoor background textures for augmented reality	Gabbard, Swan, Hix, Schulman, Lucas, Gupta	Billinghurst_et_all_(2018)	2005	
379	10.1162/pres.2006.15.1.16	The Effects of Text Drawing Styles, Background Textures, and Natural Lighting on Text Legibility in Outdoor Augmented Reality	Gabbard, Swan, Hix	Billinghurst_et_all_(2018)	2006	
380	10.1109/VR.2007.352461	Active Text Drawing Styles for Outdoor Augmented Reality: A User-Based Study and Design Implications	Gabbard, Swan, Hix, Kim, Fitch	Billinghurst_et_all_(2018)	2007	
381	10.1109/TVCG.2008.24	Usability Engineering for Augmented Reality: Employing User-Based Studies to Inform Design	Gabbard, Swan	Billinghurst_et_all_(2018)	2008	
382	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Experiences with an AR evaluation test bed: Presence, performance, and physiological measurement - Gandy et all. (2010)
383	10.1145/1823738.1823744	How does presentation method and measurement protocol affect distance estimation in real and virtual environments?	Grechkin, Nguyen, Plumert, Cremer, Kearney	Billinghurst_et_all_(2018)	2010	
384	10.1145/1056808.1056932	The power-aware cord: energy awareness through ambient information display	Gustafsson, Gyllenswärd	Billinghurst_et_all_(2018)	2005	
385	10.1145/2611009.2611014	cAR: Contact Augmented Reality with Transparent-Display Mobile Devices	Hincapié-Ramos, Roscher, Büschel, Kister, Dachselt, Irani	Billinghurst_et_all_(2018)	2014	
386	10.1109/TVCG.2012.321	View Management of Projected Labels on Nonplanar and Textured Surfaces	Iwai, Yabiki, Sato	Billinghurst_et_all_(2018)	2013	
387	10.1145/1753326.1753524	Integrating Text with Video and 3D Graphics: The Effects of Text Drawing Styles on Text Readability	Jankowski, Samp, Irzynska, Jozwowicz, Decker	Billinghurst_et_all_(2018)	2010	
388	10.1162/PRES_a_00051	Real Stiffness Augmentation for Haptic Augmented Reality	Jeon , Choi	Billinghurst_et_all_(2018)	2011	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
389	10.1109/HAPTIC.2012.6183782	Extending haptic augmented reality: Modulating stiffness during two-point squeezing	Jeon, Harders	Billinghurst_et_all_(2018)	2012	
390	10.1109/VR.2008.4480794	The Effects of Virtual Reality, Augmented Reality, and Motion Parallax on Egocentric Depth Perception	Jones, Swan, Singh, Kolstad, Ellis	Billinghurst_et_all_(2018)	2008	
391	10.1109/TVCG.2012.45	Geometric Calibration of Head-Mounted Displays and its Effects on Distance Estimation	Kellner, Bolte, Bruder, Rautenberg, Steinicke, Lappe, Koch	Billinghurst_et_all_(2018)	2012	
392	10.1145/2077451.2077457	Peripheral visual information and its effect on distance judgments in virtual and augmented environments	Jones, Swan, Singh, Ellis	Billinghurst_et_all_(2018)	2011	
393	10.1145/2541831.2541851	Is autostereoscopy useful for handheld AR?	Kerber, Lessel, Mauderer, Daiber, Oulasvirta, Krüger	Billinghurst_et_all_(2018)	2013	
394	10.1016/j.autcon.2012.10.020	A framework for context immersion in mobile augmented reality	Kim	Billinghurst_et_all_(2018)	2013	
395	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Influence of Visual and Haptic Delays on Stiffness Perception in Augmented Reality - Knorlein et all. (2009)
396	10.1145/2207676.2208729	Funneling and saltation effects for tactile interaction with virtual objects	Lee, Kim, Kim	Billinghurst_et_all_(2018)	2012	
397	10.1109/TVCG.2013.41	The Effects of Visual Realism on Search Tasks in Mixed Reality Simulation	Lee, Rincon, Meyer, Höllerer, Bowman	Billinghurst_et_all_(2018)	2013	
398	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Hear-Through and Mic-Through Augmented Reality: Using Bone Conduction to Display Spatialized Audio - Robert et all. (2007)
399	10.1109/TVCG.2009.95	A Novel Prototype for an Optical See-Through Head-Mounted Display with Addressable Focus Cues	Liu, Hua, Cheng	Billinghurst_et_all_(2018)	2009	
400	10.1145/2207676.2208706	Evaluating the benefits of real-time feedback in mobile augmented reality with hand-held devices	Liu, Huot, Diehl, Mackay, Beaudouin-Lafon	Billinghurst_et_all_(2018)	2012	
401	10.1109/VR.2005.1492798	Objective measures for the effectiveness of augmented reality	Livingston, Zanbaka, Swan, Smallman	Billinghurst_et_all_(2018)	2005	
402	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): Quantification of visual capabilities using augmented reality displays - Livingston (2006)

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
403	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): The effect of registration error on tracking distant augmented objects - et all. (2008)
404	10.1109/VR.2009.4810999	Indoor vs. Outdoor Depth Perception for Mobile Augmented Reality	Livingston, Ai, Swan, Smallman	Billinghurst_et_all_(2018)	2009	
405	10.1109/VR.2009.4811009	Quantification of Contrast Sensitivity and Color Perception using Head-worn Augmented Reality Displays	Livingston, Barrow, Sibley	Billinghurst_et_all_(2018)	2009	
406	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): A user study towards understanding stereo perception in head-worn augmented reality displays - Livingston et all. (2009)
407	10.1007/s10055-010-0179-1	User interface design for military AR applications	Livingston, Ai, Karsch, Gibson	Billinghurst_et_all_(2018)	2011	
408	10.1109/ISMAR.2012.6402553	Subtle cueing for visual search in augmented reality	Lu, Duh, Feiner	Billinghurst_et_all_(2018)	2012	
409	10.1109/VR.2014.6802047	The Mind-Mirror: See your brain in action in your head using EEG and augmented reality	Mercier-Ganady, Lotte, Loup-Escande, Marchal, Lécuyer	Billinghurst_et_all_(2018)	2014	
410	10.3233/AIS-2011-0127	User evaluation of mobile augmented reality scenarios	Olssona, Kärkkäinena, Lagerstama, Ventä-Olkkonenb	Billinghurst_et_all_(2018)	2012	
411	10.1109/3DUI.2009.4811215	Visual clutter management in augmented reality: Effects of three label separation methods on spatial judgments	Peterson, Axholt, Cooper, Ellis	Billinghurst_et_all_(2018)	2009	
412	10.1145/2556288.2557125	The use of surrounding visual context in handheld AR: device vs. user perspective rendering	Pucihar, Coulton, Alexander	Billinghurst_et_all_(2018)	2014	
413	10.1145/1180495.1180502	The benefits of third-person perspective in virtual and augmented reality?	Salamin, Thalmann, Vexo	Billinghurst_et_all_(2018)	2006	
414	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Bai and Blackwell survey (2012): An Augmented Reality X-Ray system based on visual saliency - Sandor et all. (2010)
415	10.1145/1836248.1836277	Depth judgment measures and occluding surfaces in near-field augmented reality	Singh, Swan, Jones, Ellis	Billinghurst_et_all_(2018)	2010	
416	10.1109/VR.2012.6180933	Depth judgments by reaching and matching in near-field augmented reality	Singh, Swan, Jones, Ellis	Billinghurst_et_all_(2018)	2012	
417	10.1016/j.neuropsychologia.2013.08.014	Multisensory integration across exteroceptive and interoceptive domains modulates self-experience in the rubber-hand illusion	Suzuki, Garfinkel, Critchley, Seth	Billinghurst_et_all_(2018)	2013	
418	10.1109/ISMAR.2013.6671760	Approximated user-perspective rendering in tablet-based augmented reality	Tomioka, Ikeda, Sato	Billinghurst_et_all_(2018)	2013	

ID Paper	DOI / ISBN	Name	Authors	Source	Year	Note
418	10.1109/ISMAR.2013.6671760	Approximated user-perspective rendering in tablet-based	Tomioka, Ikeda, Sato	Billinghurst_et_all_(2018)		
419	10.1145/1152399.1152412	Visualization methods for outdoor see-through vision	Tsuda, Yamamoto, Kameda, Ohta	Billinghurst_et_all_(2018)	2005	
420	10.1145/1978942.1979158	Directing attention and influencing memory with visual saliency modulation	Veas, Mendez, Feiner, Schmalstieg	Billinghurst_et_all_(2018)	2011	
421	10.1109/TVCG.2012.44	Extended Overview Techniques for Outdoor Augmented Reality	Veas, Grasset, Kruijff, Schmalstieg	Billinghurst_et_all_(2018)	2014	
422	10.1145/1178823.1178891	How real should virtual characters be?	Wagner. Billinghurst, Schmalstieg	Billinghurst_et_all_(2018)	2006	
423	10.1109/ISWC.2005.41	Pictorial depth cues for outdoor augmented reality	Wither, Hollerer	Billinghurst_et_all_(2018)	2005	
424	10.1016/j.cag.2011.04.010	Indirect augmented reality	Wither, Tsai, Azuma	Billinghurst_et_all_(2018)	2011	
425	10.1145/2325722.2325727	Minification affects verbal- and action-based distance judgments differently in head-mounted displays	Zhang, Nordman, Walker, Kuhl	Billinghurst_et_all_(2018)	2012	
426	10.1016/j.jvcir.2013.03.017	Gesture-based interaction with voice feedback for a tour-guide robot	Alvarez-Santos, Iglesias, Pardo, Regueiro, Canedo-Rodrigueza	Billinghurst_et_all_(2018)	2014	
427	10.1145/1900179.1900203	Exhibition of lunar surface navigation system facilitating collaboration between children and parents in science museum	Asai, Sugimoto, Billinghurst	Billinghurst_et_all_(2018)	2010	
428	10.1145/2406367.2406401	Private public screens: detached multi-user interaction with large displays through mobile augmented reality	Baldauf, Lasinger, Fröhlich	Billinghurst_et_all_(2018)	2012	
429	10.1007/s11257-005-2304-5	Ontology-Based User Modeling in an Augmented Audio Reality System for Museums	Hatala, Wakkary	Billinghurst_et_all_(2018)	2005	
430	\	\	\	Billinghurst_et_all_(2018)	\	Dupplicate in Lim et al. (2019): Expected user experience of mobile augmented reality services: a user study in the context of shopping centres - Olsson et al. (2013)
431	10.1109/VSMM.2012.6365903	Archeovirtual 2011: An evaluation approach to virtual museums	Pescarin, Pagano, Wallergård, Hupperetz, Ray	Billinghurst_et_all_(2018)	2012	
432	10.1016/j.ijhcs.2009.11.002	Exploring the relationship between presence and enjoyment in a virtual museum	Sylaiou, Mania, Karoulis, White	Billinghurst_et_all_(2018)	2010	
433	10.1109/ISMAR-AMH.2011.6093655	Mobile augmented reality in the museum: Can a lace-like technology take you closer to works of art?	Tillon, Marchal, Houlier	Billinghurst_et_all_(2018)	2011	

Technologies used in studies

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
1	1	Spatial Projected	HUD simulate with Projector	1	Tangible	Car controls (wheel...)	1	Mechanical	Car controls (wheel...)	1
2	1	Spatial Projected	HUD simulate with Projector	1	Tangible	Car controls (wheel...)	1	Mechanical	Car controls (wheel...)	1
3	1	Spatial Stationary See-through	HUD + Projector of Background	1	Tangible	Car controls (wheel...)	1	Mechanical	Car controls (wheel...)	1
4	1	Wearable Headsets Monitor	HWD Prototype	1	External Physical Device	e wrist-worn controller	1	Optics Marker-based	IR LEDs	1
5	1	Wearable Headsets See-through	HWD Prototype	1	External Physical Device	click-turn-wheel adjusting knob on belt	1	Optics Marker-based	A.R.T. marker target	1
6	1	Spatial Projected	3D laser Projector on Workspace	1	External Physical Device	6-DOF Input Pen	1	Optics Marker-based	Cameras + Physical Marker on Pen	1
7	1	Wearable Headsets See-through	Nomad (Microvision) Headset	1	Tangible	Shelf with small boxes	1	Optics Marker-based	Cameras + Physical Marker on Headset	1
8	1	Spatial Stationary Monitor	PC monitor + Enriched Images from car	1	Tangible	Laparoscopic camera + surgical instrument	1	Optics Marker-based	Cameras + Physical Marker on instruments	1
9	1	Wearable Headsets Monitor	RAMP system	1	Tangible	endoscopic instrument	1	Optics Marker-based	Cameras + Physical Marker on instruments	1
10	1	Handled Mobile	Tablet	1	Tangible	direct on instrumentations	1	Optics Marker-based	Trackers on hat + retro-reflective tape and IR sensing web cams	1
11	1	Spatial Stationary Monitor	PC monitor + Enriched Images from car	1	Tangible	Fiduciary Markers	1	Optics Marker-based	Camera + Fiduciary Markers	1
12	1	Wearable Headsets See-through	head-mounted projection display (HMI	1	External Physical Device	Magic Lens interface + workbench	1	Optics Marker-based	Cameras + Physical Marker on instruments	1
13	1	Spatial Projected	BUILD-IT system	1	Tangible	Physical Tokens	1	Optics Marker-based	camera + physical tokens	1
14	1	Wearable Headsets See-through	Sony LDI-D100B	1	Tangible	Fiduciary Markers	1	Optics Marker-based	Camera + Fiduciary Markers	1
15	1	Wearable Headsets Monitor	VR simulating AR	1	N/D	/	N/D	N/D	/	N/D
16	1	Spatial Stationary Monitor	Desktop Monitor	1	Tangible	Physical Tokens	1	Optics Marker-based	head mounted camera + physical tokens	1
	2	Spatial Stationary Monitor	Desktop Monitor	1	Tangible	Physical Tokens	1	Optics Marker-based	head mounted camera + physical tokens	1
17	1	Spatial Stationary Monitor	Desktop Monitor	1	Gesture Recognition/Hand Tracking + Tangible	Hands Tracked in 3D space + real objects	2	Optics Marker less	camera track hands	1
18	1	Wearable Headsets Monitor	Toshiba Protégé tablet computer used a	1	Head/Eye Tracking + External Physical Device	Gyration Ultra cordless optical mouse + camera position	2	Optics Marker-based	Camera + Fiduciary Markers	1
19	1	Wearable Headsets See-through	Sony Glasstron LDI100B	1	Head/Eye Tracking + External Physical Device	Alignment of Crosshair with world space + stylus	2	Electromagnetic	Ascension Flock of Birds 6 degree of freedom magnetic motion tracking system	1
20	1	Wearable Contact (Audio/Headphones)	AudioBone bone-conducting headset	1	None	/	none	N/D	/	N/D
21	1	Wearable Headsets Monitor + Wearable	MITSUBISHI DIATONE DS-7 + HMD Ca	2	None	/	none	Electromagnetic	N/D	1
22	1	Wearable Headsets See-through	prototype	1	None	/	none	None	N/A	none

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
23	1	Wearable Headsets See-through	Sony Glasstron LDI–100B stereo	1	External Physical Device	keyboard on desk	1	Inertia + Ultrasonic	InterSense IS-900 6-DOF ultrasonic and inertial	2
24	1	Spatial Stationary See-through	Retroreflective Screen prototype, Retro	1	None	/	none	None	/	none
25	1	Spatial Stationary Monitor	17" flat panel display	1	None	/	none	None	/	none
26	1	Wearable Headsets See-through	N/D	1	None	/	none	N/D	/	N/D
27	1	Spatial Stationary Monitor	screen + webcam	1	External Physical Device	Stylus	1	None	/	none
	2	Wearable Headsets Monitor	Screen Online survey	1	None	/	none	None	/	none
28	1	Wearable Headsets See-through + Wea	Sony Glasstron LDI-D100B, Microvision	3	None	/	none	None	Fixed Head position	none
29	1	Wearable Headsets See-through + Han	magic lens, HMD, and tablet displays	3	Direct Interaction with Device + External Physical Device	input on the device + Input on a external button	2	Optics Marker-based	physical trackers on HMD, Tablet and Magic lens	1
30	1	Spatial Projected	cyberdome screen	1	External Physical Device	joystick and Throttle	1	None	Fixed Head position	none
31	1	Handled Mobile	Handle Prototype	1	None	/	none	None	/	none
	2	Handled Mobile	Handle Prototype	1	None	/	none	None	/	none
	3	Handled Mobile	Handle Prototype	1	None	/	none	None	/	none
32	1	Spatial Stationary Monitor + Wearable H	nVisor SX OST-HMD + 22"Zalman ZM-	2	None	/	none	None	/	none
33	1	Spatial Stationary Monitor + Wearable Headsets See-through	nVisorST, nVisorST + monitor	2	None	/	none	None	Fixed Head position	none
34	1	Wearable Headsets See-through	ELMO-4 prototype	1	Gesture Recognition/Hand Tracking	bare hand interaction	1	Inertia + Ultrasonic	InterSense IS-600Mk2	2
35	1	Wearable Headsets Monitor	prototype	1	External Physical Device	wrist button	1	None	/	none
36	1	Wearable Headsets See-through	Kaiser ProView 50ST	1	None	/	none	Optics Marker-based	PhaseSpace Impulse optical tracking system	1
37	1	Spatial Stationary Monitor	N/D	1	None	/	none	Optics Marker-based	3rdTech Hiball-3000	1
38	1	Wearable Headsets See-through	Sony Glasstron	1	Tangible	Physical Tokens	1	Inertia + Optics Marker-based	InterSense IS-1200 tracker +	2
39	1	Wearable Headsets See-through	Sony Glasstron	1	Tangible	Physical Tokens	1	Inertia + Optics Marker-based	InterSense IS-1200 tracker +	2
40	1	Wearable Headsets See-through	nVisorST	1	None	/	none	N/D	N/D	N/D
41	1	Spatial Projected	d DLP projector (InFocus DepthQ)	1	None	/	none	Optics Marker-based	Camera + Fiduciary Markers	1
42	1	Wearable Headsets Monitor	ELMO mini-camera was mounted on a	1	None	/	none	Optics Marker-based	Camera + Fiduciary Markers	1
43	1	Wearable Headsets See-through	COASTAR	1	None	/	none	Optics Marker-based	Camera + Fiduciary Markers	1
44	1	Wearable Headsets See-through	N/D	1	External Physical Device	spring-like objects	1	Optics Marker-based	Camera + Fiduciary Markers	1
45	1	Wearable Headsets Monitor	eMagin HMD + PointGrey DragonFly2 ca	1	Tangible	objects in environment	1	Inertia + Ultrasonic	IS900 system	2
46	1	Wearable Headsets See-through	Olympus Eye-Trek HMD,	1	External Physical Device	Controller for navigation in VR	1	Electromagnetic + Optics Marker-based	Ascension Bird magnetic tracker + ARToolKit	2

Technologies used in studies

Technologies used in studies

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
46	2	Wearable Headsets See-through + Spat	Olympus Eye-Trek HMD, ViewSonic LCI	3	Tangible + Direct Interaction with Device	physical tokens, physical tokens, head handled position, head position	2	Electromagnetic + Optics Marker-based	Ascension Bird magnetic tracker + ARToolKit	2
47	1	Wearable Headsets See-through + Wea	Olympus Mediamask HMD + Mediamasl	2	Head/Eye Tracking	View, Gaze location of 3D objects	1	Optics Marker-based	HiBall Tracking System (LEDs tracking) + cameras	1
	2	Wearable Headsets See-through + Wearable Headsets Monitor	Olympus Mediamask HMD + Mediamask HMD,	2	External Physical Device	mouse	1	Optics Marker-based	HiBall Tracking System (LEDs tracking) + cameras	1
48	1	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
	2	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
	3	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
49	1	Wearable Headsets See-through	N/D	1	None	N/A	none	Optics Marker-based	infrared 3d position sensor	1
50	1	Handled Mobile	mobile phone (AR tennis)	1	Direct Interaction with Device	mobile phone (AR tennis)	1	Optics Marker-based	phone camera + fiduciary marker	1
	2	Handled Mobile	mobile phone (AR tennis)	1	Direct Interaction with Device	mobile phone (AR tennis)	1	Optics Marker-based	phone camera + fiduciary marker	1
51	1	Wearable Headsets Monitor	Z800 3DVisor (eMagin) + Firewire Came	1	External Physical Device	mobile Joystick	1	Optics Marker-based	ARToolkit	1
52	1	Wearable Headsets Monitor	Z800 3DVisor (eMagin) + Firewire Camera	1	External Physical Device	mobile Joystick	1	Optics Marker-based	ARToolkit	1
53	1	Wearable Headsets See-through + Spat	Sony LDI-D100B. (InFocus Proxima	2	Gesture Recognition/Hand Tracking + Voice Recognition + Direct Interaction with Device	Essential Reality P5 glove, IBM ViaVoice 10, MERL DiamondTouch table	3	Inertia + Ultrasonic	InterSense IS-900	2
54	1	Handled Mobile	Sony VAIO UX-VGN-380N/UXVGN-390	1	Direct Interaction with Device	touch-sensitive LCD screen	1	Optics Marker-based	handled device camera + fiduciary markers	1
55	\	\	\	\	\	\	\	\	\	\
56	1	Wearable Headsets See-through	Microvision Nomad ND2100	1	External Physical Device	keyboard device on arm	1	Optics Marker-based	Camera + Fiduciary Markers	1
57	1	Wearable Headsets See-through	Canon VH-2002	1	External Physical Device + Tangible	Jig controller + real objects	2	Electromagnetic	POLHEMUS Fastrak	1
	2	Wearable Headsets See-through	Canon VH-2002	1	External Physical Device + Tangible	Jig controller + real objects	2	Electromagnetic	POLHEMUS Fastrak	1
58	1	Wearable Headsets See-through	Sony LDI-D100B	1	Tangible	physical Token	1	Optics Marker-based	Camera + Fiduciary Markers	1
59	1	Handled Mobile	Vesp'R prototype	1	Direct Interaction with Device	inputs on device	1	Optics not specified	Camera inside prototype + additional tracking methods	1
	2	Handled Mobile	Vesp'R prototype	1	Direct Interaction with Device	inputs on device	1	Optics not specified	Camera inside prototype + additional tracking methods	1
	P	Handled Mobile	Vesp'R prototype	1	Direct Interaction with Device	inputs on device	1	Optics not specified	Camera inside prototype + additional tracking methods	1
60	1	Spatial Projected	NEC NP510W Sprojector	1	External Physical Device + Tangible	stylus with switch + IR LED, Physical surface	2	Optics Marker-based	Camera + IR LEDs projected on the surface	1
61	1	Wearable Headsets See-through	Sony Glasstron	1	None	N/A	none	Optics Marker-based	Camera + Fiduciary Markers	1
62	1	Wearable Headsets See-through	N/D	1	Tangible	physical objects	1	Optics Marker-based	Objects with physical trackers	1

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
63	1	Spatial Stationary Monitor + Wearable H	N/D	2	Tangible + Voice Recognition	test mannequin, test mannequin + voice recognition	2	Optics Marker-based	IR LEDs	1
64	1	Spatial Projected	N/D	1	Tangible	physical objects	1	Optics Marker-based + Electromagnetic	FlashpointTM5000 + Fastrak	2
65	1	Handled Mobile	UMPC with screen	1	Direct Interaction with Device	Joystick on device + devices inputs	1	Wireless + Inertia	GPS + IMU + Camera device	2
66	1	Wearable Headsets Monitor + Spatial St	N/D	2	None	N/A	none	Optics Marker less	Camera with object feature tracking (car engine)	1
67	1	Wearable Headsets See-through	hand heled ocular see-through	1	External Physical Device + Gesture Recognition/Hand Tracking + Voice Recognition	Hand or pen used as 3D pointer + voice controls	3	Optics Marker-based	Camera + Fiduciary Markers	1
68	1	Handled Mobile	magic lens configuration	1	Direct Interaction with Device	Tablet PC inputs	1	Optics Marker less + Inertia	environment features tracking + hybrid with inertia	2
69	1	Spatial Stationary Monitor	Laptop monitor on stationary tripod	1	Direct Interaction with Device	laptop integrated keyboard + mouse	1	Wireless + Electromagnetic	GPS + TCM2 magnetic orientation sensor	2
70	1	Wearable Headsets See-through	N/D	1	None	N/A	none	Optics Marker-based	Camera + Fiduciary Markers	1
71	1	Handled Mobile + Spatial Stationary Se	Projected Table + HMD + Palmtop	3	Tangible + Voice Recognition + Gesture Recognition/Hand Tracking + External Physical Device + Direct Interaction with Device	Magic wand + physical token + hand + laptop/palmtop inputs	5	Optics Marker-based	Camera + physical Markers	1
72	1	Handled Mobile	PDA phone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + physical Markers	1
73	1	Handled Mobile	smartphone	1	Direct Interaction with Device + Tangible	Touch on screen, Position	2	Optics Marker-based	Camera + physical Markers	1
74	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + physical Markers	1
75	1	Handled Mobile	smartphone	1	Direct Interaction with Device + Tangible	Touch on screen, Position	2	Wireless	c	1
									GPS position	1
76	P	Handled Mobile	conceptual smartphone	1	None	/	none	None	/	none
77	1	Handled Mobile	smartphone	1	Direct Interaction with Device + Tangible	Touch on screen, Position	2	Wireless	RFID/NFC tags, GPS	1
78	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
79	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
80	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
	2	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
81	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based + Wireless	Camera + Fiduciary Markers + RFID	2
82	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
83	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1

Technologies used in studies

Technologies used in studies

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
84	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
85	1	Wearable/Handled Projected	Wearable Projector	1	External Physical Device	Tablet PC paired with wearable projector	1	Optics Marker less	Integrated camera with features recognition	1
	P	Wearable/Handled Projected	Wearable Projector	1	None	/	none	None	/	none
86	1	Handled Mobile	smartphone/tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	Camera with features (symbol) recognition	1
87	1	Handled Mobile	smartphone	1	Direct Interaction with Device + Tangible	Touch on screen, Position	2	Inertia + Wireless	GPS + mobile gyro	2
88	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less + Optics Marker-based	RGB-D Cameras systems in the environment + InfiniTrack system	2
89	1	Handled Mobile	smartphone	1	Direct Interaction with Device + Tangible	Touch on screen + Tangible Token	2	Optics Marker less	Camera with features (documents holograms) recognition	1
	P	Handled Mobile	smartphone	1	Direct Interaction with Device + Tangible	Touch on screen + Tangible Token	2	Optics Marker less	Camera with features (documents holograms) recognition	1
90	1	Handled Mobile	Tablet	1	Direct Interaction with Device + Tangible	Touch on screen, Position	2	Inertia + Optics Marker-based + Wireless	GPS + mobile gyro + camera and QR	3
91	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker-based	mobile gyro + camera and QR	2
92	1	Spatial Stationary Monitor	pc monitor	1	Direct Interaction with Device	Traditional computer controls	1	Optics Marker less	webcam + face detection	1
93	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker-based	mobile gyro + camera and QR	2
94	1	Handled Mobile + Spatial Stationary Mo	tablet + smartphone + pc monitor	2	Direct Interaction with Device	Touch on screen + Traditional computer controls	1	Optics Marker less + Inertia + Optics Marker-based	webcam + face detection + mobile gyro + camera and QR	3
95	P	Handled Mobile	conceptual smartphone	1	None	/	none	None	/	none
96	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	webcam + features detection + fiduciary markers	1
97	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	webcam + fiduciary markers	1
98	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker-based + Wireless	GPS + mobile gyro + camera and QR	3
99	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker-based + Wireless	GPS + mobile gyro + camera and QR	3
100	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker-based + Wireless	GPS + mobile gyro + camera and QR	3
101	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker less + Wireless	Bluetooth + mobile gyro + camera w feature detection	3
102	1	Spatial Stationary Monitor	computer monitor	1	Gesture Recognition/Hand Tracking + Tangible	Hands + physical token	2	Optics Marker-based + Optics Marker less	Fiduciary marker + body (hands) detection	2
103	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	camera and QR	1
104	1	Spatial Stationary Monitor	laptop monitor	1	None	/	none	None	/	none

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
104	1	Spatial Stationary Monitor	laptop monitor	1	None	/	none	None		
	2	Wearable Headsets See-through	AR prototype	1	External Physical Device	Wii Nunchuck controller connected with Bluetooth	1	None	/	none
105	1	Handled Mobile + Spatial Stationary Mo	mobile phone + pc monitor	2	Tangible	Surgery induments	1	Optics Marker-based	physical markers on camera and instruments	1
106	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	camera and QR	1
107	1	Handled Mobile	Tablet	1	External Physical Device	laser pointer with Vizard PPT probe attached	1	Optics Marker-based	Vizard PPT cameras + trackers	1
108	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	camera and symbol recognition	1
109	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless	GPS position	1
110	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	Camera + body detection (face)	1
	2	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	Camera + body detection (face)	1
	P	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	Camera + body detection (face)	1
111	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
112	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	None	/	none
113	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	camera and QR	1
114	1	Spatial Stationary Monitor	Magic mirror	1	External Physical Device	App on smartphone	1	Optics Marker less	Kinect body tracking	1
115	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Electromagnetic + Inertia	mobile gyro + compass	2
116	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
117	1	Handled Mobile	PDA phone	1	Direct Interaction with Device	on device controls	1	Optics Marker-based	qi recognition	1
118	1	Spatial Stationary Monitor	computer monitor	1	Tangible	fiduciary marker	1	Optics Marker-based	qi recognition	1
119	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
120	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	image recognition	1
121	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	image recognition	1
122	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
123	1	Handled Mobile	smartphone	1	Direct Interaction with Device + Tangible	Touch on screen + Tangible Token	2	Optics Marker-based	fiduciary markers	1
124	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
125	1	Spatial Stationary Monitor	computer monitor	1	Tangible	fiduciary marker	1	Optics Marker-based	qi recognition	1
126	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
127	1	Spatial Stationary Monitor	computer monitor	1	Tangible	fiduciary marker	1	Optics Marker-based	qi recognition	1
128	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1

Technologies used in studies

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
128	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based		
129	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia	GPS + mobile gyro	2
130	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	image recognition	1
131	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	image recognition	1
132	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
133	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
	2	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
134	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	fiduciary markers	1
135	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	image recognition	1
136	1	Handled Mobile	Tablet	1	Direct Interaction with Device + Gesture Recognition/Hand Tracking	Touch on screen + hand recognition	2	Optics Marker less	image recognition	1
137	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	fiduciary markers	1
138	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	feature recognition (fruit)	1
139	1	Wearable Headsets Monitor	smartphone in headset (google cardboa	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker less	body posture recognition (Kinect)	1
140	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
141	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	image recognition	1
142	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	qi recognition	1
143	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker less	fiduciary markers	1
144	1	Spatial Stationary Monitor	computer monitor	1	Direct Interaction with Device + Gesture Recognition/Hand Tracking	Direct Computer interaction + arms mediation	2	Optics Marker less	Web camera + background separation	1
145	1	Wearable Headsets Monitor	(vuoto)	1	Tangible	P5 data glove	1	Optics Marker-based	webcam + fiduciary markers	1
146	1	Handled Mobile + Spatial Stationary Mo	MIMO 10.1" "iMo Monster" Tablet + tra	2	Direct Interaction with Device + Tangible	Direct Computer interaction + mockup instrumentations	2	Optics Marker less	webcam + image recognition	1
147	1	Handled Mobile + Spatial Stationary Monitor	Tablet + traditional Desktop	2	Direct Interaction with Device	Touch on tablet and PC monitor	1	Optics Marker less	webcam + feature recognition	1
148	1	Handled Mobile + Spatial Stationary Monitor	Tablet/smartphone + traditional Desktc	2	Direct Interaction with Device	Touch/pen on tablet and PC monitor	1	Optics Marker less	webcam + feature recognition	1
	2	Handled Mobile + Spatial Stationary Monitor	Tablet/smartphone + traditional Desktop	2	Direct Interaction with Device	Touch/pen on tablet and PC monitor	1	Optics Marker less	webcam + feature recognition	1
	3	Handled Mobile + Spatial Stationary Monitor	Tablet/smartphone + traditional Desktop	2	Direct Interaction with Device	Touch/pen on tablet and PC monitor	1	Optics Marker less	webcam + feature recognition	1
149	1	Handled Mobile + Spatial Stationary Monitor	Tablet/smartphone + traditional Desktop	2	Direct Interaction with Device	Touch/pen on tablet and PC monitor	1	Optics Marker less	webcam + feature recognition	1
150	\	\	\	\	\	\	\	\	\	\

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
151	\	\	\	\	\	\	\	\	\	\
152	1	Wearable Headsets See-through	LUMUS DK-32	1	Tangible + Gesture Recognition/Hand Tracking	User Position + hand gestures	2	Optics Marker less	SLAM recognition thought video	1
153	1	Wearable Headsets See-through	Cinemizer OLED	1	Gesture Recognition/Hand Tracking	hand gestures	1	Optics Marker less	SLAM recognition thought video	1
	P1	Wearable Headsets See-through	/	1	None	/	none	None	/	none
	P2	Wearable Headsets See-through	Cinemizer OLED	1	Gesture Recognition/Hand Tracking	hand gestures	1	Optics Marker less	SLAM recognition thought video	1
154	1	Handled Mobile	prototype with mobile phone, kinect an	1	Gesture Recognition/Hand Tracking	hand tracking	1	Optics Marker less	SLAM recognition thought Kinect + Optrima	1
155	1	Wearable Headsets Monitor	unspecify	1	Tangible	physical Token	1	Optics Marker-based	webcam + fiduciary markers	1
156	1	Spatial Stationary Monitor	Traditional monitor	1	Other	EMG amplifier (to control virtual arm with the brain)	1	Optics Marker-based	webcam + fiduciary markers	1
157	1	Wearable Headsets Monitor	n i-glasses SVGA 3D ProHMD	1	External Physical Device	mouse handheld	1	N/D	/	N/D
158	1	Wearable Headsets Monitor + Handled	Type-U (Sony) and Webcam Notebook((	2	Direct Interaction with Device	direct interaction with notebook	1	Optics Marker-based	webcam + fiduciary markers	1
159	1	Spatial Stationary Monitor	laptop monitor	1	Direct Interaction with Device + Tangible	Laptop interface + physical tokens	2	Optics Marker-based	webcam + fiduciary markers	1
160	1	Spatial Stationary Monitor	laptop monitor	1	Direct Interaction with Device + Tangible	Laptop interface + physical tokens	2	Optics Marker-based	webcam + fiduciary markers	1
161	1	Spatial Stationary Monitor	laptop monitor	1	Direct Interaction with Device + Tangible	Laptop interface + physical tokens	2	Optics Marker-based	webcam + fiduciary markers	1
162	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
163	\	\	\	\	\	\	\	\	\	\
164	1	Handled Mobile	Handel See-through monitor	1	Tangible	tokens	1	Optics Marker less	webcam + image recognition	1
165	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
166	\	\	\	\	\	\	\	\	\	\
167	1	Spatial Projected	Interactive Whiteboard	1	Tangible	tokens	1	Optics Marker less	webcam + image recognition	1
168	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
	P	Wearable Headsets See-through	/	1	None	/	none	None	/	none
169	1	Wearable Contact (Audio/Headphones)	laptop monitor	2	Gesture Recognition/Hand Tracking	Body (Arm) Tracking	1	Optics Marker less	Camera + Body detection (Arm)	1
170	1	Wearable Contact (Audio/Headphones) + Spatial Projected	Museum Installation + Audio Guide	2	Tangible	Spatial position of guest + Real Object Selection	1	Wireless	Unspecified	1
171	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	webcam + fiduciary markets	1
172	1	Spatial Projected	Traditional projector	1	Gesture Recognition/Hand Tracking	Body (Movements) Tracking	1	Optics Marker less	Webcam + Body detection (Arm)	1

Technologies used in studies

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
172	1	Spatial Projected	Traditional projector	1	Gesture Recognition/Hand Tracking	Body (Movements) Tracking	1	Optics Marker less		
173	1	Spatial Projected	Traditional projector	1	Tangible	tokens	1	Optics Marker less	Webcam + Body detection (Arm)	1
174	P	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	webcam + fiduciary markets	1
175	1	Handled Mobile	Tablet	1	Direct Interaction with Device + Tangible	Touch on screen + Tokens	2	Inertia + Optics Marker-based	mobile gyro + camera and Fiduciary Markers	2
176	1	Spatial Projected	projector	1	Tangible	direct interaction with the board	1	Optics Marker less	camera + features detection (game pieces/hands)	1
177	1	Handled Mobile	cellphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
178	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
179	1	Handled Mobile	PDA	1	Direct Interaction with Device	direct device interaction	1	Wireless	GPS position	1
180	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
181	1	Wearable Headsets Monitor	N/D	1	Tangible	direct interaction with instrument (guitar)	1	Optics Marker-based	Camera + Fiduciary Markers	1
182	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
183	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
	2	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
	3	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
	4	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
184	1	Wearable Headsets See-through + Han	HMD VS Smartphone	2	Direct Interaction with Device	direct interaction	1	Optics Marker-based	Camera + Fiduciary Markers	1
185	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + fiduciary markers + image recognition	1
186	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
187	1	Handled Mobile	Tablet	1	Direct Interaction with Device + Tangible	Touch on screen + Tokens	2	Inertia + Optics Marker-based	mobile gyro + camera and Fiduciary Markers	2
	P	Handled Mobile	Tablet	1	Direct Interaction with Device + Tangible	Touch on screen + Tokens	2	Inertia + Optics Marker-based	mobile gyro + camera and Fiduciary Markers	2
188	\	\	\	\	\	\	\	\	\	\
189	1	Handled Mobile	Tablet	1	Direct Interaction with Device + Tangible	Touch on screen + Tokens	2	Inertia + Optics Marker less	mobile gyro + camera and image recognition	2
190	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
191	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
192	1	Wearable Headsets See-through	N/D	1	Head/Eye Tracking	Eye/gaze Tracking on text	1	None	/	none
193	1	Spatial Projected	projected on instrument	1	Tangible	direct interaction on piano	1	None	/	none

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
194	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
195	1	Spatial Projected	projected on instrument	1	Tangible	direct interaction with table	1	Optics Marker less	camera + features detection (game pieces/hands)	1
	2	Spatial Projected	projected on instrument	1	Tangible	direct interaction with table	1	Optics Marker less	camera + features detection (game pieces/hands)	1
	3	Spatial Projected	projected on instrument	1	Tangible	direct interaction with table	1	Optics Marker less	camera + features detection (game pieces/hands)	1
	4	Spatial Projected	projected on instrument	1	Tangible	direct interaction with table	1	Optics Marker less	camera + features detection (game pieces/hands)	1
196	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
197	1	Spatial Stationary (Audio)	/	1	Tangible	position in real space	1	Inertia + Optics Marker-based	inertia wrists + camera and Fiduciary Markers	2
198	1	Spatial Stationary Monitor + Wearable H	N/D vs Traditional Desktop monitor	2	Direct Interaction with Device + Voice Recognition	Direct Interaction w PC + Voice Recognition	2	N/D	/	N/D
199	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker less	mobile gyro + camera and image recognition	2
200	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
	P	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
201	P1	Handled Mobile	PDA	1	Direct Interaction with Device + Tangible	Touch on screen + CD Label	2	Optics Marker less	Camera + image recognition	1
	P2	Handled Mobile	PDA	1	Direct Interaction with Device + Tangible	Touch on screen + CD Label	2	Optics Marker less	Camera + image recognition	1
202	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
203	1	Handled Mobile	PDA (Gizmondo)	1	Direct Interaction with Device	inputs on device	1	Optics Marker-based	Camera + Fiduciary Markers	1
	P	Handled Mobile	PDA (Gizmondo)	1	Direct Interaction with Device	inputs on device	1	Optics Marker-based	Camera + Fiduciary Markers	1
204	\	\	\	\	\	\	\	\	\	\
205	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker less	mobile gyro + camera and image recognition	2
206	1	Wearable Contact (Audio/Headphones)	Nokia N95 8 GB mobile phone + Beye	1	Direct Interaction with Device	inputs on device	1	Wireless + Electromagnetic	GPS + JAKE compass	2
207	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker less	mobile gyro + camera and image recognition	2
	2	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker less	mobile gyro + camera and image recognition	2
208	1	Handled Mobile	PDA (Gizmondo)	1	Direct Interaction with Device	inputs on device	1	Optics Marker-based	Camera + Fiduciary Markers	1

Technologies used in studies

Technologies used in studies

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
209	1	Handled Mobile	Thoracal	1	Tangible	tokens	1	None	/	none
210	1	Wearable Headsets See-through + Wea	HMD + headphones	2	Tangible	tokens	1	Ultrasonic + Inertia	IS-900 hybrid acoustic–inertial 6 DoF (position and orientation) tracking system	2
	2	Wearable Headsets See-through + Wearable Contact (Audio/Headphones)	HMD + headphones	2	Tangible	tokens	1	Ultrasonic + Inertia	IS-900 hybrid acoustic–inertial 6 DoF (position and orientation) tracking system	2
211	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
212	1	Wearable Headsets See-through	HMD + headphones	1	Tangible	direct interaction w simulated prototype	1	Optics Marker-based	Camera + Fiduciary Markers	1
213	1	Handled Mobile	prototype display + camera	1	Direct Interaction with Device	device inputs + touchscreen	1	Optics Marker-based	Camera + Fiduciary Markers	1
214	1	Wearable Headsets See-through	Liteye LE 750A	1	None	/	none	Optics Marker-based	Camera + Fiduciary Markers	1
215	1	Spatial Projected	wall projector	1	External Physical Device	remote presentation command	1	Optics Marker-based	Camera + Fiduciary Markers	1
216	1	Handled Mobile	Tablet	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	Camera + Fiduciary Markers	1
217	1	Handled Mobile	PDA	1	Direct Interaction with Device + Tangible	inputs on device + tangible	2	Optics Marker-based	Camera + Fiduciary Markers	1
218	1	Handled Mobile	smartphone	1	Direct Interaction with Device + Tangible	Touch on screen + Tangible Token	2	Optics Marker less	Camera with features (documents holograms) recognition	1
219	\	\	\	\	\	\	\	\	\	\
220	1	Wearable Headsets See-through	HMD	1	Tangible	"opportunistic tangible Interfaces"	1	Optics Marker-based	Camera + Fiduciary Markers	1
	2	Wearable Headsets See-through	HMD	1	Tangible	"opportunistic tangible Interfaces"	1	None	WoZ	none
221	1	Wearable Headsets Monitor	HWD Prototype	1	External Physical Device	e wrist-worn controller	1	Optics Marker-based	IR LEDs	1
222	1	Wearable Headsets See-through	n NVIS nVisor ST60 color, stereo, optica	1	Tangible	objects	1	Optics Marker-based	NaturalPoint OptiTrack FLEX:V100R2 and FLEX:V100	1
223	1	Handled Mobile	Tablet	1	Direct Interaction with Device + Tangible	Touch on screen + Tokens	2	Inertia + Optics Marker-based	mobile gyro + fiduciary markers	2
224	1	Wearable Headsets Monitor	HMD	1	Tangible	fiduciary marker	1	Optics Marker-based	Camera + Fiduciary Markers	1
225	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
226	1	Wearable Headsets See-through	OST HMD	1	Gesture Recognition/Hand Tracking	interaction with screen in mid air	1	Optics Marker-based	Camera + Fiduciary Markers	1
227	1	Spatial Projected	projected on prototype	1	Tangible	direct interaction on prototype	1	Optics Marker-based	8 OptiTrack Cameras + physical fiduciary markers on hat	1
228	P	Handled Mobile	conceptual smartphone	1	None	/	none	None	/	none
229	\	\	\	\	\	\	\	\	\	\
230	1	Handled Mobile	Nokia phone	1	Direct Interaction with Device	Phone interface	1	Optics Marker-based	Cam + fiduciary markers	1

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
230	1	Handled Mobile	Nokia phone	1	Direct Interaction with Device	Phone interface	1	Optics Marker-based		
231	1	Wearable Headsets See-through	HWD Prototype	1	External Physical Device	click-turn-wheel adjusting knob on belt	1	Optics Marker-based	A.R.T. marker target	1
232	1	Spatial Projected	Optoma DLPmicro-projector	1	Tangible	writing on paper	1	None	/	none
233	1	Handled Mobile	prototype	1	Direct Interaction with Device	handle prototype interface	1	Wireless + Inertia + Optics Marker less	GPS + Inertia + Camera and lasers	3
	P	Handled Mobile	prototype	1	Direct Interaction with Device	handle prototype interface	1	Wireless + Inertia + Optics Marker less	GPS + Inertia + Camera and lasers	3
234	1	Handled Fixed + Wearable Headsets Mc	monitor on trolley + HMD	2	Direct Interaction with Device	direct interaction on screen	1	Optics Marker-based	Cameras + physical fiduciary markers	1
	P	Handled Fixed + Wearable Headsets Monitor	monitor on trolley + HMD	2	Direct Interaction with Device	direct interaction on screen	1	Optics Marker-based	Cameras + physical fiduciary markers	1
235	\	\	\	\	\	\	\	\	\	\
236	1	Wearable Headsets See-through	Nomad (Microvision) Headset	1	Tangible	Shelf with small boxes	1	Optics Marker-based	Cameras + Physical Marker on Headset	1
237	\	\	\	\	\	\	\	\	\	\
238	1	Wearable Headsets Monitor	HMD	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Inertia	IMU on body junctures	1
239	1	Wearable/Handled Projected	Projector in helmet	1	External Physical Device	iPod touch	1	Inertia + Wireless + Optics Marker-based	GPS + mobile gyro + camera and Fiduciary Markers	3
240	1	Spatial Stationary Monitor + Wearable I	HMD + traditional monitor	2	Tangible	tracker pen used as pointer	1	Optics Marker-based + Optics Marker less	Cameras + physical fiduciary markers + features recognition (pen)	2
241	1	Wearable Headsets Monitor + Handled	HMD + handled	2	Head/Eye Tracking	gaze tracking, direct interaction on handle device	1	Optics Marker-based + Optics Marker less	Cameras + physical fiduciary markers + features recognition (faces and images)	2
242	1	Wearable Headsets See-through	HMD	1	Gesture Recognition/Hand Tracking	Body (Movements) Tracking	1	Optics Marker-based	Cameras + LEDs	1
243	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Optics Marker-based	Cameras + fiduciary marker	1
244	1	Handled Mobile	smartphone	1	Gesture Recognition/Hand Tracking	gestures recognition	1	Optics Marker-based + Optics Marker less	Cameras + fiduciary marker + features recognition (hand + fingers)	2
245	1	Wearable Headsets See-through	google glass	1	Gesture Recognition/Hand Tracking	gestures recognition	1	Optics Marker-based + Optics Marker less	Cameras + fiduciary marker + features recognition (hand + fingers)	2
246	1	Handled Mobile	virtual tablet	1	Gesture Recognition/Hand Tracking	gestures recognition	1	Wireless + Optics Marker-based	InterSenses IS900 PCTracker + WorldViz PPT tracking system	2
247	1	Spatial Projected	Proxima Ultralight x350 DLP projector +	1	Gesture Recognition/Hand Tracking	gestures recognition	1	Mechanical	digital glove	1
248	1	Spatial Projected	BenQ W1080ST	1	Gesture Recognition/Hand Tracking	Body (Movements) Tracking	1	Optics Marker less	Kinect (bod tracking)	1
249	1	Spatial Projected + Handled Mobile	projector + smartphone	2	Direct Interaction with Device + External Physical Device	direct interaction on touchscreen/external interaction on projection	2	Optics Marker-based	Fiduciary marker on fixed image	1

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
250	1	Wearable/Handled Projected	smartphone with projector	1	Direct Interaction with Device + External Physical Device	direct interaction with screen or pointer projected on projection	2	Optics Marker-based	Cameras + fiduciary marker	1
	2	Wearable/Handled Projected	smartphone with projector	1	Direct Interaction with Device + External Physical Device	direct interaction with screen or pointer projected on projection	2	Optics Marker-based	Cameras + fiduciary marker	1
251	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen on live feed	1	Inertia + Optics Marker-based	Cameras + physical fiduciary markers + features recognition (faces and images)	2
									IMU + features recognition (building facade)	2
252	1	Handled Mobile	Nokia N900 smart phone	1	Gesture Recognition/Hand Tracking	hand gestures	1	Optics Marker-based + Optics Marker less	Cameras + physical fiduciary markers (images) + features recognition (hands)	2
253	1	Wearable Headsets See-through	Vuzix Wrap 920AR	1	Gesture Recognition/Hand Tracking	hand gestures	1	Optics Marker less	SLAM recognition thought video	1
254	1	Wearable Headsets See-through	Myvu Crystal Personal Media Viewer (m	1	None	/	none	None	/	none
255	1	Wearable Headsets Monitor	HMD	1	Tangible	tokens	1	Optics Marker-based	Cameras + physical fiduciary markers	1
256	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia + Optics Marker less	GPS + mobile gyro + camera natural features tracking	3
	2	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia + Optics Marker less	GPS + mobile gyro + camera natural features tracking	3
	P	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia + Optics Marker less	GPS + mobile gyro + camera natural features tracking	3
257	1	N/D	/	N/D	None	/	none	Optics Marker less	camera natural features tracking	1
258	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	Tokens (duplos)	1	Optics Marker-based + Optics Marker less	Kinect + cameras	2
259	1	Handled Mobile	smartphone	1	Gesture Recognition/Hand Tracking	air gestures	1	Inertia + Optics Marker less	mobile gyro + camera features tracking (fingers)	2
	2	Handled Mobile	smartphone	1	Gesture Recognition/Hand Tracking + Tangible	air gestures + tangible tokens	2	Inertia + Optics Marker less	mobile gyro + camera features tracking (fingers)	2
260	1	Spatial Stationary Monitor	Traditional monitor	1	External Physical Device	physical device with markers	1	Optics Marker-based	Cameras + physical fiduciary markers	1
261	1	Wearable Headsets See-through	HMD	1	Tangible	"opportunistic tangible Interfaces"	1	Optics Marker-based	Camera + Fiduciary Markers	1
262	1	Handled Mobile	Nokia 6630	1	Direct Interaction with Device + Tangible	Phone interface + marker manipulation	2	Optics Marker-based	Cam + fiduciary markers	1
263	1	Handled Mobile	Nokia 6680	1	Direct Interaction with Device + Gesture Recognition/Hand Tracking	finger interaction with phone + finger detection (with marker)	2	Optics Marker-based	Cam + fiduciary markers	1
264	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker less	mobile gyro + camera features tracking (fingers)	2
265	1	Wearable Headsets Monitor	Tinmith outdoor videosee-through AR s	1	None	/	none	None	/	none

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
266	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker less	mobile gyro + camera features tracking (fingers)	2
267	1	Spatial Projected	projected on real environment around t	1	External Physical Device	external controller	1	Optics Marker less	Kinect	1
268	1	Wearable Headsets Monitor	monocle	1	Gesture Recognition/Hand Tracking	gestures recognition	1	Wireless + Optics Marker-based	GPS + Cam + fiduciary markers on gloves	2
269	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker less	mobile gyro + camera features tracking (fingers)	2
	P	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker less	mobile gyro + camera features tracking (fingers)	2
270	1	Wearable Headsets See-through	HMD	1	External Physical Device	remote joystick and controls	1	Mechanical + Inertia	robot sensors	2
271	1	Wearable Contact (Audio/Headphones)	headphones + smartphone	2	Direct Interaction with Device	touchscreen	1	Wireless + Inertia	GPS + mobile gyro	2
272	1	Handled See-through/Monitor	Hand handled display	1	Gesture Recognition/Hand Tracking + Voice Recognition	hands gestures + speak	2	Optics Marker-based + Optics Marker less	Cam + fiduciary markers + features recognition (hands)	2
273	1	Wearable Headsets Monitor	VR	1	Gesture Recognition/Hand Tracking	hand tracking	1	Inertia + Optics Marker-based	intersense InertiaCube2	2
274	1	Wearable Headsets Monitor	VR	1	Gesture Recognition/Hand Tracking	hand tracking	1	Inertia + Optics Marker-based	intersense InertiaCube3	2
275	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Optics Marker-based	Cam + fiduciary markers	1
276	1	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking + Voice Recognition	hand gestures / interaction with virtual obj + voice recognition	2	Optics Marker less	cam + feature tracking (hands/fingers)	1
	P	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking + Voice Recognition	hand gestures / interaction with virtual obj + voice recognition	2	Optics Marker less	cam + feature tracking (hands/fingers)	1
277	1	Spatial Stationary See-through	prototype by Samsung	1	Gesture Recognition/Hand Tracking	hand tracking	1	Optics Marker less	depth camera (Kinect) features tracking (fingers)	1
278	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia + Optics Marker less	GPS + mobile gyro	3
279	1	Handled Mobile + Spatial Stationary Se	tablet vs stereo-scopic display	2	Tangible + External Physical Device + Direct Interaction with Device	Touch on screen vs wand + shape display	3	Optics Marker-based	Vicon tracker (physical markers)	1
280	1	Wearable Headsets Monitor	HMD	1	External Physical Device	Wii mote with fiduciary marker	1	Optics Marker-based + Optics Marker less	Cam + fiduciary markers	2
281	1	Handled Mobile	smartphone attached to arm/leg	1	Gesture Recognition/Hand Tracking	hands interactions	1	Inertia + Optics Marker less	IMU smartphone + camera feature detection (fingers)	2
282	1	Wearable Headsets See-through	OSTHMD	1	External Physical Device + Voice Recognition + Head/Eye Tracking	Keyboard, Hand-held, Voice, gaze	3	N/D	N/D	N/D
283	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker-based	IMU smartphone Cam + fiduciary markers	2
284	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker-based	IMU smartphone Cam + fiduciary markers	2
285	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker less	IMU smartphone Cam + SLMA on features detection	2

Technologies used in studies

Technologies used in studies

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
285	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker less		
286	1	Wearable Contact (Audio/Headphones)	paper ghost + headphones	1	None	/	none	None	/	none
287	\	\	\	\	\	\	\	\	\	\
288	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker-based + Wireless	GPS + mobile gyro + camera and QR	3
289	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker-based + Wireless	GPS + mobile gyro + camera and QR	3
290	1	Spatial Projected	projector	1	Tangible	interaction on projected	1	Optics Marker less	cam + feature tracking (hands/fingers)	1
291	1	Wearable Headsets Monitor	HMD	1	Gesture Recognition/Hand Tracking	hand recognition	1	Optics Marker-based	Cameras + physical fiduciary markers	1
292	1	Wearable Headsets Monitor	HMD	1	Gesture Recognition/Hand Tracking	hand recognition	1	Optics Marker-based	Cameras + physical fiduciary markers	1
293	\	\	\	\	\	\	\	\	\	\
294	\	\	\	\	\	\	\	\	\	\
295	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Optics Marker-based	camera and image recognition (map)	1
296	1	Handled Mobile	Nokia N95 8GB Symbian phone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Optics Marker less	GPS + camera and image recognition (map)	2
297	1	Spatial Projected	projector	1	Gesture Recognition/Hand Tracking	hands interactions	1	Optics Marker less	depth cam + feature tracking (hands/fingers)	1
298	1	Handled Mobile	Tablet	1	Direct Interaction with Device + Tangible	Touch on screen + Tokens	2	Inertia + Optics Marker-based	mobile gyro + fiduciary markers	2
	2	Handled Mobile	Tablet	1	Direct Interaction with Device + Tangible	Touch on screen + Tokens	2	Inertia + Optics Marker-based	mobile gyro + fiduciary markers	2
299	1	Wearable Headsets See-through	monocle	1	Other	Brain Interface (EEG)	1	Optics Marker-based	fiduciary markers	1
300	\	\	\	\	\	\	\	\	\	\
301	1	Wearable Headsets See-through	smart glasses	1	Head/Eye Tracking	gaze tracking	1	Optics Marker less	cam + features detection (eye)	1
									cam + features detection (eye) SMI Eye Tracking	1
302	1	Wearable Headsets See-through	smart glasses	1	Head/Eye Tracking	gaze tracking	1	Optics Marker less	cam + features detection (eye) SMI Eye Tracking	1
303	1	Spatial Projected	projector	1	External Physical Device + Voice Recognition + Gesture Recognition/Hand Tracking	laser pointer + gesture + voice recognition	3	None	/	none
304	1	Spatial Stationary See-through	paper ghost	1	Gesture Recognition/Hand Tracking + Tangible	hand gestures + tangible tokens	2	Optics Marker less	depth camera (Kinect) features tracking (fingers)	1
305	\	\	\	\	\	\	\	\	\	\
306	\	\	\	\	\	\	\	\	\	\

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
307	\	\	\	\	\	\	\	\	\	\
308	1	Spatial Stationary Monitor	Traditional monitor	1	External Physical Device	robot controls	1	Mechanical	robot sensors	1
309	\	\	\	\	\	\	\	\	\	\
310	1	Spatial Stationary See-through	reality mirror	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker less	Kinect	1
311	1	Spatial Stationary Monitor	Traditional monitor	1	External Physical Device	robot controls	1	Mechanical	robot sensors	1
312	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
	P1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
	P2	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
	P3	Spatial Stationary Monitor	Traditional monitor	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
313	\	\	\	\	\	\	\	\	\	\
314	1	Spatial Stationary Monitor	Enriched Images from camera	1	Tangible	Laparoscopic camera + surgical instrument	1	Mechanical	simulator sensors	1
315	1	Spatial Stationary Monitor	Enriched Images from camera	1	Tangible	Laparoscopic camera + surgical instrument	1	Mechanical	simulator sensors	1
316	1	Wearable Headsets Monitor	5DT	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
317	1	Wearable Headsets Monitor	5DT	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
318	1	Handled Mobile	mobile phone	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
319	1	Wearable Headsets Monitor	5DT	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
320	1	Spatial Stationary Monitor + Wearable H	Enriched Images from camera + VR	2	Tangible	Laparoscopic camera + surgical instrument	1	Mechanical	simulator sensors	1
321	1	Spatial Stationary Monitor	Traditional monitor	1	External Physical Device	robot controls	1	Mechanical	robot sensors	1
	2	Spatial Stationary Monitor	Traditional monitor	1	External Physical Device	robot controls	1	Mechanical	robot sensors	1
322	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	Laparoscopic camera + surgical instrument	1	Optics Marker-based	Camera + reflective Markers	1
323	1	Wearable Contact (Audio/Headphones)	reality goggles + headphones	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Inertia	IMU strapped at belt	1
324	1	Spatial Stationary See-through	pepper ghost	1	Tangible	direct operation on patient	1	None	/	none
325	1	Spatial Stationary See-through	pepper ghost	1	Tangible	direct operation on patient	1	None	/	none
326	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	direct operation on patient	1	Optics Marker-based	Camera + Fiduciary Markers	1
327	1	Spatial Stationary Monitor	Enriched Images from camera	1	Tangible	Laparoscopic camera + surgical instrument	1	Optics Marker-based	Cameras + Physical Marker on instruments	1
328	1	Spatial Stationary Monitor	Enriched Images from camera	1	Tangible	surgical instrument	1	None	/	none
329	1	Handled Fixed	phantom interface	1	Direct Interaction with Device	phantom handle	1	Mechanical	phantom sensors	1

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
330	1	Wearable Headsets Monitor	VR HMD + AR HMD	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker-based	Camera + Fiduciary Markers	1
331	1	Wearable Headsets Monitor	Prototype HMD	1	Tangible	Real objects use	1	Optics Marker-based + Optics Marker less	Camera + fiduciary markers + feature recognition	2
332	1	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker-based	Camera + Fiduciary Markers	1
333	1	Spatial Stationary Monitor	Enriched Images from camera	1	Tangible	Laparoscopic camera + surgical instrument	1	Optics Marker-based	Cameras + Physical Marker on instruments	1
334	1	Spatial Stationary Monitor	Enriched Images from camera	1	Tangible	syringe with hepatic mechanism	1	Optics Marker-based	Camera + Fiduciary Markers	1
335	1	Wearable Headsets See-through	head mounted display googles Sony Gla	1	Gesture Recognition/Hand Tracking	hand movements	1	Mechanical	gloves sensors	1
336	1	Wearable Headsets See-through	head mounted display googles Sony Glasstron	1	Gesture Recognition/Hand Tracking	hand movements	1	Mechanical	gloves sensors	1
337	1	Wearable Headsets Monitor	AR glasses with an integrated pair of st	1	Other	selection and control with two-channel myoelectric interface	1	Optics Marker less	camera + features detection (desks objects)	1
338	1	Spatial Stationary Monitor	Enriched Images from camera	1	Tangible	surgical needle	1	Optics Marker-based	Camera + Fiduciary Markers	1
339	1	Wearable Headsets See-through	head mounted display googles Sony Gla	1	Tangible	Real objects to assemble	1	Optics Marker-based	Camera + Fiduciary Markers	1
340	1	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker less	camera + features detection (hands)	1
	2	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker less	camera + features detection (hands)	1
	3	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker less	camera + features detection (hands)	1
341	1	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker less	camera + features detection (hands)	1
	2	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker less	camera + features detection (hands)	1
	3	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker less	camera + features detection (hands)	1
342	1	Spatial Stationary Monitor	Traditional monitor	1	Gesture Recognition/Hand Tracking	Body (Position / Movements) Tracking	1	Optics Marker less	camera + features detection (hands)	1
343	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	surgical tools	1	Optics Marker-based	Camera + Fiduciary Markers	1
344	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	surgical tools	1	Optics Marker less	endoscopic vide real-time processing	1
345	1	Spatial Stationary Monitor	Traditional monitor	1	External Physical Device	tokens used as brain and slicing plane	1	Optics Marker-based	Camera + Fiduciary Markers	1
346	1	Wearable Headsets Monitor	HMD	1	Tangible	surgical tools	1	Optics Marker-based	Camera + Fiduciary Markers	1
347	1	Wearable Headsets Monitor	HMD	1	N/D	/	N/D	N/D	/	N/D
348	1	Wearable Headsets Monitor	HMD	1	Tangible	tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
349	1	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
350	1	Spatial Stationary See-through	image reflected on a half-silvered mirro	1	External Physical Device	haptic stylus	1	N/D	N/D	N/D
351	1	Handled Mobile + Wearable/Handled Pr	smartphone and handled projector	2	Direct Interaction with Device	touchscreen	1	Wireless + Inertia	tilting sensor and phone sensors	2
352	\	\	\	\	\	\	\	\	\	\
353	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Wireless + Inertia	GPS + IMU smartphone	2

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
353	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Wireless + Inertia		
354	\	\	\	\	\	\	\	\	\	\
355	\	\	\	\	\	\	\	\	\	\
356	1	Handled Mobile	ToMAR system (backpack with touchsc	1	Direct Interaction with Device	display and stylus	1	Wireless + Optics Marker less	indoor (UWB), outdoor (GPS) cam + feature recognition (environment points)	2
357	1	Wearable Headsets See-through	BARS system	1	Tangible	movements in space	1	Wireless	GPS + internal beacons	1
358	1	Wearable Headsets See-through	bi-ocular video see-through HMD	1	External Physical Device	tracked wand	1	Optics Marker-based	Camera + Fiduciary Markers	1
	2	Wearable Headsets See-through	bi-ocular video see-through HMD	1	External Physical Device	tracked wand	1	Optics Marker-based	Camera + Fiduciary Markers	1
359	1	Wearable Contact (Audio/Headphones)	full headphones	1	External Physical Device	external controller	1	Electromagnetic + Wireless	Ubisense RTLS + a tilt-compensated compass HMC6343	2
360	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia	GPS + IMU smartphone	2
	2	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia	GPS + IMU smartphone	2
	3	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia	GPS + IMU smartphone	2
361	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia	GPS + IMU smartphone	2
362	1	Handled Mobile	smartphone	1	Direct Interaction with Device	Touch on screen	1	Wireless + Inertia	GPS + IMU smartphone	2
363	1	Handled Mobile	Symbian OS S60 Nokia mobile phones	1	Direct Interaction with Device	Phone interface	1	Wireless + Inertia + Optics Marker less	GPS + IMU smartphone + camera feature recognition (paper map)	3
364	1	Wearable Headsets Monitor	HMD	1	Tangible	Car controls (wheel...)	1	Wireless + Optics Marker less	GPS + camera and image recognition (road)	2
365	1	Handled Mobile	HTC HD2 smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker-based	IMU smartphone + camera feature recognition (paper map)	2
366	1	Handled Mobile	HTC HD2 smartphone	1	Direct Interaction with Device	touchscreen	1	Inertia + Optics Marker-based	IMU smartphone + camera feature recognition (paper map)	2
367	1	Spatial Projected	Car HUD simulate with Projector	1	Tangible	Car controls (wheel...)	1	Mechanical	Car controls (wheel...)	1
	P1	Spatial Projected	car HUD	1	None	/	none	None	/	none
	P2	Spatial Projected	car HUD	1	None	/	none	None	/	none
368	1	Handled Mobile	Nokia N80 phone	1	Direct Interaction with Device + Tangible	phone interface + physical map	2	Optics Marker-based	Camera + Fiduciary Markers	1
369	1	Handled Mobile	Nokia N95	1	Direct Interaction with Device + Tangible	phone interface + physical map	2	Optics Marker-based	camera and image recognition (map)	1
	2	Handled Mobile	Nokia N95	1	Direct Interaction with Device + Tangible	phone interface + physical map	2	Optics Marker-based	camera and image recognition (map)	1
370	1	Spatial Projected	Car HUD simulate with Projector	1	Tangible	Car controls (wheel...)	1	Mechanical	Car controls (wheel...)	1
371	1	Spatial Projected	Car HUD simulate with Projector	1	Tangible	Car controls (wheel...)	1	Mechanical	Car controls (wheel...)	1

Technologies used in studies

Technologies used in studies

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
372	\	\	\	\	\	\	\	\	\	\
373	\	\	\	\	\	\	\	\	\	\
374	1	Spatial Projected	Car HUD simulate with Projector	1	Tangible	Car controls (wheel...)	1	Mechanical	Car controls (wheel...)	1
375	\	\	\	\	\	\	\	\	\	\
376	1	Handled Mobile	7" handheld display	1	None	/	none	None	/	none
377	1	Handled Mobile	iPhone4S	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker-based	IMU smartphone + camera feature recognition (paper map)	2
	2	Handled Mobile	iPhone4S	1	Direct Interaction with Device	Touch on screen	1	Inertia + Optics Marker-based	IMU smartphone + camera feature recognition (paper map)	2
378	1	Wearable Headsets See-through	Sony Glasstron	1	None	/	none	None	/	none
379	1	Wearable Headsets See-through	Sony Glasstron	1	None	/	none	None	/	none
380	1	Wearable Headsets See-through	Sony Glasstron	1	None	/	none	None	/	none
381	1	Wearable Headsets See-through	Sony Glasstron	1	None	/	none	None	/	none
382	\	\	\	\	\	\	\	\	\	\
383	1	Wearable Headsets Monitor	NVIS nVisor ST head-mounted display s	1	None	/	none	Optics Marker-based	Intersense Vistracker IS-1200 6 DOF optical tracker	1
384	X	N/A	luminisent power cord	N/A	Tangible	use	1	N/A	/	N/A
385	1	Handled See-through/Monitor	tPad prototype	1	Direct Interaction with Device + Tangible	direct interaction with prototype and surface "sensitive"	2	None	/	none
386	1	Spatial Projected	projector	1	None	/	none	None	/	none
387	1	Spatial Stationary Monitor	Traditional monitor	1	None	/	none	None	/	none
	2	Spatial Stationary Monitor	Traditional monitor	1	None	/	none	None	/	none
388	1	Handled Fixed	PHANToM	1	Direct Interaction with Device	PHANToM "stylus"	1	Mechanical	PHANToM mechanisms	1
389	1	Wearable Headsets See-through + Han	PHANToM, Visette45; Cybermind	2	Direct Interaction with Device	PHANToM "stylus"	1	Mechanical + Optics Marker-based	PHANToM mechanisms + Fiduciary Markers	2
390	1	Wearable Headsets See-through	Vis nVisor	1	None	/	none	Inertia + Optics Marker-based	IS-1200	2
391	1	Wearable Headsets See-through	Vis nVisor	1	External Physical Device	Nintendo Wii controller	1	Inertia + Optics Marker-based	InertiaCube 3 - InterSense	2
392	1	Wearable Headsets See-through	Vis nVisor	1	None	/	none	Inertia + Optics Marker-based	IS-1200	2
	2	Wearable Headsets See-through	Vis nVisor	1	None	/	none	Inertia + Optics Marker-based	IS-1200	2
	3	Wearable Headsets See-through	Vis nVisor	1	None	/	none	Inertia + Optics Marker-based	IS-1200	2
	4	Wearable Headsets See-through	Vis nVisor	1	None	/	none	Inertia + Optics Marker-based	IS-1200	2
393	1	Handled Mobile	HTC Evo 3Dand LG Optimus 3D Max	1	None	/	none	None	/	none

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
394	1	Wearable/Handled Projected	"mobile theater" Ovjet prototype	1	External Physical Device	smartphone connected with system	1	Wireless	smartphone GPS and WPS	1
395	\	\	\	\	\	\	\	\	\	\
396	1	Handled Mobile + Spatial Stationary Mo	traditional monitor + coin-type vibrator	2	Gesture Recognition/Hand Tracking	finger distance	1	Optics Marker-based	Camera + Fiduciary Markers	1
	2	Handled Mobile + Spatial Stationary Monitor	traditional monitor + coin-type vibrator	2	Gesture Recognition/Hand Tracking	finger distance	1	Optics Marker-based	Camera + Fiduciary Markers	1
397	1	Wearable Headsets Monitor	NVis SX111 HMD	1	None	/	none	Optics Marker-based	InterSense IS900 tracking system	1
398	\	\	\	\	\	\	\	\	\	\
399	1	Wearable Headsets See-through	prototype	1	None	/	none	None	N/A	none
400	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Optics Marker-based	Camera + Fiduciary Markers	1
401	1	Wearable Headsets See-through	Sony Glasstron LDI-D100BE	1	None	/	none	None	N/A	none
402	\	\	\	\	\	\	\	\	\	\
403	\	\	\	\	\	\	\	\	\	\
404	1	Wearable Headsets See-through	nVisorST	1	External Physical Device	trackball	1	Inertia + Optics Marker-based	IS-1200	2
405	1	Wearable Headsets See-through	nVisorST	1	External Physical Device	keyboard	1	None	Fixed Head position	none
	2	Wearable Headsets See-through	nVisorST, Glasstron, Arvision	1	External Physical Device	trackball	1	None	Fixed Head position	none
406	\	\	\	\	\	\	\	\	\	\
407	1	Wearable Headsets Monitor	HMD not specify	1	None	/	none	None	/	none
408	1	Spatial Stationary Monitor	Traditional monitor	1	None	/	none	None	/	none
409	1	Spatial Stationary Monitor	TV simulating mirror	1	None	/	none	Optics Marker less	Microsoft Kinect	1
410	P	Handled Mobile	conceptual smartphone	1	None	/	none	None	/	none
411	1	Spatial Projected	projector screen with HUD	1	None	/	none	Inertia + Optics Marker-based	IS-900	2
412	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Optics Marker less	camera + feature recognition	1
413	1	Wearable Headsets Monitor	HMD Kaiser ProView XL50	1	None	/	none	None	/	none
414	\	\	\	\	\	\	\	\	\	\
415	1	Wearable Headsets See-through	nVisor ST	1	None	/	none	Optics Marker-based	ARTtrack system	1
416	1	Wearable Headsets See-through	nVisor ST	1	Tangible	tracked physical token	1	Optics Marker-based	camera + physical marker	1
417	1	Wearable Headsets Monitor	MZ-T2 Sony	1	Gesture Recognition/Hand Tracking	real/fake hand	1	Optics Marker-based + Optics Marker less	camera + fiduciary markers + Kinect	2
418	1	Handled Mobile	touch panel screen Hanwha HM-TL7T a	1	Direct Interaction with Device	touchscreen	1	Optics Marker-based + Optics Marker less	camera + fiduciary markers + feature Tracking (eyes)	2
	2	Handled Mobile	touch panel screen Hanwha HM-TL7T and Sony Vaio Duo 11 tablet	1	Direct Interaction with Device	touchscreen	1	Optics Marker-based + Optics Marker less	camera + fiduciary markers + feature Tracking (eyes)	2

Technologies used in studies

ref. paper	ref. Study	Output Type	Output Device	N. Output used	Input Type	Input Device	N. Input Device Used	Tracking Type	Tracking Device	N. Tracking Used
418	2	Handled Mobile	touch panel screen Hanwha HM-TL7T	1	Direct Interaction with Device	touchscreen	1	Optics Marker-based + Optics Marker		
419	1	Handled Mobile	Sony VAIO type UVGN-U70P PAD	1	Direct Interaction with Device	device interface	1	Optics Marker-based + Optics Marker less	Camera + Fiduciary Markers	2
420	1	Wearable Headsets Monitor	HMD not specify	1	None	/	none	None	/	none
	2	Wearable Headsets Monitor	HMD not specify	1	None	/	none	None	/	none
	3	Wearable Headsets Monitor	HMD not specify	1	None	/	none	None	/	none
	P1	Wearable Headsets Monitor	HMD not specify	1	None	/	none	None	/	none
	P2	Wearable Headsets Monitor	HMD not specify	1	None	/	none	None	/	none
421	1	Handled Mobile	unspecified used handheld platform	1	Direct Interaction with Device	device interface	1	N/D	Unspecified	N/D
	2	Handled Mobile	PanasonicCF-U1	1	Direct Interaction with Device	device interface	1	Wireless + Inertia	Ublox AEK-4H (GPS) + Intersense InertiaCube 3 (Inertia)	2
422	1	Handled Mobile	PDA	1	Direct Interaction with Device	device interface	1	Optics Marker-based + Optics Marker less	Camera + Fiduciary Markers	2
423	1	Wearable Headsets Monitor	SVGA Sony Glasstron PLM-S700E	1	External Physical Device	ErgoTouch RocketMouse	1	Inertia + Optics Marker less	InterSense InertiaCube2 + camera and features recognition	2
424	1	Handled Mobile	Nokia N900	1	Direct Interaction with Device	touchscreen	1	Inertia	phone IMU	1
	2	Handled Mobile	Nokia N901	1	Direct Interaction with Device	touchscreen	1	Inertia	intersense InertiaCube3	1
425	1	Wearable Headsets Monitor	NVIS nVisor ST	1	None	/	none	Inertia + Optics Marker-based	InertiaCube2 + camera with IR LEDs	2
	2	Wearable Headsets Monitor	NVIS nVisor ST	1	None	/	none	Inertia + Optics Marker-based	InertiaCube2 + camera with IR LEDs	2
	3	Wearable Headsets Monitor	NVIS nVisor ST	1	None	/	none	Inertia + Optics Marker-based	InertiaCube2 + camera with IR LEDs	2
426	1	Spatial Stationary Monitor	screen on robot	1	Gesture Recognition/Hand Tracking	gestures	1	Optics Marker less	Kinect + features recognition (hands)	1
427	1	Spatial Projected	Traditional projector	1	Tangible	virtual button on table	1	Optics Marker-based	Camera + Fiduciary Markers	1
428	1	Handled Mobile	smartphone	1	Direct Interaction with Device	touchscreen	1	Optics Marker-based	camera + image recognition (Vuforia)	1
429	1	Wearable Contact (Audio/Headphones)	Headphones	1	Tangible	position in real space	1	Wireless	RFID	1
	P	Wearable Contact (Audio/Headphones)	Headphones	1	Tangible	position in real space	1	Wireless	RFID	1
430	\	\	\	\	\	\	\	\	\	\
431	1	Spatial Projected	Traditional projector	1	Tangible	position in real space	1	Optics Marker less	Kinect + features recognition (body position)	1
432	1	Spatial Stationary Monitor	Traditional monitor	1	Tangible	Physical Tokens	1	Optics Marker-based	Camera + Fiduciary Markers	1
433	1	Handled Fixed	Samsung Q1 Ultra Premium UMPC	1	Direct Interaction with Device	device interface	1	Optics Marker-based	camera + feature detection (image/painting)	1

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
1	1	Visual	Navigation & Driving	Driving	Perception Method Comparison	Lab	12
2	1	Visual	Navigation & Driving	Driving	Perception Method Comparison	Lab	27
3	1	Auditory, Visual	Navigation & Driving	Driving	Perception Method Comparison	Lab	24
4	1	Visual	Industry	Maintenance	Perception Method Comparison	Lab	6
5	1	Visual	Industry	Logistics	Perception Method Comparison	Both	19
6	1	Visual	Industry	Manufacturing	Interaction Evaluation	Lab	9
7	1	Auditory, Visual	Industry	Logistics	Perception Method Comparison	Lab	34
8	1	Visual	Health Care & Medicine	Surgery	Perception Method Comparison	Lab	12
9	1	Visual	Health Care & Medicine	Surgery	Perception Method Comparison	Lab	31
10	1	Visual	Health Care & Medicine	Training	Prototype Evaluation	Lab	19
11	1	Visual	Generic Interface	Tangible Interface	Interactions Comparison	Lab	24
12	1	Visual	Generic Interface	Tangible Interface	Perception Method Comparison	Lab	9
13	1	Visual	Generic Interface	Tangible Interface	Interactions Comparison	Lab	30
14	1	Visual	Generic Interface	Tangible Interface	Interactions Comparison	Lab	13
15	1	Visual	Generic Interface	Info presentation / visualization	Interactions Comparison	Lab	24
16	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	3
	2	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	10
17	1	Visual	Generic Interface	Tangible Interface	Interactions Comparison	Lab	15
18	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	25

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
19	1	Visual	Generic Interface	Calibration	Interactions Comparison	Lab	21
20	1	Auditory	Generic Interface	Perception	Perception Method Comparison	Lab	24
21	1	Auditory, Visual	Generic Interface	Perception	Perception Method Comparison	Lab	N/D
22	1	Visual	Generic Interface	Perception	Technologies and Solutions Valuation / Comparisons	Lab	5
23	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	8
24	1	Visual	Generic Interface	Perception	Technologies and Solutions Valuation / Comparisons	Lab	6
25	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	8
26	1	Visual	Generic Interface	Perception	Perception Method Comparison	Both	34
27	1	Visual	Generic Interface	Perception	Perception Method Comparison	Field	16
	2	Visual	Generic Interface	Perception	Perception Method Comparison	N/A	27
28	1	Visual	Generic Interface	Perception	Technologies and Solutions Valuation / Comparisons	Lab	5
29	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	21
30	1	Visual	Communication & Telepresence	Telepresence & Remote collaboration	Perception Method Comparison	Lab	9 10
31	1	Haptic	Generic Interface	Perception	Prototype Evaluation	N/A	N/D
	2	Haptic	Generic Interface	Perception	Prototype Evaluation	N/A	N/D
	3	Haptic	Generic Interface	Perception	Prototype Evaluation	Lab	16
32	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	18
33	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	11

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
34	1	Visual	Entertainment	Gaming	Perception Method Comparison	Lab	615
35	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Field	9
36	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Field	14
37	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Evaluation	Field	6
38	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	28
39	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	26
40	1	Visual	Generic Interface	Perception	Perception Method Comparison	Field	12
41	1	Visual	Communication & Telepresence	Telepresence & Remote collaboration	Perception Method Comparison	Lab	28
42	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	16
43	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	20
44	1	Haptic	Generic Interface	Perception	Perception Method Evaluation	Lab	14
45	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	20
46	1	Visual	Generic Interface	Collaboration	Interactions Comparison	Lab	18
	2	Visual	Generic Interface	Collaboration	Interactions Comparison	Lab	18
47	1	Visual	Generic Interface	Collaboration	Interactions Comparison	Lab	40
	2	Visual	Generic Interface	Collaboration	Interactions Comparison	Lab	26
48	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	N/D
	2	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	N/D
	3	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	20
49	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	N/D

Domain/Field focus and Studies Design

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
49	1	Visual	Generic Interface	Perception	Perception Method Comparison		
50	1	Visual	Entertainment	Gaming	Interactions Comparison	Lab	12
	2	Auditory, Haptic, Visual	Entertainment	Gaming	Interactions Comparison	Lab	12
51	1	Visual	Health Care & Medicine	Emergency	Interaction Evaluation	Lab	30
52	1	Visual	Health Care & Medicine	Emergency	Interaction Evaluation	Lab	24
53	1	Visual	Field Operations	Archaeological	Prototype Evaluation	Lab	6
54	1	Auditory, Visual	Entertainment	Gaming	Interactions Comparison	Lab	18
55	\	\	\	\	\	\	\
56	1	Visual	Industry	Logistics	Perception Method Comparison	Field	12
57	1	Haptic, Visual	Industry	Design & Engineering	Prototype Evaluation	Lab	11
	2	Haptic, Visual	Industry	Design & Engineering	Prototype Evaluation	Lab	N/D
58	1	Visual	Generic Interface	Tangible Interface	Interactions Comparison	Lab	7
59	1	Haptic, Visual	Generic Interface	Interactions & Ergonomics	Prototype Evaluation	Lab	17
	2	Haptic, Visual	Generic Interface	Interactions & Ergonomics	Prototype Evaluation	Lab	15
	P	Haptic, Visual	Generic Interface	Interactions & Ergonomics	Informal feedback or Design process	N/A	N/A
60	1	Visual	Generic Interface	Tangible Interface	Prototype Evaluation	Lab	10
61	1	Visual	Industry	Manufacturing	Prototype Evaluation	Lab	N/A
62	1	Visual	Industry	Manufacturing	Prototype Evaluation	Lab	N/A
63	1	Auditory, Visual	Health Care & Medicine	Training	Prototype Evaluation	Lab	N/A
64	1	Visual	Entertainment	Gaming	Prototype Evaluation	Lab	N/A

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
65	1	Visual	Field Operations	On site planning / maintenance	Prototype Evaluation	Field	5
66	1	Visual	Industry	Maintenance	Perception Method Evaluation	Lab	6
67	1	Visual	Field Operations	On site planning / maintenance	Interaction Evaluation	Both	37
68	1	Visual	Cultural & Tourism	Museum & Exhibitions	Prototype Evaluation	Field	25
69	1	Visual	Field Operations	On site planning / maintenance	Prototype Evaluation	Field	1
70	1	Visual	Entertainment	Narrative experience	Interactions Comparison	Lab	N/D
71	1	Visual	Entertainment	Gaming	Interactions Comparison	Lab	100
72	1	Auditory, Visual	Education & Training	Languages	Methodology Evaluation	Field	64
73	1	Visual	Education & Training	Languages	Methodology Evaluation	Field	5
74	1	Visual	Health Care & Medicine	Training	Methodology Evaluation	Lab	10
75	1	Visual	Education & Training	History	Methodology Evaluation	Field	34
76	P	Visual	Business & Services	Retail	Concept investigation	Field	28
77	1	Visual	Cultural & Tourism	Heritage exploration & discovery	Methodology Evaluation	Field	293
78	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Field	57
79	1	Visual	Education & Training	History	Methodology Evaluation	Field	61
80	1	Auditory, Visual	Industry	Logistics	Prototype Evaluation	Field	21
	2	Auditory, Visual	Industry	Logistics	Prototype Evaluation	Field	63
81	1	Auditory, Visual	Education & Training	Special needs education	Prototype Evaluation	Field	12

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
82	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Field	11
83	1	Visual	Education & Training	Orientation	Prototype Evaluation	Field	18
84	1	Visual	Education & Training	Design, Engineering and Architecture	Prototype Evaluation	Field	40
85	1	Visual	Health Care & Medicine	Elderly / Disables Help	Prototype Evaluation	N/A	13
	P	Visual	Health Care & Medicine	Elderly / Disables Help	Informal feedback or Design process	N/A	35
86	1	Visual	Education & Training	Design, Engineering and Architecture	Prototypes Comparison	Lab	50
87	1	Visual	Cultural & Tourism	Heritage exploration & discovery	Prototype Evaluation	Field	105
88	1	Visual	Health Care & Medicine	Training	Technologies and Solutions Valuation / Comparisons	Lab	N/D
89	1	Visual	Other	Security	Prototype Evaluation	Lab	24
	P	Visual	Other	Security	Informal feedback or Design process	Lab	N/D
90	1	Visual	Cultural & Tourism	Heritage exploration & discovery	Prototype Evaluation	Field	N/D
91	1	Visual	Business & Services	Advertising / Product preview	Interactions Comparison	Lab	60
92	1	Visual	Business & Services	Advertising / Product preview	Interaction Evaluation	Lab	318
93	1	Visual	Education & Training	Science subjects	Interaction Evaluation	Lab	75
94	1	Visual	Business & Services	Advertising / Product preview	Interactions Comparison	Lab	245
95	P	Visual	Business & Services	Retail	Concept investigation	N/A	10154

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
96	1	Visual	Industry	Maintenance	Technologies and Solutions Valuation / Comparisons	Lab	N/D
97	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Lab	41
98	1	Visual	Entertainment	Gaming	Prototype Evaluation	Lab	28
99	1	Visual	Navigation & Driving	Outside orientation & space navigation	Interactions Comparison	Field	65
100	1	Visual	Cultural & Tourism	Heritage exploration & discovery	Technologies and Solutions Valuation / Comparisons	Field	32
101	1	Visual	Cultural & Tourism	Museum & Exhibitions	Prototype Evaluation	Field	122
102	1	Visual	Generic Interface	Tangible Interface	Interactions Comparison	Lab	100
103	1	Visual	Industry	Training	Methodology Evaluation	Lab	10
104	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	16
	2	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	17
105	1	Visual	Health Care & Medicine	Surgery	Perception Method Evaluation	Lab	12
106	1	Visual	Industry	Design & Engineering	Prototype Evaluation	N/D	18
107	1	Visual	Industry	Maintenance	Perception Method Comparison	Lab	20
108	1	Visual	Navigation & Driving	Remote orientation & navigation (i.e. on map)	Interactions Comparison	Lab	44
109	1	Visual	Cultural & Tourism	Commercial exploration & discovery	Prototype Evaluation	Field	220
110	1	Visual	Business & Services	Fashion / Makeup	Concept investigation	Field	31
	2	Visual	Business & Services	Fashion / Makeup	Concept investigation	Field	16
	P	Visual	Business & Services	Fashion / Makeup	Concept investigation	Field	N/A

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
111	1	Visual	Field Operations	On site planning / maintenance	Concept investigation	Field	17
112	1	Visual	Generic Interface	Perception	Perception Method Comparison	N/A	20
113	1	Visual	Cultural & Tourism	Heritage exploration & discovery	Prototypes Comparison	Field	48
114	1	Visual	Business & Services	Fashion / Makeup	Prototype Evaluation	Lab	60
115	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	N/D
116	1	Visual	Industry	Training	Methodology Evaluation	Field	36
117	1	Visual	Education & Training	Languages	Prototype Evaluation	Field	23
118	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Lab	10
119	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Field	25
120	1	Auditory, Visual	Education & Training	History	Prototype Evaluation	Field	5
121	1	Visual	Education & Training	Design, Engineering and Architecture	Prototype Evaluation	Field	16
122	1	Visual	Education & Training	Science subjects	Prototype Evaluation	Field	11
123	1	Visual	Education & Training	Design, Engineering and Architecture	Interaction Evaluation	Lab	36
124	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Field	N/D
125	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Lab	54
126	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Lab	146

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
127	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Lab	35
128	1	Visual	Education & Training	Design, Engineering and Architecture	Interactions Comparison	Lab	22
129	1	Visual	Cultural & Tourism	Heritage exploration & discovery	Prototype Evaluation	Field	10
130	1	Auditory, Visual	Education & Training	Languages	Methodology Evaluation	Field	40
131	1	Visual	Education & Training	Science subjects	Prototype Evaluation	Lab	37
132	1	Visual	Education & Training	Orientation	Prototype Evaluation	Lab	30
133	1	Visual	Health Care & Medicine	Training	Prototype Evaluation	Lab	30
	2	Visual	Health Care & Medicine	Training	Prototype Evaluation	Lab	31 32
134	1	Visual	Education & Training	Design, Engineering and Architecture	Prototype Evaluation	Lab	24
135	1	Auditory, Visual	Education & Training	Languages	Prototype Evaluation	Field	24
136	1	Visual	Education & Training	Languages	Prototype Evaluation	Lab	20
137	1	Visual	Education & Training	Science subjects	Methodology Evaluation	Field	44
138	1	Visual	Health Care & Medicine	Personal Help	Prototype Evaluation	Field	20
139	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Field	74
140	1	Visual	Generic Interface	Perception	Methodology Evaluation	Lab	15
141	1	Visual	Education & Training	Science subjects	Prototype Evaluation	Lab	5
142	1	Visual	Industry	Maintenance	Perception Method Comparison	Lab	20
143	1	Visual	Business & Services	Advertising / Product preview	Prototype Evaluation	N/A	N/A

Domain/Field focus and Studies Design

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
144	1	Visual	Communication & Telepresence	Telepresence & Remote collaboration	Perception Method Evaluation	Lab	10
145	1	Visual	Generic Interface	Collaboration	Interactions Comparison	Lab	16
146	1	Visual	Communication & Telepresence	Remote Help	Perception Method Comparison	Lab	48
147	1	Auditory, Visual	Communication & Telepresence	Remote Help	Interactions Comparison	Field	16
148	1	Visual	Communication & Telepresence	Telepresence & Remote collaboration	Informal feedback or Design process	N/A	25
	2	Visual	Communication & Telepresence	Telepresence & Remote collaboration	Perception Method Comparison	Lab	11
	3	Visual	Communication & Telepresence	Telepresence & Remote collaboration	Interactions Comparison	Lab	11
149	1	Visual	Communication & Telepresence	Telepresence & Remote collaboration	Perception Method Comparison	Field	60
150	\	\	\	\	\	\	\
151	\	\	\	\	\	\	\
152	1	Visual	Communication & Telepresence	Telepresence & Remote collaboration	Perception Method Comparison	Lab	10
153	1	Visual	Field Operations	CSI	Prototype Evaluation	Lab	3
	P1	Visual	Field Operations	CSI	Informal feedback or Design process	N/A	5
	P2	Visual	Field Operations	CSI	Informal feedback or Design process	N/A	5
154	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	8
155	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	16

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
156	1	Visual	Health Care & Medicine	Rehabilitation	Prototypes Comparison	Lab	22
157	1	Visual	Education & Training	Special needs education	Prototype Evaluation	Lab	5
158	1	Visual	Education & Training	Science subjects	Perception Method Comparison	Lab	22
159	1	Visual	Education & Training	Science subjects	Prototype Evaluation	Field	50
160	1	Visual	Education & Training	Science subjects	Prototype Evaluation	Field	29
161	1	Visual	Education & Training	Science subjects	Prototype Evaluation	Lab	3
162	1	Auditory, Visual	Education & Training	Science subjects	Methodology Evaluation	Field	57
163	\	\	\	\	\	\	\
164	1	Visual	Education & Training	Science subjects	Prototypes Comparison	Lab	10
165	1	Visual	Education & Training	Design, Engineering and Architecture	Methodology Evaluation	Field	48
166	\	\	\	\	\	\	\
167	1	Auditory, Visual	Education & Training	Serious game	Methodology Evaluation	Field	54
168	1	Auditory, Visual	Education & Training	Serious game	Prototype Evaluation	Lab	84
	P	Auditory, Visual	Education & Training	Serious game	Informal feedback or Design process	N/A	150
169	1	Visual	Health Care & Medicine	Rehabilitation	Prototype Evaluation	Lab	10
170	1	Auditory, Visual	Cultural & Tourism	Museum & Exhibitions	Prototype Evaluation	Field	8
171	1	Visual	Industry	Assembly	Methodology Evaluation	Lab	28
172	1	Visual	Education & Training	PA	Methodology Evaluation	Field	687
173	1	Visual	Education & Training	Science subjects	Methodology Evaluation	Field	884
174	P	Visual	Education & Training	Other	Prototype Evaluation	Lab	9
175	1	Visual	Education & Training	Science subjects	Methodology Evaluation	Field	60

Domain/Field focus and Studies Design

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
175	1	Visual	Education & Training	Science subjects	Methodology Evaluation		
176	1	Visual	Education & Training	Serious game	Methodology Evaluation	Field	17
177	1	Visual	Education & Training	Serious game	Prototype Evaluation	Lab	38
178	1	Visual	Education & Training	Serious game	Perception Method Comparison	Lab	31
179	1	Auditory, Visual	Education & Training	Serious game	Prototype Evaluation	Field	55
180	1	Visual	Education & Training	Science subjects	Methodology Evaluation	Lab	36
181	1	Auditory, Visual	Education & Training	Music	Prototype Evaluation	Lab	9
182	1	Visual	Education & Training	Serious game	Methodology Evaluation	Field	40
183	1	Auditory, Visual	Education & Training	Other	Concept investigation	Field	304
	2	Auditory, Visual	Education & Training	Other	Concept investigation	Field	304
	3	Auditory, Visual	Education & Training	Other	Concept investigation	Field	304
	4	Auditory, Visual	Education & Training	Other	Comparison with Traditional	Field	304
184	1	Visual	Industry	Maintenance	Interactions Comparison	Lab	16
185	1	Visual	Education & Training	Other	Prototype Evaluation	Lab	15
186	1	Visual	Education & Training	Science subjects	Prototype Evaluation	Lab	21
187	1	Visual	Education & Training	Other	Prototype Evaluation	Lab	47
	P	Visual	Education & Training	Other	Prototype Evaluation	Lab	23
188	\	\	\	\	\	\	\
189	1	Visual	Cultural & Tourism	Museum & Exhibitions	Prototype Evaluation	Field	101
190	1	Visual	Education & Training	Science subjects	Prototype Evaluation	Lab	33
191	1	Auditory, Haptic	Cultural & Tourism	Heritage exploration & discovery	Prototype Evaluation	Field	34

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
192	1	Visual	Health Care & Medicine	Personal Help	Interaction Evaluation	Lab	12
193	1	Auditory, Haptic, Visual	Education & Training	Music	Perception Method Evaluation	Lab	4
194	1	Visual	Education & Training	Science subjects	Prototype Evaluation	Lab	42
195	1	Visual	Education & Training	Serious game	Prototype Evaluation	Lab	18
	2	Visual	Education & Training	Serious game	Prototype Evaluation	Lab	8
	3	Visual	Education & Training	Serious game	Prototype Evaluation	Lab	6
	4	Visual	Education & Training	Serious game	Prototype Evaluation	Lab	6
196	1	Visual	Education & Training	Science subjects	Methodology Evaluation	Both	147
197	1	Visual	Entertainment	Gaming	Prototype Evaluation	Lab	30
198	1	Visual	Entertainment	Narrative experience	Perception Method Evaluation	Lab	12
199	1	Visual	Entertainment	Gaming	Interactions Comparison	Both	16
200	1	Visual	Cultural & Tourism	Museum & Exhibitions	Concept investigation	Both	42
	P	Visual	Cultural & Tourism	Museum & Exhibitions	Concept investigation	N/A	200
201	P1	Visual	Business & Services	Retail	Informal feedback or Design process	N/A	10
	P2	Visual	Business & Services	Retail	Informal feedback or Design process	N/A	10
202	1	Visual	Entertainment	Gaming	Interaction Evaluation	Lab	3
203	1	Visual	Entertainment	Gaming	Interaction Evaluation	Field	12
	P	Visual	Entertainment	Gaming	Informal feedback or Design process	Field	65 66
204	\	\	\	\	\	\	\
205	1	Visual	Navigation & Driving	Outside orientation & space navigation	Perception Method Comparison	Field	26

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
206	1	Auditory	Navigation & Driving	Outside orientation & space navigation	Perception Method Comparison	Field	8
207	1	Visual	Entertainment	Narrative experience	Concept investigation	N/A	56 57 58
	2	Visual	Entertainment	Narrative experience	Informal feedback or Design process	Both	16
208	1	Visual	Entertainment	Gaming	Interaction Evaluation	Lab	18
209	1	Visual	Entertainment	Gaming	Informal feedback or Design process	N/D	9 10
210	1	Auditory, Visual	Entertainment	Gaming	Perception Method Comparison	Lab	40
	2	Auditory, Visual	Entertainment	Gaming	Perception Method Comparison	Lab	20
211	1	Visual	Industry	Design & Engineering	Prototype Evaluation	Field	18
212	1	Visual	Industry	Design & Engineering	Methodology Evaluation	Field	30
213	1	Visual	Industry	Design & Engineering	Interactions Comparison	Lab	10
214	1	Visual	Industry	Maintenance	Perception Method Comparison	Lab	14
215	1	Visual	Industry	Maintenance	Methodology Evaluation	Lab	14
216	1	Visual	Industry	Maintenance	Methodology Evaluation	Lab	40
217	1	Visual	Industry	Assembly	Prototype Evaluation	Lab	8
218	1	Visual	Other	Security	Prototype Evaluation	Lab	17
219	\	\	\	\	\	\	\
220	1	Haptic, Visual	Industry	Training	Interactions Comparison	Lab	15
	2	Haptic, Visual	Generic Interface	Tangible Interface	Concept investigation	Lab	15
221	1	Visual	Industry	Maintenance	Comparison with Traditional	Lab	6

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
222	1	Visual	Industry	Training	Comparison with Traditional	Lab	6
223	1	Visual	Industry	Design & Engineering	Prototype Evaluation	Lab	30
224	1	Visual	Industry	Design & Engineering	Interactions Comparison	Lab	10
225	1	Auditory	Health Care & Medicine	Elderly / Disables Help	Prototype Evaluation	Field	6
226	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	6
227	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	24
228	P	Visual	Business & Services	Retail	Concept investigation	N/A	23
229	\	\	\	\	\	\	\
230	1	Visual	Field Operations	On site planning / maintenance	Prototype Evaluation	Lab	10
231	1	Visual	Industry	Logistics	Perception Method Comparison	Field	16
232	1	Visual	Generic Interface	Tangible Interface	Interactions Comparison	Lab	30
233	1	Visual	Field Operations	On site planning / maintenance	Prototype Evaluation	Field	16
	P	Visual	Field Operations	On site planning / maintenance	Informal feedback or Design process	N/A	N/D
234	1	Visual	Field Operations	On site planning / maintenance	Prototypes Comparison	Field	36
	P	Visual	Field Operations	On site planning / maintenance	Prototypes Comparison	Field	N/D
235	\	\	\	\	\	\	\
236	1	Auditory, Visual	Industry	Logistics	Perception Method Comparison	Lab	34
237	\	\	\	\	\	\	\
238	1	Visual	Industry	Logistics	Perception Method Comparison	Field	12

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
238	1	Visual	Industry	Logistics	Perception Method Comparison		
239	1	Visual	Field Operations	On site planning / maintenance	Comparison with Traditional	Lab	34
240	1	Visual	Industry	Assembly	Comparison with Traditional	Lab	14
241	1	Auditory, Visual	Generic Interface	Interactions & Ergonomics	Perception Method Comparison	Field	15
242	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	11
243	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	10
244	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	32
245	1	Visual	Generic Interface	Interactions & Ergonomics	Prototype Evaluation	Lab	5
246	1	Visual	Generic Interface	Interactions & Ergonomics	Perception Method Comparison	Lab	48
247	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	12
248	1	Visual	Generic Interface	Collaboration	Perception Method Comparison	Lab	11
249	1	Visual	Generic Interface	Collaboration	Perception Method Comparison	Lab	12
250	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	16
	2	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	10
251	1	Visual	Generic Interface	Interactions & Ergonomics	Prototype Evaluation	Field	15
252	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	30

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
253	1	Visual	Field Operations	CSI	Prototype Evaluation	Lab	25
254	1	Visual	Other	Generic Perception on AR - Privacy	Concept investigation	Field	31
255	1	Auditory, Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	22
256	1	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Interactions Comparison	Field	20
					Perception Method Evaluation	Field	20
	2	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Perception Method Evaluation	Field	20
	P	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Interactions Comparison	Field	5
257	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	7
258	1	Visual	Industry	Assembly	Perception Method Comparison	Lab	16
259	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	21
	2	Visual	Generic Interface	Interactions & Ergonomics	Perception Method Comparison	Lab	21
260	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	20
261	1	Haptic, Visual	Industry	Training	Interactions Comparison	Lab	15
262	1	Visual	Generic Interface	Tangible Interface	Interactions Comparison	Lab	9
263	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	12
264	1	Visual	Navigation & Driving	Remote orientation & navigation (i.e. on map)	Perception Method Comparison	Lab	12

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
264	1	Visual	Navigation & Driving	Remote orientation &	Perception Method Comparison		
265	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Field	16
266	1	Visual	Generic Interface	Interactions & Ergonomics	Perception Method Comparison	Field	16
267	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Evaluation	Lab	10
268	1	Visual	Navigation & Driving	Outside orientation & space navigation	Prototype Evaluation	Field	8
269	1	Visual	Cultural & Tourism	Commercial exploration & discovery	Prototypes Comparison	Lab	20
	P	Visual	Cultural & Tourism	Commercial exploration & discovery	Informal feedback or Design process	N/A	N/A
270	1	Auditory, Haptic, Visual	Communication & Telepresence	Telepresence & Remote collaboration	Perception Method Evaluation	Lab	40
271	1	Auditory	Generic Interface	Perception	Perception Method Evaluation	Field	30
272	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	12
273	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	14
274	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	14
275	1	Visual	Generic Interface	Interactions & Ergonomics	Interaction Evaluation	Lab	8
276	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	25
	P	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	5

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
277	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	10
278	1	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Perception Method Evaluation	Field	17
279	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	10
280	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	16
281	1	Visual	Generic Interface	Interactions & Ergonomics	Concept investigation	Lab	15
282	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	24 25
283	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	28
284	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	28
285	1	Visual	Generic Interface	Interactions & Ergonomics	Perception Method Comparison	Lab	7
286	1	Auditory, Visual	Generic Interface	Collaboration	Perception Method Comparison	Lab	48
287	\	\	\	\	\	\	\
288	1	Visual	Other	Generic Perception on AR - State of the art	Concept investigation	N/A	90
289	1	Visual	Other	Generic Perception on AR - State of the art	Concept investigation	N/A	90
290	1	Visual	Generic Interface	Tangible Interface	Comparison with Traditional	Lab	24
291	1	Haptic	Generic Interface	Interactions & Ergonomics	Perception Method Evaluation	Lab	13

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
291	1	Haptic	Generic Interface	Interactions & Ergonomics	Perception Method Evaluation		
292	1	Haptic	Generic Interface	Interactions & Ergonomics	Perception Method Evaluation	Lab	13
293	\	\	\	\	\	\	\
294	\	\	\	\	\	\	\
295	1	Visual	Navigation & Driving	Remote orientation & navigation (i.e. on map)	Perception Method Comparison	Lab	17
296	1	Visual	Generic Interface	Interactions & Ergonomics	Interaction Evaluation	Field	12
297	1	Visual	Navigation & Driving	Inside orientation & space navigation	Interaction Evaluation	Lab	10
298	1	Visual	Generic Interface	Tangible Interface	Interaction Evaluation	Lab	9
	2	Visual	Generic Interface	Tangible Interface	Interaction Evaluation	Lab	21
299	1	Visual	Generic Interface	Interactions & Ergonomics	Comparison with Traditional	Lab	15
300	\	\	\	\	\	\	\
301	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	9
302	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	14
303	1	Visual	Generic Interface	Interactions & Ergonomics	Informal feedback or Design process	Lab	9
304	1	Visual	Industry	Design & Engineering	Interactions Comparison	Lab	10 12
305	\	\	\	\	\	\	\
306	\	\	\	\	\	\	\

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
307	\	\	\	\	\	\	\
308	1	Visual	Communication & Telepresence	Telepresence Surgery	Perception Method Comparison	Lab	9
309	\	\	\	\	\	\	\
310	1	Visual	Health Care & Medicine	Rehabilitation	Comparison with Traditional	Lab	8
311	1	Visual	Communication & Telepresence	Telepresence Surgery	Comparison with Traditional	Field	12
312	1	Visual	Health Care & Medicine	Elderly / Disables Help	Prototype Evaluation	Field	12
	P1	Visual	Health Care & Medicine	Elderly / Disables Help	Prototype Evaluation	N/A	N/D
	P2	Visual	Health Care & Medicine	Elderly / Disables Help	Prototype Evaluation	Field	4
	P3	Visual	Health Care & Medicine	Elderly / Disables Help	Prototype Evaluation	Field	4
313	\	\	\	\	\	\	\
314	1	Haptic, Visual	Health Care & Medicine	Surgery	Prototypes Comparison	Lab	90
315	1	Haptic, Visual	Health Care & Medicine	Surgery	Prototype Evaluation	Lab	55
316	1	Visual	Health Care & Medicine	Phobia Treatment	Methodology Evaluation	Field	1
317	1	Visual	Health Care & Medicine	Phobia Treatment	Methodology Evaluation	Field	6
318	1	Visual	Health Care & Medicine	Phobia Treatment	Methodology Evaluation	Field	1
319	1	Visual	Health Care & Medicine	Phobia Treatment	Methodology Evaluation	Field	6
320	1	Haptic, Visual	Health Care & Medicine	Training	Methodology Evaluation	Lab	36 37
321	1	Visual	Communication & Telepresence	Telepresence Surgery	Comparison with Traditional	Lab	15
	2	Visual	Communication & Telepresence	Telepresence Surgery	Comparison with Traditional	Lab	11

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
321	2	Visual	Communication &	Telepresence Surgery	Comparison with Traditional		
322	1	Visual	Health Care & Medicine	Surgery	Perception Method Comparison	Lab	12
323	1	Auditory, Visual	Health Care & Medicine	Rehabilitation	Perception Method Comparison	Field	13
324	1	Visual	Health Care & Medicine	Surgery	Prototype Evaluation	Field	N/D
325	1	Visual	Health Care & Medicine	Surgery	Prototype Evaluation	Field	N/D
326	1	Visual	Health Care & Medicine	Training	Prototype Evaluation	Field	3 4 5
327	1	Visual	Health Care & Medicine	Training	Comparison with Traditional	Lab	12 13 14
328	1	Visual	Health Care & Medicine	Training	Perception Method Comparison	Lab	25
329	1	Haptic	Health Care & Medicine	Training	Perception Method Evaluation	Lab	12
330	1	Visual	Health Care & Medicine	Phobia Treatment	Technologies and Solutions Valuation / Comparisons	Lab	20
331	1	Visual	Health Care & Medicine	Phobia Treatment	Perception Method Comparison	Lab	24
332	1	Visual	Health Care & Medicine	Rehabilitation	Prototype Evaluation	Field	4
333	1	Visual	Health Care & Medicine	Training	Comparison with Traditional	Lab	34
334	1	Auditory, Haptic, Visual	Health Care & Medicine	Training	Comparison with Traditional	Lab	40
335	1	Haptic, Visual	Health Care & Medicine	Rehabilitation	Prototype Evaluation	Lab	1
336	1	Haptic, Visual	Health Care & Medicine	Rehabilitation	Prototypes Comparison	Lab	3
337	1	Visual	Health Care & Medicine	Rehabilitation	Prototype Evaluation	Lab	13
338	1	Visual	Health Care & Medicine	Training	Prototype Evaluation	Lab	2
339	1	Auditory, Visual	Health Care & Medicine	Training	Prototype Evaluation	Lab	12

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
340	1	Visual	Health Care & Medicine	Rehabilitation	Prototype Evaluation	Lab	43
	2	Visual	Health Care & Medicine	Rehabilitation	Prototype Evaluation	Lab	100
	3	Visual	Health Care & Medicine	Rehabilitation	Prototype Evaluation	Lab	7
341	1	Haptic, Visual	Generic Interface	Perception	Prototype Evaluation	Lab	24
	2	Haptic, Visual	Generic Interface	Perception	Prototype Evaluation	Lab	29
	3	Visual	Health Care & Medicine	Rehabilitation	Prototype Evaluation	Lab	5
342	1	Visual	Health Care & Medicine	Rehabilitation	Prototype Evaluation	Lab	6
343	1	Visual	Health Care & Medicine	Training	Prototype Evaluation	Lab	60
344	1	Visual	Health Care & Medicine	Surgery	Prototype Evaluation	Lab	1 2
345	1	Visual	Health Care & Medicine	Training	Methodology Evaluation	Field	34
346	1	Visual	Health Care & Medicine	Surgery	Prototype Evaluation	Lab	1
347	1	Visual	Health Care & Medicine	Training	Methodology Evaluation	Field	34
348	1	Visual	Health Care & Medicine	Phobia Treatment	Methodology Evaluation	Field	22 23
349	1	Visual	Health Care & Medicine	Rehabilitation	Comparison with Traditional	Lab	21
350	1	Haptic, Visual	Health Care & Medicine	Training	Prototype Evaluation	Lab	16
351	1	Visual	Navigation & Driving	Inside orientation & space navigation	Perception Method Comparison	Field	24
352	\	\	\	\	\	\	\
353	1	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Prototypes Comparison	Field	11
354	\	\	\	\	\	\	\

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
355	\	\	\	\	\	\	\
356	1	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Prototype Evaluation	Field	12
357	1	Visual	Navigation & Driving	Inside orientation & space navigation	Perception Method Comparison	Lab	120
358	1	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	15
	2	Visual	Generic Interface	Interactions & Ergonomics	Interactions Comparison	Lab	18
359	1	Visual	Navigation & Driving	Inside orientation & space navigation	Perception Method Comparison	Field	33
360	1	Visual	Cultural & Tourism	Commercial exploration & discovery	Prototype Evaluation	Field	10
	2	Visual	Cultural & Tourism	Commercial exploration & discovery	Prototype Evaluation	Field	6
	3	Visual	Cultural & Tourism	Commercial exploration & discovery	Prototype Evaluation	Field	42
361	1	Visual	Navigation & Driving	Inside orientation & space navigation	Perception Method Comparison	N/A	81
362	1	Visual	Navigation & Driving	Inside orientation & space navigation	Perception Method Comparison	Field	12
363	1	Visual	Entertainment	Gaming	Prototype Evaluation	Field	37
364	1	Visual	Navigation & Driving	Driving	Perception Method Evaluation	Field	44
365	1	Visual	Navigation & Driving	Inside orientation & space navigation	Interaction Evaluation	Field	10
366	1	Visual	Navigation & Driving	Outside orientation & space navigation	Prototype Evaluation	Field	9

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
367	1	Visual	Navigation & Driving	Driving	Perception Method Evaluation	Lab	16
	P1	Visual	Navigation & Driving	Driving	Informal feedback or Design process	Field	12
	P2	Visual	Navigation & Driving	Driving	Informal feedback or Design process	Field	N/D
368	1	Visual	Navigation & Driving	Remote orientation & navigation (i.e. on map)	Perception Method Comparison	Lab	17
369	1	Visual	Navigation & Driving	Remote orientation & navigation (i.e. on map)	Interactions Comparison	Lab	16
	2	Visual	Navigation & Driving	Remote orientation & navigation (i.e. on map)	Interactions Comparison	Lab	17
370	1	Visual	Navigation & Driving	Driving	Perception Method Comparison	Lab	27
371	1	Visual	Navigation & Driving	Driving	Perception Method Comparison	Lab	20
372	\	\	\	\	\	\	\
373	\	\	\	\	\	\	\
374	1	Visual	Navigation & Driving	Driving	Perception Method Comparison	Lab	5
375	\	\	\	\	\	\	\
376	1	Visual	Generic Interface	Perception	Perception Method Comparison	Field	20
377	1	Visual	Generic Interface	Perception	Perception Method Comparison	Field	27
	2	Visual	Generic Interface	Perception	Perception Method Comparison	Field	12
378	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	18
379	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	18
380	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	24

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
381	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	24
382	\	\	\	\	\	\	\
383	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	107
384	X	Visual	Generic Interface	Info presentation / visualization	Informal feedback or Design process	Lab	15
385	1	Visual	Generic Interface	Interactions & Ergonomics	Prototype Evaluation	Lab	8
386	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Evaluation	Lab	10
387	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	N/A	6
	2	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	N/A	20
388	1	Haptic	Generic Interface	Perception	Perception Method Evaluation	Lab	12
389	1	Haptic	Generic Interface	Perception	Perception Method Evaluation	Lab	6
390	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	N/D
391	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	11
392	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	39
	2	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	11
	3	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	11
	4	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	16
393	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	12
394	1	Visual	Other	Generic Perception on AR - Immersion / motivation	Concept investigation	Field	20

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
394	1	Visual	Other	Generic Perception on AR -	Concept investigation		
395	\	\	\	\	\	\	\
396	1	Haptic, Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	14
	2	Haptic, Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	14
397	1	Visual	Generic Interface	Perception	Perception Method Comparison	Field	10
398	\	\	\	\	\	\	\
399	1	Visual	Generic Interface	Perception	Technologies and Solutions Valuation / Comparisons	Lab	8
400	1	Visual	Communication & Telepresence	Remote Help	Perception Method Comparison	Lab	16
401	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	8
402	\	\	\	\	\	\	\
403	\	\	\	\	\	\	\
404	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	12
405	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	12
	2	Visual	Generic Interface	Perception	Technologies and Solutions Valuation / Comparisons	Lab	24
406	\	\	\	\	\	\	\
407	1	Visual	Field Operations	Military Operations	Perception Method Comparison	Field	14
408	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	20
							21
409	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	12
410	P	Visual	Other	Generic Perception on AR - Expectations / acceptance	Concept investigation	N/A	260

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
410	P	Visual	Other	Generic Perception on AR -	Concept investigation		
411	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	16
412	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	15
413	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	8
414	\	\	\	\	\	\	\
415	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	18
416	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	40
417	1	Visual	Generic Interface	Perception	Perception Method Evaluation	Lab	21
418	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	8
	2	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	8
419	1	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Perception Method Comparison	Field	14
420	1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	16
	2	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	40
	3	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	40
	P1	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	3
	P2	Visual	Generic Interface	Info presentation / visualization	Perception Method Comparison	Lab	3
421	1	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Informal feedback or Design process	Field	8

ref. paper	ref. Study	Senses Augmented / Used	Field / Domain	Field / Sub-Domain	Type Of Study Evaluation	Study Setting	n. Participants
421	2	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Perception Method Evaluation	Field	9
422	1	Visual	Cultural & Tourism	Museum & Exhibitions	Perception Method Comparison	Lab	13
423	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	19
424	1	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Perception Method Evaluation	Field	9
	2	Visual	Navigation & Driving	Info / Annotations AR & Remote viewing	Perception Method Comparison	Field	18
425	1	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	25
	2	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	13
	3	Visual	Generic Interface	Perception	Perception Method Comparison	Lab	13
426	1	Visual	Other	human/robot/AI interaction	Interaction Evaluation	Lab	12
427	1	Auditory, Visual	Cultural & Tourism	Museum & Exhibitions	Prototype Evaluation	Field	155
428	1	Auditory, Visual	Other	Generic Perception on AR - Privacy	Interactions Comparison	Field	31
429	1	Auditory	Cultural & Tourism	Museum & Exhibitions	Interaction Evaluation	Field	6
	P	Auditory	Cultural & Tourism	Museum & Exhibitions	Informal feedback or Design process	Field	2
430	\	\	\	\	\	\	\
431	1	Auditory, Visual	Cultural & Tourism	Museum & Exhibitions	Interaction Evaluation	Field	362
432	1	Visual	Cultural & Tourism	Museum & Exhibitions	Technologies and Solutions Valuation / Comparisons	Lab	29
433	1	Visual	Cultural & Tourism	Museum & Exhibitions	Methodology Evaluation	Field	16

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
1	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	response time	Task performance	reaction time
1	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	car position	Task performance	accuracy
1	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Task performance	errors
1	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived ease of use	UX - Usability	ease of use
1	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
1	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	preference	UX - Usability	preference
2	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	car position	Task performance	accuracy
2	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	car speed	Task performance	accuracy
2	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 6 scale	-	concentration	Ergonomics / Load / Comfort	cognitive load
2	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 6 scale	-	perceived performance	UX - Usability	perceived performance
2	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 6 scale	-	perceived safety	UX - Emotion	trust (perceived safety)
2	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 6 scale	-	pleasure	UX - Emotion	amusement / fun
2	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	task load	Ergonomics / Load / Comfort	cognitive load
3	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	car position	Task performance	accuracy
3	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	car speed	Task performance	accuracy
3	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Task performance	errors
3	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	response time	Task performance	reaction time
3	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 6 scale	-	perceive efficiency	UX - Usability	efficiency
3	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 6 scale	-	perceived performance	UX - Usability	perceived performance
3	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 6 scale	-	preference	UX - Usability	preference
4	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
4	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	errors	Task performance	errors
4	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	head position	Task performance	accuracy
4	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use
4	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
4	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
5	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Task performance	errors
5	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
5	1	2	Quantitative	Objective	Empirical Experimental	User Measurements	Heart Rate Variability (HRV)	-	-	strain	Ergonomics / Load / Comfort	physical load
5	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	strain	Ergonomics / Load / Comfort	physical load
6	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	accuracy	Task performance	accuracy
6	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
7	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Task performance	errors

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
7	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-			
7	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
7	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	usability problem cope strategy	interaction	learning / problem coping strategy
7	1	3	Quantitative	Objective	Empirical Experimental	User Measurements	Heart Rate Variability (HRV)	-	-	strain	Ergonomics / Load / Comfort	physical load
7	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Cornell Musculoskeletal Discomfort Questionnaires (CMDQ)	-	-	perceived discomfort	Ergonomics / Load / Comfort	comfort / sickness
7	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	EZ-Scale	-	-	strain	Ergonomics / Load / Comfort	physical load
7	1	5	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	questions on the interaction/strategy	interaction	interaction strategy and system use
8	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	accuracy	Task performance	accuracy
8	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	complexation time	Task performance	completion time
8	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	ease of use	UX - Usability	ease of use
8	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived performance	UX - Usability	perceived performance
8	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	preference	UX - Usability	preference
9	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	accuracy	Task performance	accuracy
9	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
9	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	motions	Task performance	accuracy
9	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	suggestions	Prototype focus	comments / suggestions
9	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	ease of use	UX - Usability	ease of use
9	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived performance	UX - Usability	perceived performance
9	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	preference	UX - Usability	preference
10	1	1	Qualitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	attention	interaction	attention / focus
10	1	1	Qualitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	level of understanding	Task performance	errors
10	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	preference	UX - Usability	preference
10	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived confidence	UX - Emotion	trust (perceived safety)
10	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
11	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Task performance	errors
11	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
11	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	preference	UX - Usability	preference
12	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
12	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	hand positions	Task performance	accuracy
12	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	system preference	UX - Usability	preference
12	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of use	UX - Usability	ease of use

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
12	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	naturalness	UX - Usability	naturalness
12	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived speed	UX - Usability	effectiveness
12	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	strain	Ergonomics / Load / Comfort	physical load
12	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	opinions	Prototype focus	feedbacks / insights
13	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	attempts	Task performance	n. trails
13	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
13	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	opinions	Prototype focus	feedbacks / insights
13	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	balanced scale: -2 -1 +1 +2	-	ease of use	UX - Usability	ease of use
13	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	balanced scale: -2 -1 +1 +2	-	usability mixed	UX - Usability	usability - unspecified
14	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
14	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Task performance	errors
14	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open comments	-	opinions	Prototype focus	feedbacks / insights
14	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use
14	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
14	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
14	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference	UX - Usability	preference
15	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	accuracy	Task performance	accuracy
15	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
15	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	ease of use	UX - Usability	ease of use
15	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	intuitiveness	UX - Usability	intuitiveness
15	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	preference	UX - Usability	preference
16	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
16	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	attempts	Task performance	n. trails
16	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
16	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	confidence	UX - Emotion	trust (perceived safety)
16	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use
17	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
17	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	ease of use	UX - Usability	ease of use
17	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	intuitiveness	UX - Usability	intuitiveness
17	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	naturalness	UX - Usability	naturalness
17	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference	UX - Usability	preference
18	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	attempts	Task performance	n. trails
18	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
18	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-			
18	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - 2000(E)	Yes	ease of use	UX - Usability	ease of use
18	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - 2000(E)	Yes	effectiveness	UX - Usability	effectiveness
18	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - 2000(E)	Yes	effort	Ergonomics / Load / Comfort	task perceived effort
18	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - 2000(E)	Yes	preference	UX - Usability	preference
18	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - 2000(E)	Yes	smoothness	UX - Usability	system smoothness / response time
18	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - 2000(E)	Yes	strain	Ergonomics / Load / Comfort	physical load
19	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
19	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Task performance	errors
20	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	auditory perception (movement)	Perception/Cognition	virtual environment / object recognition
20	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	auditory perception (position)	Perception/Cognition	virtual environment / object recognition
21	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	auditory perception (movement)	Perception/Cognition	virtual environment / object recognition
21	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	auditory perception (position)	Perception/Cognition	virtual environment / object recognition
22	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	eye accommodation	-	-	accommodation response	Perception/Cognition	physical body responses
22	1	2	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	perceived depth	Perception/Cognition	perceived (or evaluated) depth or distance
23	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
23	1	2	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	errors	Perception/Cognition	perception related errors
23	1	3	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception related completion time
24	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perceived distance	Perception/Cognition	perceived (or evaluated) depth or distance
25	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	perceived depth	Perception/Cognition	perceived (or evaluated) depth or distance
26	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	accuracy	Perception/Cognition	perception related accuracy
26	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception related completion time
26	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open comments	-	feedbacks	Prototype focus	feedbacks / insights
26	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
26	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
26	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	strain	Ergonomics / Load / Comfort	physical load
26	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
27	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception related completion time
27	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open comments	-	preference	UX - Usability	preference

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
27	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open comments	-			
27	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived performance	UX - Usability	perceived performance
27	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	preference	UX - Usability	preference
27	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	perceived performance	UX - Usability	perceived performance
28	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	target perception	Perception/Cognition	virtual environment / object recognition
28	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perceived color	Perception/Cognition	virtual environment / object recognition
28	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
28	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception related completion time
29	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users search behavior	interaction	interaction strategy and system use
29	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception related completion time
29	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Perception/Cognition	perception related errors
29	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	search time	Perception/Cognition	perception related completion time
29	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived performance	UX - Usability	perceived performance
30	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived operability	UX - Usability	ease of use
30	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived searchability	UX - Usability	efficiency
31	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
31	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	Preferences	UX - Usability	preference
31	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
31	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	Preferences	UX - Usability	preference
31	3	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	observed ergonomics	Ergonomics / Load / Comfort	ergonomic properties
31	3	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
31	3	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference	UX - Usability	preference
31	3	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	usability	UX - Usability	usability - unspecified
32	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	subject general tech use	Mixed background questions	subject technological comfort / general use
32	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ITU-R BT - Methodology for the Subjective Assessment of the Quality of Television Pictures	1 to 5 scale	-	perceived visual quality	Perception/Cognition	virtual environment / object perceived quality
33	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	perceived depth	Perception/Cognition	perceived (or evaluated) depth or distance
33	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	response time	Perception/Cognition	perception related response time
34	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	amusement	UX - Emotion	amusement / fun
34	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	comfort	Ergonomics / Load / Comfort	comfort / sickness

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
34	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	perceived visual quality	Perception/Cognition	virtual environment / object perceived quality
34	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	real world perception	Perception/Cognition	real environment / object recognition
35	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	perception	Perception/Cognition	virtual environment / object recognition
35	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	text readability	Perception/Cognition	virtual environment / object perceived quality
35	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	visibility	Perception/Cognition	virtual environment / object recognition
36	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
36	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	response time	Perception/Cognition	perception related response time
36	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	concentration	Ergonomics / Load / Comfort	cognitive load
36	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	pain/fatigue	Ergonomics / Load / Comfort	comfort / sickness
36	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perception problems	Perception/Cognition	virtual environment / object recognition
36	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	real world perception	Perception/Cognition	real environment / object recognition
36	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	strain	Ergonomics / Load / Comfort	physical load
37	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
37	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	response time	Perception/Cognition	perception related response time
38	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
38	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	effort	Ergonomics / Load / Comfort	task perceived effort
38	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
38	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	metal demand	Ergonomics / Load / Comfort	cognitive load
38	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	physical demand	Ergonomics / Load / Comfort	physical load
38	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	attempts	Perception/Cognition	perception related n. attempts
38	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	time	Perception/Cognition	perception related completion time
38	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	hand positions	interaction	users movements / gestures / physical utilization of prototype
38	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	user gaze	interaction	attention / focus
39	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
39	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	attempts	Perception/Cognition	perception related n. attempts
39	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception related completion time
39	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	hand positions	interaction	users movements / gestures / physical utilization of prototype
39	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	user gaze	interaction	attention / focus
39	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	effort	Ergonomics / Load / Comfort	task perceived effort

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
39	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-			
39	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
39	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	metal demand	Ergonomics / Load / Comfort	cognitive load
39	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	physical demand	Ergonomics / Load / Comfort	physical load
40	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
40	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception related completion time
40	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale	-	perceived difficulty	UX - Usability	perceived task/interaction difficulty
40	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open comments	-	discomfort (dizziness, eye strain, fatigue)	Ergonomics / Load / Comfort	comfort / sickness
41	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 3 scale	-	perceived discomfort	Ergonomics / Load / Comfort	comfort / sickness
42	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception related completion time
42	1	2	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	errors	Perception/Cognition	perception related errors
42	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	ease of use	UX - Usability	ease of use
42	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	perceived performance	UX - Usability	perceived performance
42	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	physical ease	Ergonomics / Load / Comfort	physical load
42	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference	UX - Usability	preference
43	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	virtual e/o perception	Perception/Cognition	virtual environment / object recognition
43	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	virtual object presence	Perception/Cognition	virtual environment / object recognition
43	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	virtual object quality	Perception/Cognition	virtual environment / object perceived quality
43	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception related completion time
43	1	3	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	head movements	interaction	attention / focus
44	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	force applied	Perception/Cognition	hepatics
44	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	perceived stiffness	Perception/Cognition	hepatics
45	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	stress/anxiety behaviors	Ergonomics / Load / Comfort	frustration / stress / anxiety
45	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	exclamations	Ergonomics / Load / Comfort	frustration / stress / anxiety
45	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	work loads	Ergonomics / Load / Comfort	task perceived effort
45	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	Yes	distractions	interaction	attention / focus
45	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	Yes	perceived presence	Perception/Cognition	sense of presence / immersion
45	1	3	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	accuracy	Perception/Cognition	perception related accuracy
45	1	3	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	attempts	Perception/Cognition	perception related n. attempts
45	1	4	Quantitative	Objective	Empirical Experimental	User Measurements	Galvanic Skin Response (GSR)	-	-	stress/anxiety	Ergonomics / Load / Comfort	frustration / stress / anxiety
45	1	4	Quantitative	Objective	Empirical Experimental	User Measurements	Heart Rate Variability (HRV)	-	-	stress/anxiety	Ergonomics / Load / Comfort	frustration / stress / anxiety

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
45	1	5	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	comments	Prototype focus	comments / suggestions
45	1	5	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	quality of experience	Perception/Cognition	sense of presence / immersion
46	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Collaboration/Communication	collaboration - completion time
46	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Collaboration/Communication	communication - score / errors / accuracy
46	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	path length travel	Collaboration/Communication	communication - score / errors / accuracy
46	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	head movements	Collaboration/Communication	gaze / head communication
46	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	head position	Collaboration/Communication	gaze / head communication
46	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale	-	awareness	Perception/Cognition	sense of presence / immersion
46	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale	-	ease of communication	Collaboration/Communication	ease of communication
46	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale	-	perceived performance	UX - Usability	perceived performance
46	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	speech dialogue protocols	Collaboration/Communication	speech / dialog protocols and communication
46	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	high level communication processes	Collaboration/Communication	communication behavior
46	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	users communication behavior	Collaboration/Communication	communication behavior
46	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	users interactions behavior	interaction	general interaction behavior
46	1	4	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	opinions	Prototype focus	feedbacks / insights
46	1	4	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	Preferences	UX - Usability	preference
46	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Collaboration/Communication	collaboration - completion time
46	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Collaboration/Communication	communication - score / errors / accuracy
46	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	head movements	Collaboration/Communication	gaze / head communication
46	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	head position	Collaboration/Communication	gaze / head communication
46	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale	-	awareness	Perception/Cognition	sense of presence / immersion
46	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale	-	ease of communication	Collaboration/Communication	ease of communication
46	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale	-	perceived performance	UX - Usability	perceived performance
46	2	3	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	opinions	Prototype focus	feedbacks / insights
46	2	3	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	Preferences	UX - Usability	preference
46	2	4	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	hand movement	Collaboration/Communication	gaze / head communication
46	2	4	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	head movement	Collaboration/Communication	gaze / head communication
46	2	4	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	users communication behavior	Collaboration/Communication	communication behavior
46	2	4	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	users interactions behavior	interaction	general interaction behavior

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
47	1	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	deictic/positional phrases counts	Collaboration/Communication	speech / dialog protocols and communication
47	1	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	pointing gesture counts	Collaboration/Communication	gestures / hands / body communication
47	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Some Advantages of Video Conferencing Over High-quality Audio Conferencing: Fluency and Awareness of Attentional Focus. By Daly-Jones et al. (10.1006/ijhc.1998.0195) - 1 to 7 scale with polar terms	Yes	ease of communication	Collaboration/Communication	ease of communication
47	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Some Advantages of Video Conferencing Over High-quality Audio Conferencing: Fluency and Awareness of Attentional Focus. By Daly-Jones et al. (10.1006/ijhc.1998.0195) - 1 to 7 scale with polar terms	Yes	ease of use	UX - Usability	ease of use
47	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Some Advantages of Video Conferencing Over High-quality Audio Conferencing: Fluency and Awareness of Attentional Focus. By Daly-Jones et al. (10.1006/ijhc.1998.0195) - 1 to 7 scale with polar terms	Yes	perceived performance	UX - Usability	perceived performance
47	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Some Advantages of Video Conferencing Over High-quality Audio Conferencing: Fluency and Awareness of Attentional Focus. By Daly-Jones et al. (10.1006/ijhc.1998.0195) - 1 to 7 scale with polar terms	Yes	preference	UX - Usability	preference
47	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Some Advantages of Video Conferencing Over High-quality Audio Conferencing: Fluency and Awareness of Attentional Focus. By Daly-Jones et al. (10.1006/ijhc.1998.0195) - 1 to 7 scale with polar terms	Yes	real world perception	Perception/Cognition	real environment / object recognition
47	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	in experiment comments	Collaboration/Communication	speech / dialog protocols and communication
47	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	users communication behavior	Collaboration/Communication	communication behavior
47	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
47	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	opinions	Prototype focus	feedbacks / insights
47	2	2	Quantitative	Objective	Empirical Inquiry	Self-Reported / Diaries	Participants artefacts (notebooks, emails, drawings, produced materials etc.)	-	-	designs outcomes (video recordings)	Collaboration/Communication	organization behavior and strategies between users
47	2	3	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	mouse motion	interaction	users movements / gestures / physical utilization of prototype
47	2	3	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	head movements	Collaboration/Communication	gaze / head communication
47	2	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	classified sentences counts	Collaboration/Communication	speech / dialog protocols and communication
47	2	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	deictic phrases counts	Collaboration/Communication	speech / dialog protocols and communication
47	2	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	gesture counts	Collaboration/Communication	gestures / hands / body communication

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
47	2	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	Laughs counts	Collaboration/Communication	speech / dialog protocols and communication
47	2	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	speech overlaps counts	Collaboration/Communication	speech / dialog protocols and communication
47	2	5	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	ease of communication	Collaboration/Communication	ease of communication
47	2	5	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	ease of use	UX - Usability	ease of use
47	2	5	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	perceived performance	UX - Usability	perceived performance
47	2	5	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	preference	UX - Usability	preference
47	2	5	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	real world perception	Perception/Cognition	real environment / object recognition
47	2	6	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	opinions	Prototype focus	feedbacks / insights
48	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	virtual object perception	Perception/Cognition	virtual environment / object recognition
48	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	naturalness	UX - Usability	naturalness
48	3	1	Qualitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	gaze direction	Collaboration/Communication	gaze / head communication
49	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	naturalness	UX - Usability	naturalness
49	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	custom-made	-3 to +3 scale	-	comments	Prototype focus	comments / suggestions
50	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	gameplay style	interaction	general interaction behavior
50	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users communication behavior	Collaboration/Communication	communication behavior
50	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
50	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	score	Collaboration/Communication	communication - score / errors / accuracy
50	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	amusement	UX - Emotion	amusement / fun
50	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of collaboration	Collaboration/Communication	ease of communication
50	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	real world perception	Perception/Cognition	real environment / object recognition
50	2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	gameplay style	interaction	gaming style / behavior
50	2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users communication behavior	Collaboration/Communication	communication behavior
50	2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
50	2	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	score	Collaboration/Communication	communication - score / errors / accuracy
50	2	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	amusement	UX - Emotion	amusement / fun
50	2	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of collaboration	Collaboration/Communication	ease of communication
50	2	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	system interaction feedback	UX - Usability	system status information and feedback
51	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	opinions	Prototype focus	feedbacks / insights
51	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	amusement	UX - Emotion	amusement / fun

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
51	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	ease of collaboration	Collaboration/Communication	ease of communication
51	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	ease of use	UX - Usability	ease of use
51	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	perceived confidence	UX - Emotion	trust (perceived safety)
51	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	perceived performance	UX - Usability	perceived performance
51	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	virtual object perception	Perception/Cognition	virtual environment / object recognition
52	1	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	eye contacts counts	Collaboration/Communication	gaze / head communication
52	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	opinions	Prototype focus	feedbacks / insights
52	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	amusement	UX - Emotion	amusement / fun
52	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	ease of collaboration	Collaboration/Communication	ease of communication
52	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	ease of use	UX - Usability	ease of use
52	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	perceived confidence	UX - Emotion	trust (perceived safety)
52	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	perceived performance	UX - Usability	perceived performance
52	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	virtual object perception	Perception/Cognition	virtual environment / object recognition
53	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	desires	Prototype focus	requirements and missing features
53	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	feedbacks	Prototype focus	feedbacks / insights
53	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	missing features	Prototype focus	requirements and missing features
53	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	opinions	Prototype focus	feedbacks / insights
54	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Collaboration/Communication	collaboration - completion time
54	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	distance between players	Collaboration/Communication	communication - score / errors / accuracy
54	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
54	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived distraction	interaction	attention / focus
54	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived effectiveness	UX - Usability	effectiveness
55	\	\	\	\	\	\	\	-	-	\	\	\
56	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Cornell Musculoskeletal Discomfort Questionnaires (CMDQ)	-	-	perceived discomfort	Ergonomics / Load / Comfort	comfort / sickness
56	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Cornell Musculoskeletal Discomfort Questionnaires (CMDQ)	-	-	strain	Ergonomics / Load / Comfort	physical load
56	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	EZ-Scale	-	-	strain	Ergonomics / Load / Comfort	physical load
56	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Sensitivity scale questionnaire by Detlev von Zerssen	-	-	perceived wellbeing	Ergonomics / Load / Comfort	comfort / sickness

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
56	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Sensitivity scale questionnaire by Detlev von Zerssen	-	-	strain	Ergonomics / Load / Comfort	physical load
56	1	2	Quantitative	Objective	Empirical Experimental	User Measurements	Heart Rate Variability (HRV)	-	-	strain	Ergonomics / Load / Comfort	physical load
57	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments	Prototype focus	comments / suggestions
57	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	ease of use	UX - Usability	ease of use
57	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	opinions	Prototype focus	feedbacks / insights
57	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived control	UX - Usability	system perceived control / interactivity
57	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived input feedback	UX - Usability	system status information and feedback
57	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived speed	UX - Emotion	trust (perceived safety)
57	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	amusement	UX - Emotion	amusement / fun
57	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	gesture performed	interaction	users movements / gestures / physical utilization of prototype
57	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	interactions performed	interaction	learning / problem coping strategy
57	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	strain	Ergonomics / Load / Comfort	physical load
57	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
57	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	opinions	Prototype focus	feedbacks / insights
57	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	suggestions	Prototype focus	comments / suggestions
57	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	used practices/strategies	interaction	learning / problem coping strategy
58	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	learning strategy	interaction	learning / problem coping strategy
58	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments	Prototype focus	comments / suggestions
58	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	opinions	Prototype focus	feedbacks / insights
58	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference	UX - Usability	preference
59	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived effectivity	UX - Usability	effectiveness
59	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived ergonomics	Ergonomics / Load / Comfort	ergonomic properties
59	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	strain	Ergonomics / Load / Comfort	physical load
59	2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	observed ergonomics	Ergonomics / Load / Comfort	ergonomic properties
59	2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	observed strain	Ergonomics / Load / Comfort	physical load
59	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived effectivity	UX - Usability	effectiveness
59	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived ergonomics	Ergonomics / Load / Comfort	ergonomic properties
59	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	strain	Ergonomics / Load / Comfort	physical load
59	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Tasks analysis	-	-	requirements	Prototype focus	requirements and missing features
59	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Tasks analysis	-	-	users interactions	interaction	interaction strategy and system use

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
59	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Tasks analysis	-	-	users tasks	other	users tasks
60	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	N/D	N/D	N/D
60	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	based on SIE's ease of use	-	amusement	UX - Emotion	amusement / fun
60	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	based on SIE's ease of use	-	ease of use	UX - Usability	ease of use
60	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	based on SIE's ease of use	-	interactions opinions	UX - Usability	preference
60	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	based on SIE's ease of use	-	perceived ergonomics	Ergonomics / Load / Comfort	ergonomic properties
60	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	based on SIE's ease of use	-	perceived performance	UX - Usability	perceived performance
60	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	based on SIE's ease of use	-	uses possibilities	Prototype focus	possible use / potentials of system
60	1	3	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
61	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	feedbacks	Prototype focus	feedbacks / insights
61	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	interest	UX - Emotion	interest / attractiveness
61	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	requirements	Prototype focus	requirements and missing features
62	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	interest	UX - Emotion	interest / attractiveness
63	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	feedbacks	Prototype focus	feedbacks / insights
63	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	interest	UX - Emotion	interest / attractiveness
63	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	requirements	Prototype focus	requirements and missing features
64	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	feedbacks	Prototype focus	feedbacks / insights
64	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	interest	UX - Emotion	interest / attractiveness
65	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	feedbacks	Prototype focus	feedbacks / insights
65	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	interest	UX - Emotion	interest / attractiveness
65	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	requirements	Prototype focus	requirements and missing features
66	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	interest	UX - Emotion	interest / attractiveness
67	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	feedbacks	Prototype focus	feedbacks / insights
67	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	interest	UX - Emotion	interest / attractiveness

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
67	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	problems individuation	Prototype focus	problem individuation
68	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	problems individuation	Prototype focus	problem individuation
68	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
68	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	utilization	Prototype focus	possible use / potentials of system
68	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	comments	Prototype focus	comments / suggestions
68	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
69	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	comments	Prototype focus	comments / suggestions
69	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	feedbacks	Prototype focus	feedbacks / insights
69	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	problems individuation	Prototype focus	problem individuation
70	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	problems individuation	Prototype focus	problem individuation
70	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	amusement	UX - Emotion	amusement / fun
70	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
70	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	problems individuation	Prototype focus	problem individuation
71	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	ease of use	UX - Usability	ease of use
71	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	metaphor performance	UX - Usability	usability - unspecified
71	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	problems individuation	Prototype focus	problem individuation
71	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
72	1	1	Quantitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	learning performance	Education specific	learning performance (error / score comparation)
73	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	number and quality of stance used	Education specific	learning performance (error / score comparation)
73	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived experience	UX - Usability	satisfaction
73	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived performance	UX - Usability	perceived performance
74	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Profile of Mood States questionnaire (POMS)	-	-	fatigue	Ergonomics / Load / Comfort	physical load
74	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Profile of Mood States questionnaire (POMS)	-	-	initial emotional status	Ergonomics / Load / Comfort	frustration / stress / anxiety
74	1	2	Qualitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + POST evaluation)	-	-	Test with 10 item single choice (post knowledge about topic)	Education specific	learning performance (error / score comparation)
74	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	AttrakDiff	Second Version	-	attractiveness	UX - Emotion	interest / attractiveness
74	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	AttrakDiff	Second Version	-	interest	UX - Emotion	interest / attractiveness
74	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	AttrakDiff	Second Version	-	opinions	Prototype focus	feedbacks / insights

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
74	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	AttrakDiff	Second Version	-			
74	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	AttrakDiff	Second Version	-	usability	UX - Usability	usability - unspecified
74	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Profile of Mood States questionnaire (POMS)	-	-	fatigue	Ergonomics / Load / Comfort	physical load
74	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Profile of Mood States questionnaire (POMS)	-	-	post emotional status	Ergonomics / Load / Comfort	frustration / stress / anxiety
75	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	environment (lighting conditions)	Mixed background questions	mixed background questions
75	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	weather	Mixed background questions	mixed background questions
75	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	time	Task performance	completion time
75	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	later coded	structured evaluation from evaluators with 1 to 5 scale	-	subject interest on topic	Mixed background questions	subject interest / knowledge on topic
75	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	later coded	structured evaluation from evaluators with 1 to 5 scale	-	subject technological comfort	Mixed background questions	subject technological comfort / general use
75	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	appealed/dislike	UX - Emotion	interest / attractiveness
75	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	perceived experience	UX - Usability	satisfaction
75	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	perceived performance	UX - Usability	perceived performance
75	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	subject motivations	UX - Emotion	motivation
76	P	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	subject comfort with privacy	UX - Meaning	Privacy
76	P	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	subject interest in tech	Mixed background questions	subject technological comfort / general use
76	P	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	possible use of tech	Prototype focus	possible use / potentials of system
76	P	3	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Shadowing	-	-	common patterns and behavior in the environment	interaction	interaction patterns
76	P	4	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	usage of mock in environment	interaction	users movements / gestures / physical utilization of prototype
77	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	learning performance	Education specific	learning performance (error / score comparation)
77	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	organization of the test	Mixed background questions	mixed background questions
77	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	preference	UX - Usability	preference
77	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	Close-Ended Questions	-	feedbacks	Prototype focus	feedbacks / insights
77	1	4	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	utilization behavior	interaction	interaction strategy and system use
77	1	5	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	App utilization	interaction	common general live / interaction behavior
78	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	learning performance	Education specific	learning performance (error / score comparation)
78	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject interest in tech	Mixed background questions	subject technological comfort / general use
78	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject general tech use	Mixed background questions	subject technological comfort / general use

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
78	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-			
78	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject technological comfort	Mixed background questions	subject technological comfort / general use
78	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	usefulness	UX - Usefulness	perceived usefulness
78	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	effectiveness	UX - Usability	effectiveness
78	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	efficiency	UX - Usability	efficiency
78	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	satisfaction	UX - Usability	satisfaction
79	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	open comments	Prototype focus	comments / suggestions
79	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	level of entertainment	UX - Emotion	amusement / fun
79	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	perceived educational potential	UX - Usefulness	perceived usefulness
79	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	perceived quality of experience	Prototype focus	feedbacks / insights
79	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	number of comments/interaction between participants	Collaboration/Communication	communication behavior
79	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	rating of negative/positive interactions between participants	Collaboration/Communication	organization behavior and strategies between users
80	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	shorting and searching time	Task performance	task completion time
80	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open comments	-	opinions	Prototype focus	feedbacks / insights
80	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness Perceive Ease of Use (PUEU)	-	-	ease of use	UX - Usability	ease of use
80	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness Perceive Ease of Use (PUEU)	-	-	interaction flexibility	UX - Usability	system flexibility
80	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness Perceive Ease of Use (PUEU)	-	-	learnability	UX - Usability	learnability
80	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness Perceive Ease of Use (PUEU)	-	-	perceived effectiveness	UX - Usability	effectiveness
80	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness Perceive Ease of Use (PUEU)	-	-	perceived performance	UX - Usability	perceived performance
80	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness Perceive Ease of Use (PUEU)	-	-	perceived usefulness	UX - Usefulness	perceived usefulness
80	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	shorting time alone	Collaboration/Communication	collaboration - completion time
80	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	shorting time in group	Collaboration/Communication	collaboration - completion time
81	1	1	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	emotion of the subject	UX - Emotion	reactions and emotion individuation / shifting
81	1	1	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	time between emotions switch	UX - Emotion	reactions and emotion individuation / shifting
81	1	1	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	time on/off task	Task performance	task completion time

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
81	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	amusement	UX - Emotion	amusement / fun
81	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	ease of use	UX - Usability	ease of use
81	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	perceived performance	UX - Usability	perceived performance
81	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	perceived students emotions	UX - Emotion	reactions and emotion individuation / shifting
81	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	usage behavior	interaction	interaction strategy and system use
81	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	usage issues	Prototype focus	problem individuation
81	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	usefulness	UX - Usefulness	perceived usefulness
82	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	effectiveness	UX - Usability	effectiveness
82	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	efficiency	UX - Usability	efficiency
82	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	satisfaction	UX - Usability	satisfaction
82	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	tool perceived performance	UX - Usability	perceived performance
82	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	usefulness	UX - Usefulness	perceived usefulness
83	1	1	Qualitative	Subjective	Empirical Inquiry	Self-Reported / Diaries	Participants artefacts (notebooks, emails, drawings, produced materials etc.)	-	-	documentation	other	documentation
83	1	2	Qualitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	on material recorded	-	time of design and deployment	Task performance	task completion time
83	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	impressions (Audio/video recordings + Pictures + notes)	UX - Emotion	reactions and emotion individuation / shifting
83	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	Interactions with system (Audio/video recordings + Pictures + notes)	interaction	interaction strategy and system use
83	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	students/teacher issues (Audio/video recordings + Pictures + notes)	Prototype focus	problem individuation
83	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 6 scale	-	pre-interview data gathering	Mixed background questions	mixed background questions
83	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	opinions	Prototype focus	comments / suggestions
83	1	5	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	post experiment feedbacks	Prototype focus	feedbacks / insights
84	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Keller's Instructional Materials Motivation Survey (IMMS)	-	attention	interaction	attention / focus
84	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Keller's Instructional Materials Motivation Survey (IMMS)	-	confidence	UX - Emotion	trust (perceived safety)
84	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Keller's Instructional Materials Motivation Survey (IMMS)	-	relevance	UX - Emotion	motivation
84	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Keller's Instructional Materials Motivation Survey (IMMS)	-	satisfaction	UX - Usability	satisfaction
84	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Pintrich's Motivated Strategies for Learning Questionnaire (MSLQ)	-	self-regulation	Education specific	learning attitude (self-regulation / autonomy / motivation)

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
84	1	2	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	effective behavior	interaction	general interaction behavior
84	1	2	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	usability	UX - Usability	usability - unspecified
84	1	3	Quantitative	Subjective	Empirical Experimental	User Action Logging	evaluators timing	-	-	actions time	Task performance	task completion time
84	1	4	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	right/wrong answers	Education specific	learning performance (error / score comparation)
85	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	ergonomics	Ergonomics / Load / Comfort	ergonomic properties
85	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	expected features	Prototype focus	requirements and missing features
85	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	usage in autonomy	Education specific	learning attitude (self-regulation / autonomy / motivation)
85	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	usage preferences	UX - Usability	preference
85	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	ease of use	UX - Usability	ease of use
85	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	general interest of subjects	Mixed background questions	subject interest / knowledge on topic
85	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	possible use of tech	UX - Usefulness	perceived usefulness
85	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	problems	Prototype focus	problem individuation
85	P	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Pre focus group	-	-	autonomy impact	Education specific	learning attitude (self-regulation / autonomy / motivation)
85	P	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Pre focus group	-	-	desiderate features	Prototype focus	requirements and missing features
85	P	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Pre focus group	-	-	device social interaction impact	Collaboration/Communication	Social presence / interaction impact
85	P	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Pre focus group	-	-	usability	UX - Usability	usability - unspecified
85	P	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Pre focus group	-	-	usefulness	UX - Usefulness	perceived usefulness
85	P	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Pre focus group	-	-	well-being/happiness impact	Ergonomics / Load / Comfort	comfort / sickness
86	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use
86	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived experience	UX - Usability	satisfaction
86	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived learning performance	UX - Usability	efficiency
86	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived usefulness	UX - Usefulness	perceived usefulness
86	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	portability	Prototype focus	requirements and missing features
86	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	virtual objects quality	Perception/Cognition	virtual environment / object perceived quality
86	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	-	-	ease of use	UX - Usability	ease of use
86	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	-	-	perceived learnability	UX - Usability	learnability
86	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	-	-	perceived safety	UX - Emotion	trust (perceived safety)

Evaluation methodologies and main HCI aspects investigated

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
87	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Arousal	UX - Emotion	arousal / engagement
87	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Behavioral intention	interaction	general interaction behavior
87	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Dominance	UX - Emotion	trust (perceived safety)
87	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Effort expectancy	Ergonomics / Load / Comfort	task perceived effort
87	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Performance expectancy	UX - Usability	perceived performance
87	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Personal innovativeness	UX - Emotion	perceived innovativeness / wow factor
87	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	pleasure	UX - Emotion	amusement / fun
87	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Price value	UX - Meaning	price / value
88	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	Effectiveness (accuracy - Absolute pose error (APE) as evaluation metrics)	Task performance	accuracy
88	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	Effectiveness (accuracy - on system response time)	Task performance	reaction time
88	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	efficiency(Relative pose error (RPE))	Task performance	errors
89	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
89	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	score	Task performance	score
89	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	decisions (effectiveness)	UX - Usability	effectiveness
89	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	efficiency	UX - Usability	efficiency
89	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	learning curve	UX - Usability	learnability
89	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	likeness	UX - Usability	preference
89	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	validity (perceived performance)	UX - Usability	perceived performance
89	P	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	angle of inclination of device	interaction	users movements / gestures / physical utilization of prototype
89	P	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
90	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	connectivity used	Prototype focus	requirements and missing features

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
90	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	geographical position/navigation	interaction	users movements / gestures / physical utilization of prototype
90	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	queries made	interaction	learning / problem coping strategy
90	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	resources accessed	Prototype focus	requirements and missing features
90	1	2	Qualitative	Subjective	N/D	N/D	N/D	-	-	perceived learning performance	UX - Usability	efficiency
90	1	2	Qualitative	Subjective	N/D	N/D	N/D	-	-	perceived performance	UX - Usability	preference
90	1	2	Qualitative	Subjective	N/D	N/D	N/D	-	-	usability	UX - Usability	usability - unspecified
91	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	Yes	ease of use	UX - Usability	ease of use
91	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	Yes	effectiveness	UX - Usability	effectiveness
91	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	Yes	expectation	UX - Meaning	believes/opinions
91	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	Yes	frustration/stress in use	Ergonomics / Load / Comfort	frustration / stress / anxiety
91	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	Yes	happiness in use	UX - Emotion	amusement / fun
91	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	Yes	perceived control	UX - Usability	system perceived control / interactivity
91	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
91	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	Yes	privacy perceived	UX - Meaning	Privacy
91	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	A Mixed Reality Virtual Clothes Try-On System by Yuan et al. (10.1109/TMM.2013.2280560)	Yes	satisfaction	UX - Usability	satisfaction
92	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	aesthetic quality	UX - Usability	aesthetic
92	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	Attitude	UX - Meaning	believes/opinions
92	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	Behavioral intention	interaction	common general live / interaction behavior
92	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	ease of use	UX - Usability	ease of use
92	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	enjoyment	UX - Emotion	amusement / fun

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
92	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	interactivity	UX - Usability	system perceived control / interactivity
92	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	perceived response time	UX - Usability	system smoothness / response time
92	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	quality of information	UX - Usability	efficiency
92	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	usefulness	UX - Usefulness	perceived usefulness
93	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	post knowledge about topic	Education specific	learning performance POST (meta test comparation)
93	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	pre knowledge about topic	Education specific	learning performance POST (error / score comparation)
93	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments/suggestions	Prototype focus	comments / suggestions
93	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	-	Yes	ease of use	UX - Usability	ease of use
93	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	-	Yes	Effectiveness	UX - Usability	effectiveness
93	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	-	Yes	Engagement	UX - Emotion	arousal / engagement
93	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	-	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
93	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	-	Yes	Understandability	UX - Usability	understandability
94	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	attitude towards using	UX - Meaning	believes/opinions
94	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	behavioral intention to use	interaction	common general live / interaction behavior
94	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	ease of use	UX - Usability	ease of use
94	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	Perceived enjoyment	UX - Emotion	amusement / fun
94	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	perceived informativeness (efficiency)	UX - Usability	efficiency
94	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
95	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey	-	efficiency	UX - Usability	efficiency
95	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey	-	perceived usefulness	UX - Usefulness	perceived usefulness
95	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey	-	possible use of tech	Prototype focus	possible use / potentials of system
95	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey	-	satisfaction	UX - Usability	satisfaction
95	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey	-	subject general tech use	Mixed background questions	subject technological comfort / general use
96	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	accuracy	Task performance	accuracy

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
96	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-			
96	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time efficiency	Task performance	completion time
96	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	Effectiveness (correct points)	Task performance	score
96	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	errors	Task performance	errors
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	post knowledge about topic	Education specific	learning performance POST (meta test comparation)
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	pre knowledge about topic	Education specific	learning performance POST (error / score comparation)
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments/considerations	Prototype focus	comments / suggestions
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	attitude towards using	UX - Meaning	believes/opinions
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	behavioral intention to use	interaction	common general live / interaction behavior
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	ease of use	UX - Usability	ease of use
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	effectiveness	UX - Usability	effectiveness
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	Perceived enjoyment	UX - Emotion	amusement / fun
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
97	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	UI style preference	UX - Usability	preference
98	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	pre knowledge about topic	Task performance	score
98	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
98	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	impressions	Prototype focus	feedbacks / insights
98	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	-	Yes	confidence	UX - Emotion	trust (perceived safety)
98	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	-	Yes	consistency	UX - Usability	system consistency / standards
98	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	-	Yes	ease of use	UX - Usability	ease of use
98	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	-	Yes	enjoyment of use	UX - Emotion	amusement / fun
98	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	-	Yes	learnability	UX - Usability	learnability
99	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
99	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	wrong location	Task performance	errors
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	-	cognitive efforts (attention)	interaction	attention / focus

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	-	cognitive efforts (real vs virtual distinction)	Perception/Cognition	virtual environment / object perceived quality
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	-	context awareness (meaning of places)	UX - Meaning	meaning of context / place / interaction
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	-	quality of experience (new captivating delight)	UX - Meaning	captivating / delightful experience
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	-	self-expressiveness (inspired develop express creativity/self)	UX - Meaning	self-expression
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Behavioral intention	interaction	common general live / interaction behavior
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Effort expectancy	Ergonomics / Load / Comfort	task perceived effort
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	habits	interaction	common general live / interaction behavior
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	hedonic motivations	UX - Meaning	hedonic quality
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Performance expectancy	UX - Usability	perceived performance
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Price value	UX - Meaning	price / value
99	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Unified Theory of Acceptance and Use of Technology (UTAUT2)	7 Likert scale	Yes	Social influence	Collaboration/Communication	Social presence / interaction impact
100	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	-	information-feedback presentation	UX - Usability	system status information and feedback
100	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	-	preference	UX - Usability	preference
100	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	-	usability (font size/navigation)	UX - Usability	aesthetic
100	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
101	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	amusement	UX - Emotion	amusement / fun
101	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	ease of use	UX - Usability	ease of use
101	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	feedbacks	Prototype focus	feedbacks / insights
101	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	interactions pleasure	UX - Usability	satisfaction

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
101	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-			
101	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	problems	Prototype focus	problem individuation
101	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	subject general tech use	Mixed background questions	subject technological comfort / general use
101	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	want to recommend	UX - Usefulness	would recommend the use
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Assessing dimensions of perceived visual aesthetics of web sites by Lavie and Tractinsky (2004) - 1 to 5 scale	Yes	control	UX - Usability	system perceived control / interactivity
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Assessing dimensions of perceived visual aesthetics of web sites by Lavie and Tractinsky (2004) - 1 to 5 scale	Yes	ease of use	UX - Usability	ease of use
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Assessing dimensions of perceived visual aesthetics of web sites by Lavie and Tractinsky (2004) - 1 to 5 scale	Yes	navigation	UX - Usability	system consistency / standards
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Assessing dimensions of perceived visual aesthetics of web sites by Lavie and Tractinsky (2004) - 1 to 5 scale	Yes	response	UX - Usability	system smoothness / response time
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	want to recommend	UX - Usefulness	would recommend the use
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposed adjective Likert 5 scale	-	Arousal	UX - Emotion	arousal / engagement
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposed adjective Likert 5 scale	-	confusing / disappointing	UX - Meaning	captivating / delightful experience
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposed adjective Likert 5 scale	-	entertaining / boring	UX - Emotion	arousal / engagement
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposed adjective Likert 5 scale	-	gratifying / pleasant	UX - Usability	satisfaction
102	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposed adjective Likert 5 scale	-	interesting / annoying	UX - Emotion	interest / attractiveness
102	1	2	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	Emotions (facial expressions)	UX - Emotion	reactions and emotion individuation / shifting
102	1	2	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	Interactions behavior (movements)	interaction	users movements / gestures / physical utilization of prototype
102	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Emotional intensity: Measurement and theoretical implications by Bachorowski & Braaten (1994) - 1 to 5 scale	Yes	Positive/Negative emotion inclination	interaction	common general live / interaction behavior
102	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Emotional intensity: Measurement and theoretical implications by Bachorowski & Braaten (1994) - 1 to 5 scale	Yes	subject innovativeness propension	interaction	common general live / interaction behavior
102	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject interest in topic	Mixed background questions	subject interest / knowledge on topic
103	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
103	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	safety perception	UX - Emotion	trust (perceived safety)
103	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
103	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	subject work methodology/interactions	Education specific	learning attitude (self-regulation / autonomy / motivation)
103	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
103	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	want to recommend	UX - Usefulness	would recommend the use

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
103	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	post knowledge about topic	Education specific	learning performance POST (meta test comparation)
103	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	pre knowledge about topic	Education specific	learning performance POST (error / score comparation)
104	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived visibility	Perception/Cognition	virtual environment / object recognition
104	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Understandability	UX - Usability	understandability
104	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference	UX - Usability	preference
104	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	fatigue	Ergonomics / Load / Comfort	physical load
104	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	feature usefulness	Prototype focus	feature usefulness / importance
104	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	information conspicuity	UX - Usability	efficiency
104	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	naturalness	UX - Usability	naturalness
104	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived fast recognition/cognition	Perception/Cognition	virtual environment / object recognition
104	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	fatigue	Ergonomics / Load / Comfort	physical load
104	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference	UX - Usability	preference
104	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference comprehension	Perception/Cognition	virtual environment / object recognition
104	2	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception related completion time
104	2	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Perception/Cognition	perception related errors
105	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	number of attentions changes	interaction	attention / focus
105	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	time spent on looking at the system	Perception/Cognition	perception related completion time
105	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	intuitiveness	UX - Usability	intuitiveness
105	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived accuracy	UX - Usability	system perceived accuracy
105	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived comfort	Ergonomics / Load / Comfort	comfort / sickness
105	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	preference	UX - Usability	preference
105	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
105	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	mental effort	Ergonomics / Load / Comfort	cognitive load
105	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort
105	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived performance	UX - Usability	perceived performance
105	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	physical effort	Ergonomics / Load / Comfort	physical load
106	1	1	Qualitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Task performance	errors
106	1	1	Qualitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
106	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	Yes	feature importance	Prototype focus	feature usefulness / importance

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
106	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire	(vuoto)	Yes			
106	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	Yes	issues	Prototype focus	problem individuation
106	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	Yes	perceived performance	UX - Usability	perceived performance
106	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	Yes	possible use of tech	Prototype focus	possible use / potentials of system
106	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	Yes	subject tech use	Mixed background questions	subject technological comfort / general use
107	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	accuracy	Task performance	accuracy
107	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
107	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert scale	-	perceived task difficulty	UX - Usability	perceived task/interaction difficulty
107	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post Experiment Questionnaire for UX for MARs by Olsson et al. (10.1007/978-1-4614-4205-9_9)	(vuoto)	Yes	subject tech use	Mixed background questions	subject technological comfort / general use
108	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
108	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	success rate	Task performance	accuracy
108	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	phone orientation (correct use of device)	Task performance	errors
108	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	advantages/disadvantages	Prototype focus	feedbacks / insights
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	enjoyment	UX - Emotion	amusement / fun
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	perceived learnability	UX - Usability	learnability
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference	UX - Usability	preference
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Short Feedback Questionnaire (SFQ)	5 Likert scale	-	enjoyment	UX - Emotion	amusement / fun
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Short Feedback Questionnaire (SFQ)	5 Likert scale	-	information understanding	UX - Usability	efficiency
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Short Feedback Questionnaire (SFQ)	5 Likert scale	-	perceived control	UX - Usability	system perceived control / interactivity
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Short Feedback Questionnaire (SFQ)	5 Likert scale	-	perceived discomfort	Ergonomics / Load / Comfort	comfort / sickness
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Short Feedback Questionnaire (SFQ)	5 Likert scale	-	perceived success	UX - Usability	system status information and feedback
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	7 Likert scale	Yes	ease of use	UX - Usability	ease of use
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	7 Likert scale	Yes	intuitiveness	UX - Usability	intuitiveness

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	7 Likert scale	Yes			
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	7 Likert scale	Yes	perceived information overload	Ergonomics / Load / Comfort	cognitive load
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	7 Likert scale	Yes	perceived performance	UX - Usability	perceived performance
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	7 Likert scale	Yes	satisfaction	UX - Usability	satisfaction
108	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	7 Likert scale	Yes	want to use in future	UX - Usefulness	would use again in future
108	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	opinions/preferences	UX - Usability	preference
108	1	4	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	subjects behaviors/learning strategies	interaction	learning / problem coping strategy
109	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	aesthetic	UX - Usability	aesthetic
109	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Education - (curiosity stimulation)	UX - Emotion	interest / attractiveness
109	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Entertainment	UX - Emotion	amusement / fun
109	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Escapism	Perception/Cognition	sense of presence / immersion
109	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Memories	UX - Meaning	memories
109	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
109	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Visitor Engagement	UX - Emotion	arousal / engagement
110	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	understanding general feelings (actions/motivations)	UX - Emotion	motivation
110	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	understanding general feelings (concerns)	interaction	long period interactions studies with system
110	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	understanding general feelings (struggles)	interaction	long period interactions studies with system
110	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	understanding utilization	interaction	common general live / interaction behavior
110	1	2	Qualitative	Subjective	Empirical Inquiry	Self-Reported / Diaries	Self-reported data / Diaries	-	-	understanding general feelings (actions/motivations)	UX - Emotion	motivation
110	1	2	Qualitative	Subjective	Empirical Inquiry	Self-Reported / Diaries	Self-reported data / Diaries	-	-	understanding general feelings (concerns)	interaction	long period interactions studies with system
110	1	2	Qualitative	Subjective	Empirical Inquiry	Self-Reported / Diaries	Self-reported data / Diaries	-	-	understanding general feelings (struggles)	interaction	long period interactions studies with system
110	1	2	Qualitative	Subjective	Empirical Inquiry	Self-Reported / Diaries	Self-reported data / Diaries	-	-	understanding utilization	interaction	common general live / interaction behavior
110	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	app usage	interaction	common general live / interaction behavior
110	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	aspirations	UX - Meaning	aspirations
110	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	background info	Mixed background questions	mixed background questions
110	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	perception of brand	UX - Meaning	perception of brand

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
110	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Digital Ethnography	-	-	Conducted on app store reviews (app adaption - n. downloads)	other	Digital Ethnography - Apps adaption
110	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Digital Ethnography	-	-	Conducted on app store reviews (app perception - Rating)	other	Digital Ethnography - Apps perception / rating
111	1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	usability problems	Prototype focus	problem individuation
111	1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Tasks analysis	-	-	specification	Prototype focus	requirements and missing features
111	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	ease of use	UX - Usability	ease of use
111	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	tech problems	Prototype focus	problem individuation
111	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users movements	interaction	users movements / gestures / physical utilization of prototype
111	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users reactions	UX - Emotion	reactions and emotion individuation / shifting
111	1	3	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	co-design	Prototype focus	co-design
111	1	3	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	feedbacks	Prototype focus	feedbacks / insights
111	1	3	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	specification	Prototype focus	requirements and missing features
112	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale	-	coherence between obj/shadows	Perception/Cognition	virtual environment / object perceived quality
112	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	11 Likert scale	-	coherence between color/shadows	Perception/Cognition	virtual environment / object perceived quality
112	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	recognition of real shadow	Perception/Cognition	real environment / object recognition
113	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	comments	Prototype focus	comments / suggestions
113	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	visitors behavior	interaction	general interaction behavior
113	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	The Development and Evaluation of a Survey to Measure User Engagement - 5 Likert scale	Yes	aesthetic quality	UX - Usability	aesthetic
113	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	The Development and Evaluation of a Survey to Measure User Engagement - 5 Likert scale	Yes	ease of use	UX - Usability	ease of use
113	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	The Development and Evaluation of a Survey to Measure User Engagement - 5 Likert scale	Yes	emotion engagement	UX - Emotion	arousal / engagement
113	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	The Development and Evaluation of a Survey to Measure User Engagement - 5 Likert scale	Yes	interest in topic	Mixed background questions	subject interest / knowledge on topic
113	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	The Development and Evaluation of a Survey to Measure User Engagement - 5 Likert scale	Yes	novelty	UX - Emotion	perceived innovativeness / wow factor
113	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	The Development and Evaluation of a Survey to Measure User Engagement - 5 Likert scale	Yes	satisfaction	UX - Usability	satisfaction
113	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject general tech use	Mixed background questions	subject technological comfort / general use
114	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	aesthetic quality	UX - Usability	aesthetic

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
114	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	information-feedback presentation	UX - Usability	system status information and feedback
114	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	preference	UX - Usability	preference
114	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
114	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usability	UX - Usability	usability - unspecified
114	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject interest in topic	Mixed background questions	subject interest / knowledge on topic
115	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	3 Separate Propositions (Not Acceptable/Acceptable/Excellent)	-	acceptable stability limit (effectiveness)	UX - Usability	effectiveness
116	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	subject tech use	Mixed background questions	subject technological comfort / general use
116	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	usefulness	UX - Usefulness	perceived usefulness
116	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	want to use in future	UX - Usefulness	would use again in future
117	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	attitudes toward the system (use in other contexts)	Prototype focus	possible use / potentials of system
117	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	usefulness	UX - Usefulness	perceived usefulness
117	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	user-friendliness	UX - Usability	understandability
118	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	effectiveness	UX - Usability	effectiveness
118	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	efficiency	UX - Usability	efficiency
118	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	learnability	UX - Usability	learnability
118	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	subject tech use	Mixed background questions	subject technological comfort / general use
118	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	utility	UX - Usefulness	perceived usefulness
119	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	learning performance	Education specific	learning performance (error / score comparation)
119	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	effectiveness	UX - Usability	effectiveness
119	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	efficiency	UX - Usability	efficiency
119	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	satisfaction	UX - Usability	satisfaction
120	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	satisfaction	UX - Usability	satisfaction
120	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	usability	UX - Usability	usability - unspecified
120	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	post knowledge about topic	Education specific	learning performance POST (error / score comparation)
120	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	pre knowledge about topic	Education specific	learning performance PRE (error / score comparation)
120	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	task completion time	Task performance	task completion time
121	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments/feedbacks	Prototype focus	feedbacks / insights
121	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	interest	UX - Emotion	interest / attractiveness

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
121	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-			
121	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived learning experience	UX - Usability	perceived performance
121	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	want to recommend	UX - Usefulness	would recommend the use
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject tech use	Mixed background questions	subject technological comfort / general use
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	10 Likert scale	Yes	Satisfaction Evaluation (attractiveness: curiosity)	UX - Emotion	interest / attractiveness
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	11 Likert scale	Yes	Satisfaction Evaluation (aesthetic interface: nice)	UX - Usability	aesthetic
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	12 Likert scale	Yes	Satisfaction Evaluation (pleasure: happy/frustrated)	Ergonomics / Load / Comfort	frustration / stress / anxiety
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	13 Likert scale	Yes	Satisfaction Evaluation (aesthetic interface: nice)	UX - Usability	satisfaction
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	5 Likert scale	Yes	Effectiveness (Completed the task)	UX - Usability	effectiveness
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	6 Likert scale	Yes	efficiency(User Effort / Understood the task)	UX - Usability	efficiency
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	7 Likert scale	Yes	Utility (Can be used to learn)	UX - Usefulness	perceived usefulness
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	8 Likert scale	Yes	Satisfaction Evaluation (fun)	UX - Emotion	amusement / fun
122	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	9 Likert scale	Yes	Satisfaction Evaluation (interest: Would use again)	UX - Usefulness	would use again in future
123	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	pre knowledge about topic	Education specific	learning performance PRE (error / score comparation)
123	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	completion time	Task performance	completion time
123	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	interactions errors	Task performance	errors
123	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	interactions time	Task performance	interaction time
123	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	solutions errors	Task performance	errors
123	1	3	Quantitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	graded test (post knowledge about topic)	Education specific	learning performance (error / score comparation)
123	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	interest in leering (after experiment)	UX - Emotion	interest / attractiveness
123	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	motivation in learning	UX - Emotion	motivation

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
124	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	post knowledge about topic	Education specific	learning performance POST (error / score comparation)
124	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	pre knowledge about topic	Education specific	learning performance PRE (error / score comparation)
124	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	effectiveness	UX - Usability	effectiveness
124	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	efficiency	UX - Usability	efficiency
124	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	satisfaction	UX - Usability	satisfaction
125	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	motivation	UX - Emotion	motivation
125	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	system perception	UX - Usability	system status information and feedback
125	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	general motivation	UX - Emotion	motivation
125	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject tech use	Mixed background questions	subject technological comfort / general use
125	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	5 Likert scale	Yes	ease of use	UX - Usability	ease of use
125	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	5 Likert scale	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
125	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	5 Likert scale	Yes	usability	UX - Usability	usability - unspecified
126	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	post knowledge about topic	Education specific	learning performance POST (error / score comparation)
126	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	pre knowledge about topic	Education specific	learning performance PRE (error / score comparation)
126	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	effectiveness	UX - Usability	effectiveness
126	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	efficiency	UX - Usability	efficiency
126	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	satisfaction	UX - Usability	satisfaction
127	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	motivation	UX - Emotion	motivation
127	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	system perception	UX - Usability	system status information and feedback
127	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	general motivation	UX - Emotion	motivation
127	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject tech use	Mixed background questions	subject technological comfort / general use
127	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	5 Likert scale	Yes	ease of use	UX - Usability	ease of use
127	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	5 Likert scale	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
127	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	5 Likert scale	Yes	usability	UX - Usability	usability - unspecified
128	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
128	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-			
128	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	interaction opinions	interaction	interaction strategy and system use
128	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
128	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	visual quality	UX - Usability	aesthetic
129	1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Usability problems detection	Prototype focus	problem individuation
129	1	2	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on task	-	-	comments	Prototype focus	comments / suggestions
129	1	2	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on task	-	-	usability problems	Prototype focus	problem individuation
129	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use
129	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	entertainability	UX - Emotion	amusement / fun
129	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	expected features	Prototype focus	requirements and missing features
129	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	information navigation	UX - Usability	system consistency / standards
129	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	overall impression (satisfaction)	UX - Usability	satisfaction
129	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
129	1	3	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	want to recommend	UX - Usefulness	would recommend the use
130	1	1	Quantitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (Control + Experiment groups)	-	-	learning performance	Education specific	learning performance (error / score comparation)
130	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	un-structured	-	feedbacks	Prototype focus	feedbacks / insights
130	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	un-structured	-	opinions	Prototype focus	comments / suggestions
131	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Likert 4	-	ease of use	UX - Usability	ease of use
131	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Likert 4	-	efficiency	UX - Usability	efficiency
131	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Likert 4	-	motivation/interest in system	UX - Emotion	interest / attractiveness
131	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Likert 4	-	perceived usefulness	UX - Usefulness	perceived usefulness
132	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	feedbacks/comments	Prototype focus	comments / suggestions
132	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	motivation	UX - Emotion	motivation
132	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject tech use	Mixed background questions	subject technological comfort / general use
132	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	7 Likert scale	-	quality o interface design	UX - Usability	aesthetic
132	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	7 Likert scale	-	quality of information	UX - Usability	efficiency
132	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	7 Likert scale	-	system usefulness	UX - Usefulness	perceived usefulness
133	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	image smoothness	Perception/Cognition	virtual environment / object perceived quality

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
133	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	obj manipulation	interaction	users movements / gestures / physical utilization of prototype
133	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance (learning)	UX - Usability	perceived performance
133	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	precision of 3D maps	Perception/Cognition	virtual environment / object perceived quality
133	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	realism of visualization	Perception/Cognition	real environment / object recognition
133	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	unbeatability	UX - Usability	understandability
133	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	post knowledge about topic	Education specific	learning performance POST (error / score comparation)
133	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	pre knowledge about topic	Education specific	learning performance PRE (error / score comparation)
134	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	feedbacks/comments	Prototype focus	feedbacks / insights
134	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	attractiveness	UX - Emotion	interest / attractiveness
134	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	efficiency	UX - Usability	efficiency
134	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	motivation of using system	UX - Emotion	motivation
134	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	perceived flexibility	UX - Usability	system flexibility
134	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	perceived satisfaction	UX - Usability	satisfaction
134	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
135	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	feedbacks/comments	Prototype focus	feedbacks / insights
135	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	attractiveness	UX - Emotion	interest / attractiveness
135	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	efficiency	UX - Usability	efficiency

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
135	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	motivation of using system	UX - Emotion	motivation
135	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	perceived flexibility	UX - Usability	system flexibility
135	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	perceived satisfaction	UX - Usability	satisfaction
135	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	adapted from Evaluating the Usability of an Augmented Reality Based Educational Application by Aleven et al. (10.1007/978-3-642-13388-6 34) (Likert 5)	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
136	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + POST evaluation)	-	-	learning performance	Education specific	learning performance (error / score comparation)
137	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	learning performance	Education specific	learning performance (error / score comparation)
137	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	comments	Prototype focus	comments / suggestions
138	1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Cognitive Walkthrough	-	-	Usability problems detection	Prototype focus	problem individuation
138	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	app interface well designed	UX - Usability	aesthetic
138	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	comfort in use	Ergonomics / Load / Comfort	comfort / sickness
138	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	ease of use	UX - Usability	ease of use
138	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	effectiveness	UX - Usability	effectiveness
138	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	intention of use	UX - Usefulness	would use again in future
138	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	intuitiveness	UX - Usability	intuitiveness
138	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	System Usability Scale (SUS)	5 Likert scale	Yes	want to recommend	UX - Usefulness	would recommend the use
139	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	position accuracy (with real word)	Perception/Cognition	perception related accuracy
139	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Appreciation	UX - Meaning	believes/opinions
139	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	comfort	Ergonomics / Load / Comfort	comfort / sickness
139	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Easiness (intuitive)	UX - Usability	intuitiveness
139	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Eyestrain	Ergonomics / Load / Comfort	comfort / sickness
139	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Realism	Perception/Cognition	sense of presence / immersion
139	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Sickness	Ergonomics / Load / Comfort	comfort / sickness
139	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject tech use	Mixed background questions	subject technological comfort / general use

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
140	1	1	Qualitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	children's understanding/reasoning on topic	Education specific	learning performance POST (free discussion)
140	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	amusement (satisfaction)	UX - Emotion	amusement / fun
140	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	children's emotions reactions	UX - Emotion	reactions and emotion individuation / shifting
140	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	Interactions behavior (movements)	interaction	users movements / gestures / physical utilization of prototype
140	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	children's arguments	Education specific	learning performance POST (free discussion)
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	Accessibility	Ergonomics / Load / Comfort	ergonomic properties
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	Effectiveness	UX - Usability	effectiveness
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	efficiency	UX - Usability	efficiency
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	Learnability	UX - Usability	learnability
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	Productivity	UX - Usability	perceived performance
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	Safety	UX - Emotion	trust (perceived safety)
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	Satisfaction	UX - Usability	satisfaction
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	Trustfulness	UX - Emotion	trust (perceived safety)
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	Universality	Ergonomics / Load / Comfort	ergonomic properties
141	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	QUIM (Quality In Use Integrated Measurement)	-	Yes	Usefulness	UX - Usefulness	perceived usefulness
142	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
142	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort
142	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
142	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived mental demand	Ergonomics / Load / Comfort	cognitive load
142	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived own performance	UX - Usability	perceived performance
142	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived physical demand	Ergonomics / Load / Comfort	physical load
142	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived temp demand	Ergonomics / Load / Comfort	cognitive load
142	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived workload	Ergonomics / Load / Comfort	task perceived effort
142	1	3	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on task	-	-	users statements	Prototype focus	comments / suggestions

ef. udy	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
1	4	Quantitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	body language	interaction	users movements / gestures / physical utilization of prototype
1	4	Quantitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	Interactions with system	interaction	interaction strategy and system use
1	5	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Preferences	UX - Usability	preference
1	5	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	subject tech use	Mixed background questions	subject technological comfort / general use
1	5	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	subject comfort with tech	Mixed background questions	subject technological comfort / general use
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - aesthetic design	UX - Usability	aesthetic
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - consistency and standards	UX - Usability	system consistency / standards
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - error prevention	UX - Usability	system errors recovery, prevention and warning
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - errors recover	UX - Usability	system errors recovery, prevention and warning
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - flexibility and efficiency	UX - Usability	efficiency
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - interaction pleasure	UX - Usability	satisfaction
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - intuitiveness	UX - Usability	intuitiveness
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - mental model accuracy (expectation)	UX - Meaning	believes/opinions
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - recognition/recall	UX - Usability	learnability
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - system's status visibility	UX - Usability	system status information and feedback
1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Gómez et al. + Nielsen modified - user control and freedom	UX - Usability	system perceived control / interactivity
1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	notes on participants behaviors patterns	interaction	interaction patterns

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
144	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-			
144	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	enjoyment	UX - Emotion	amusement / fun
144	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
144	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived closeness	Collaboration/Communication	Social presence / interaction impact
145	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	in experiment comments	Collaboration/Communication	speech / dialog protocols and communication
145	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	users communication behavior	Collaboration/Communication	communication behavior
145	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
145	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
145	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	missing features/suggestions	Prototype focus	requirements and missing features
145	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	opinions on better interaction patterns	Prototype focus	comments / suggestions
146	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
146	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	closed response (during evaluation)	-	-	comfort/discomfort in continuing the study	Ergonomics / Load / Comfort	comfort / sickness
146	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	3 Separate Propositions (disagree/neutral/strongly agree)	-	difficulty with the interface	UX - Usability	perceived task/interaction difficulty
146	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	3 Separate Propositions (disagree/neutral/strongly agree)	-	perceived confidence	UX - Emotion	trust (perceived safety)
146	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	3 Separate Propositions (disagree/neutral/strongly agree)	-	perceived helpless	UX - Usefulness	perceived usefulness
146	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments on study	Prototype focus	comments / suggestions
146	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preference	UX - Usability	preference
147	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	completion time	Perception/Cognition	perception related completion time
147	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived helpless	UX - Usefulness	perceived usefulness
147	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	preference on use (tech)	UX - Usability	preference
147	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	suggestions	Prototype focus	comments / suggestions
147	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	want to use in future	UX - Usefulness	would use again in future
148	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	features utilization insights	Prototype focus	requirements and missing features
148	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
148	2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	features utilization insights	Prototype focus	feature usefulness / importance
148	2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
148	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
148	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	visualization version preference	UX - Usability	preference
148	3	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	features utilization insights	Prototype focus	feature usefulness / importance

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
148	3	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
148	3	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
148	3	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	visualization version preference	UX - Usability	preference
149	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
149	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception related completion time
149	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	difficulty with the interface	UX - Usability	perceived task/interaction difficulty
149	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	features usefulness	Prototype focus	feature usefulness / importance
149	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived confidence	UX - Emotion	trust (perceived safety)
149	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived helpless	UX - Usefulness	perceived usefulness
150	\	\	\	\	\	\	\	-	-	\	\	\
151	\	\	\	\	\	\	\	-	-	\	\	\
152	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease in finding the target	UX - Usability	efficiency
152	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease in learning how to use	UX - Usability	learnability
152	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease in operating the system	UX - Usability	effectiveness
152	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease in understating remote situation	UX - Usability	understandability
152	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	comments during evaluation	Prototype focus	comments / suggestions
152	1	3	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	frequent communications patterns (estimate body camera position/rotation)	Collaboration/Communication	communication behavior
152	1	3	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	frequent interactions patterns (estimate body camera position/rotation)	Collaboration/Communication	gestures / hands / body communication
153	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Evaluation method for computer supported collaborative learning (CSCL) by Spada et al.' - 5 Likert	-	Argumentation reaching consensus	Collaboration/Communication	speech / dialog protocols and communication
153	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Evaluation method for computer supported collaborative learning (CSCL) by Spada et al.' - 5 Likert	-	Cooperative orientation	Collaboration/Communication	individual action vs collaboration
153	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Evaluation method for computer supported collaborative learning (CSCL) by Spada et al.' - 5 Likert	-	Fluidity of collaboration	Collaboration/Communication	ease of collaboration
153	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Evaluation method for computer supported collaborative learning (CSCL) by Spada et al.' - 5 Likert	-	Individual task orientation	Collaboration/Communication	individual action vs collaboration
153	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Evaluation method for computer supported collaborative learning (CSCL) by Spada et al.' - 5 Likert	-	Information exchanges problem solving	Collaboration/Communication	communication behavior
153	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Evaluation method for computer supported collaborative learning (CSCL) by Spada et al.' - 5 Likert	-	Sustaining mutual understanding	Collaboration/Communication	ease of communication

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
153	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Education specific	Evaluation method for computer supported	-			
153	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Evaluation method for computer supported collaborative learning (CSCL) by Spada et al.' - 5 Likert	-	Task and time management	Collaboration/Communication	organization behavior and strategies between users
153	P1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	problems	Prototype focus	problem individuation
153	P1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	requirements	Prototype focus	requirements and missing features
153	P2	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Cognitive Walkthrough	-	-	Expert + Users walkthrough with mockup prototype (early feedbacks)	Prototype focus	feedbacks / insights
154	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use
154	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	fatigue	Ergonomics / Load / Comfort	physical load
154	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	overall impression (satisfaction)	UX - Usability	satisfaction
154	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	deictic/positional phrases counts	Collaboration/Communication	speech / dialog protocols and communication
154	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	intuitiveness of interaction	UX - Usability	intuitiveness
154	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	perceived usefulness	UX - Usefulness	perceived usefulness
154	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	possible use of tech	Prototype focus	possible use / potentials of system
155	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
155	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	Unspecified	-	task load	Ergonomics / Load / Comfort	cognitive load
156	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	Yes	competency	UX - Usability	understandability
156	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	Yes	effort-intensity	Ergonomics / Load / Comfort	task perceived effort
156	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	Yes	enjoyment-interest	UX - Emotion	amusement / fun
156	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	Yes	tension-pressure	Ergonomics / Load / Comfort	frustration / stress / anxiety
156	1	2	Quantitative	Objective	Empirical Experimental	User Measurements	Electromyography (EMG)	-	-	co-contraction of muscles	Task performance	accuracy
156	1	2	Quantitative	Objective	Empirical Experimental	User Measurements	Electromyography (EMG)	-	-	muscle control	Task performance	accuracy
157	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	Heart Rate Variability (HRV)	-	-	energy expended	Ergonomics / Load / Comfort	physical load
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	Borg RPE - 1 to 5 scale	-	Relative perceived exertion	Ergonomics / Load / Comfort	physical load
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	Borg-CR10 - 1 to 5 scale	-	Localized pain and discomfort	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	comfort rating scales (CRS) - 1 to 5 scale	-	well-being anxiety	Ergonomics / Load / Comfort	frustration / stress / anxiety
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	comfort rating scales (CRS) - 1 to 5 scale	-	well-being attachment	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	comfort rating scales (CRS) - 1 to 5 scale	-	well-being emotion	Ergonomics / Load / Comfort	comfort / sickness

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale	comfort rating scales (CRS) - 1 to 5 scale	-			
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	comfort rating scales (CRS) - 1 to 5 scale	-	well-being harm	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	comfort rating scales (CRS) - 1 to 5 scale	-	well-being movement	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	comfort rating scales (CRS) - 1 to 5 scale	-	well-being perceived change	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	Visual Effects scales (VES) - 1 to 5 scale	-	dizziness	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	Visual Effects scales (VES) - 1 to 5 scale	-	Eyes irritation/fatigue	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	Visual Effects scales (VES) - 1 to 5 scale	-	general tiredness	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	Visual Effects scales (VES) - 1 to 5 scale	-	headache	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	Visual Effects scales (VES) - 1 to 5 scale	-	nausea	Ergonomics / Load / Comfort	comfort / sickness
157	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Wearability Levels (WL) scale Knight et al.	Visual Effects scales (VES) - 1 to 5 scale	-	Visual discomfort	Ergonomics / Load / Comfort	comfort / sickness
158	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
158	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
158	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived responsiveness	UX - Usability	system smoothness / response time
158	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived stability	UX - Usability	system perceived robustness / stability
158	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	system learnability	UX - Usability	learnability
158	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	virtual objects quality	Perception/Cognition	virtual environment / object perceived quality
158	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	want to use in future	UX - Usefulness	would use again in future
158	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments	Prototype focus	comments / suggestions
159	1	1	Quantitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (Control + Experiment groups)	-	-	learning performance	Education specific	learning performance (error / score comparation)
159	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Concentration during class	Ergonomics / Load / Comfort	cognitive load
159	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	easiness to operate	UX - Usability	ease of use
159	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	impressions	Mixed background questions	subject interest / knowledge on topic
159	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	motivation/facilitation of learning with AR	UX - Usefulness	perceived usefulness
159	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	preference	UX - Usability	preference
159	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	students interests in topic	Mixed background questions	subject interest / knowledge on topic
159	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	understand the lecture topic (performance)	UX - Usability	perceived performance

Evaluation methodologies and main HCI aspects investigated

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
160	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + POST evaluation)	-	-	learning performance	Education specific	learning performance (error / score comparation)
160	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert scale	-	cognitive accessibility (time/energy in use)	Ergonomics / Load / Comfort	cognitive load
160	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert scale	-	cognitive validity (performance/effective)	UX - Usability	effectiveness
160	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert scale	-	Learning attitude	Education specific	learning attitude (self-regulation / autonomy / motivation)
160	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert scale	-	satisfaction	UX - Usability	satisfaction
160	1	3	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	emotion engagement	UX - Emotion	arousal / engagement
160	1	3	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	interaction behavior	interaction	general interaction behavior
160	1	4	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	comparation with other applications	Prototype focus	requirements and missing features
160	1	4	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	usefulness of application	UX - Usefulness	perceived usefulness
161	1	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	errors during test	Education specific	learning performance POST (error / score comparation)
161	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	questions on test	Education specific	learning performance POST (free discussion)
161	1	2	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	NASA TLX	-	effort	Ergonomics / Load / Comfort	task perceived effort
161	1	2	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	NASA TLX	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
161	1	2	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	NASA TLX	-	mental demands	Ergonomics / Load / Comfort	cognitive load
161	1	2	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	NASA TLX	-	own performance (satisfaction)	UX - Usability	satisfaction
161	1	2	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	NASA TLX	-	physical demands	Ergonomics / Load / Comfort	physical load
161	1	2	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	NASA TLX	-	temporal demands (pressure under task)	Ergonomics / Load / Comfort	cognitive load
162	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	Learning interactions / behavior (control)	interaction	learning / problem coping strategy
162	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	learnings outcomes (control)	Education specific	learning performance (error / score comparation)
162	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	learnings outcomes (experiment)	Education specific	learning performance (error / score comparation)
163	\	\	\	\	\	\	\	-	-	\	\	\
164	1	1	Quantitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (Control + Experiment groups)	-	-	learning performance	Education specific	learning performance (error / score comparation)
165	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	lack of time/resources	Ergonomics / Load / Comfort	task perceived effort
165	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	learning effort	UX - Usability	learnability

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
165	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	motivation	UX - Emotion	motivation
165	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	novelty/appeal of AR methods	UX - Emotion	perceived innovativeness / wow factor
165	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	organization of the subject	Mixed background questions	mixed background questions
165	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	system stability	UX - Usability	system perceived robustness / stability
165	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Bipolar Laddering (BLA system)	-	Yes	usefulness	UX - Usefulness	perceived usefulness
165	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	effectiveness	UX - Usability	effectiveness
165	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	efficiency	UX - Usability	efficiency
165	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	ISO 9241	part 11	Yes	satisfaction	UX - Usability	satisfaction
165	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	difficulty	UX - Usability	perceived task/interaction difficulty
165	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	utility	UX - Usefulness	perceived usefulness
165	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject general tech use	Mixed background questions	subject technological comfort / general use
165	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	graded questions	-	pre knowledge about topic	Mixed background questions	subject interest / knowledge on topic
166	\	\	\	\	\	\	\	-	-	\	\	\
167	1	1	Quantitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (Control + Experiment groups)	-	-	learning performance	Education specific	learning performance (error / score comparation)
167	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	usability problems	Prototype focus	problem individuation
168	1	1	Quantitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (Control + Experiment groups)	-	-	learning performance	Education specific	learning performance (error / score comparation)
168	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	experienced amusement	UX - Emotion	amusement / fun
168	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	interest in topic	Mixed background questions	subject interest / knowledge on topic
168	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	perceived learning	UX - Usability	perceived performance
168	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	priderite game (in system)	UX - Usability	preference
168	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	subject general tech use	Mixed background questions	subject technological comfort / general use
168	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	want to use in future	UX - Usefulness	would use again in future
168	1	3	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	behavior during game (on a 1 to 10 scale)	interaction	gaming style / behavior
168	1	3	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	collaboration (on a 1 to 10 scale)	Collaboration/Communication	ease of collaboration
168	1	3	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	Engagement (on a 1 to 10 scale)	UX - Emotion	arousal / engagement

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
168	1	3	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	initial behavior (on an 1 to 10 scale)	interaction	learning / problem coping strategy
168	1	3	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	Initial motivation (on an 1 to 10 scale)	UX - Emotion	motivation
168	1	3	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	perceived understanding of topic (on a 1 to 10 scale)	Education specific	learning performance POST (free discussion)
168	1	3	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	understanding of rules (on a 1 to 10 scale)	UX - Usability	understandability
168	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	game requirements/features/outcomes	Prototype focus	requirements and missing features
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Depth perception	Perception/Cognition	perceived (or evaluated) depth or distance
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Easy	UX - Usability	perceived task/interaction difficulty
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Fun	UX - Emotion	amusement / fun
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Information clarity	UX - Usability	system status information and feedback
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Instructions	UX - Usability	system status information and feedback
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Legible	UX - Usability	aesthetic
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	motivation	UX - Emotion	motivation
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Playability	UX - Emotion	amusement / fun
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Real environment recognition	Perception/Cognition	real environment / object recognition
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	satisfaction	UX - Usability	satisfaction

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation	base on VRUSE—a computerized diagnostic	Yes			
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Stimulus	UX - Emotion	arousal / engagement
169	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	base on VRUSE—a computerized diagnostic tool: for usability evaluation of virtual/synthetic environment systems by S. Roy - 5 Likert scale	Yes	Task Guidance/Help	UX - Usability	system status information and feedback
170	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Ben Schneiderman's acceptance test	5 Likert scale	Yes	appropriateness audio experience	UX - Usability	system status information and feedback
170	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Ben Schneiderman's acceptance test	5 Likert scale	Yes	ease of use	UX - Usability	ease of use
170	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Ben Schneiderman's acceptance test	5 Likert scale	Yes	satisfaction	UX - Usability	satisfaction
170	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	recorded	-	approach to system (interest)	UX - Emotion	interest / attractiveness
170	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	recorded	-	opinion on traditional system	Prototype focus	comments / suggestions
170	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	recorded	-	opinions	Prototype focus	feedbacks / insights
171	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	attempts	Task performance	n. trails
171	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	errors	Task performance	errors
171	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	on material recorded	-	completion time	Task performance	completion time
172	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + POST evaluation)	-	-	learning performance	Education specific	learning performance (error / score comparation)
172	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	opinions	Prototype focus	feedbacks / insights
173	1	1	Quantitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + POST evaluation)	-	-	learning performance	Education specific	learning performance (error / score comparation)
173	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Learning Attitude towards Ecosystems (LATE) - 5 Likert scale	-	Anxiety	Ergonomics / Load / Comfort	frustration / stress / anxiety
173	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Learning Attitude towards Ecosystems (LATE) - 5 Likert scale	-	confidence	UX - Emotion	trust (perceived safety)
173	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Learning Attitude towards Ecosystems (LATE) - 5 Likert scale	-	Liking	UX - Usability	preference
173	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	Learning Attitude towards Ecosystems (LATE) - 5 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
174	P	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	interaction behavior	interaction	general interaction behavior
174	P	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	Interaction patterns	interaction	interaction patterns
174	P	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	interaction/usage understandability	UX - Usability	understandability
175	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (Control + Experiment groups)	-	-	learning performance	Education specific	learning performance (error / score comparation)

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
175	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test	test with evaluation give by	-	-			
175	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	feedbacks	Prototype focus	feedbacks / insights
175	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived benefits	UX - Usefulness	perceived usefulness
175	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived-difficulties	UX - Usability	perceived task/interaction difficulty
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	based on The ebb and flow of online learning by Pearce (10.1016/j.chb.2004.02.019) - 5 Likert scale	-	perceived challenge	Ergonomics / Load / Comfort	task perceived effort
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Education specific Questionnaire	based on The ebb and flow of online learning by Pearce (10.1016/j.chb.2004.02.019) - 5 Likert scale	-	perceived skill	UX - Usability	perceived performance
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	autotelic experience	UX - Emotion	motivation
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	balance between ability level and challenge	UX - Usability	perceived task/interaction difficulty
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	concentration on task being performed	Ergonomics / Load / Comfort	cognitive load
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	direct and clear feedback	UX - Usability	system status information and feedback
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	distortion of sense of time	Perception/Cognition	sense of presence / immersion
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	Lear goals	UX - Emotion	motivation
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	loss of self-consciousness or inhibition	Perception/Cognition	sense of presence / immersion
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	merging of action and awareness	interaction	interaction strategy and system use
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	perceived challenge	Ergonomics / Load / Comfort	task perceived effort
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	perceived skill	UX - Usability	perceived performance
175	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow State Scale (FSS)	5 Likert scale	Yes	sense of control	UX - Emotion	trust (perceived safety)
176	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments	Prototype focus	comments / suggestions
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	concentration	Ergonomics / Load / Comfort	cognitive load
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	enjoy	UX - Emotion	amusement / fun
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	interaction preferences	UX - Usability	preference
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived errors/limit of the tech to task	Prototype focus	requirements and missing features
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	7 Likert polar terms scale	Yes	interest/enjoyment	UX - Emotion	amusement / fun
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	7 Likert polar terms scale	Yes	perceive competence	UX - Usability	perceived performance
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	7 Likert polar terms scale	Yes	pressure/tension	Ergonomics / Load / Comfort	frustration / stress / anxiety

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory	7 Likert polar terms scale	Yes			
176	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	7 Likert polar terms scale	Yes	value/usefulness	UX - Usefulness	perceived usefulness
176	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	attempts	Task performance	n. trails
176	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
176	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	number of helps required to system	UX - Usability	perceived task/interaction difficulty
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of use	UX - Usability	ease of use
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	engagement/fun	UX - Emotion	arousal / engagement
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived learning on topic	UX - Usability	effectiveness
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived learning performance	UX - Usability	perceived performance
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived value	UX - Meaning	price / value
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	post believes about topic	UX - Meaning	believes/opinions
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	post Intended behavior	interaction	common general live / interaction behavior
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	post motivation to change Behavior	UX - Emotion	motivation
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	pre believes about topic	UX - Meaning	believes/opinions
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	pre Intended behavior	interaction	common general live / interaction behavior
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	pre knowledge about topic	Mixed background questions	subject interest / knowledge on topic
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	pre motivation to change Behavior	UX - Emotion	motivation
177	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	pre subject tech use	Mixed background questions	subject technological comfort / general use
178	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + POST evaluation)	-	-	learning performance	Education specific	learning performance (error / score comparation)
178	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments	Prototype focus	comments / suggestions
178	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	motivation	UX - Emotion	motivation
178	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	Preferences	UX - Usability	preference
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of use	UX - Usability	ease of use
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	enjoy/fun	UX - Emotion	amusement / fun
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived learning on topic	UX - Usability	effectiveness
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived learning performance	UX - Usability	perceived performance
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived value	UX - Meaning	price / value
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	post believes about topic	UX - Meaning	believes/opinions

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-			
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	post motivation to change Behavior	UX - Emotion	motivation
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	pre believes about topic	UX - Meaning	believes/opinions
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	pre motivation to change Behavior	UX - Emotion	motivation
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Slater et al. (1994) - reduced version	Yes	perception of physical tokens	Perception/Cognition	real environment / object recognition
178	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Slater et al. (1994) - reduced version	Yes	Perception of virtual objects	Perception/Cognition	virtual environment / object recognition
179	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	learnings outcomes (evaluation)	Education specific	learning performance (error / score comparation)
179	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	learnings outcomes (researcher field notes)	Education specific	learning performance (error / score comparation)
179	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	perceived performance	UX - Usability	perceived performance
179	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	perceived students emotions	UX - Emotion	reactions and emotion individuation / shifting
179	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	possible use of tech	UX - Usefulness	perceived usefulness
179	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	semi-structured	-	usage issues	Prototype focus	problem individuation
179	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	unstructured - unformal	-	feedbacks	Prototype focus	feedbacks / insights
179	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	unstructured - unformal	-	opinions	Prototype focus	comments / suggestions
179	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	unstructured - unformal	-	possible pros/cons	Prototype focus	problem individuation
179	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	unstructured - unformal	-	usefulness for teaching	UX - Usefulness	perceived usefulness
179	1	3	Qualitative	Subjective	Empirical Inquiry	Self-Reported / Diaries	Participants artefacts (notebooks, emails, drawings, produced materials etc.)	-	-	learnings outcomes (produced artefacts)	other	documentation
180	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + POST evaluation)	-	-	learning performance	Education specific	learning performance (error / score comparation)
180	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Computer-Mediated Collaborative Learning: An Empirical Evaluation	5 Likert scale	-	group learning evaluation	Collaboration/Communication	ease of collaboration
180	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Computer-Mediated Collaborative Learning: An Empirical Evaluation	5 Likert scale	-	group performance	Collaboration/Communication	organization behavior and strategies between users
180	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Computer-Mediated Collaborative Learning: An Empirical Evaluation	5 Likert scale	-	individual achievements	Collaboration/Communication	individual action vs collaboration
180	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Computer-Mediated Collaborative Learning: An Empirical Evaluation	5 Likert scale	-	learning interest	Mixed background questions	subject interest / knowledge on topic
180	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Computer-Mediated Collaborative Learning: An Empirical Evaluation	5 Likert scale	-	perceived skill development	UX - Usability	perceived performance

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
180	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Computer-Mediated Collaborative Learning: An Empirical Evaluation	5 Likert scale	-	self-reported learning	UX - Usability	efficiency
181	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	ease of use	UX - Usability	ease of use
181	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	interaction usefulness	UX - Usefulness	perceived usefulness
181	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	preference vs traditional hardware/software	UX - Usability	preference
181	1	2	Qualitative	Subjective	Empirical Experimental	Observation	comments collection during test	-	-	prototype issues	Prototype focus	problem individuation
182	1	1	Qualitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + Post -> Control + Experiment group)	-	-	learning performance	Education specific	learning performance (error / score comparation)
182	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + Post -> Control + Experiment group)	-	-	learning performance	Education specific	learning performance (error / score comparation)
183	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	email survey - closed question/s	-	background info	Mixed background questions	mixed background questions
183	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	email survey - closed question/s	-	enjoyment	UX - Emotion	amusement / fun
183	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	email survey - closed question/s	-	possible use of tech	Prototype focus	possible use / potentials of system
183	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	email survey - closed question/s	-	recommendations/feedbacks	Prototype focus	feedbacks / insights
183	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	email survey - closed question/s	-	technical difficulties experienced	Prototype focus	problem individuation
183	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	later coded	unstructured interview later coded in topics	-	added value	UX - Meaning	price / value
183	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	later coded	unstructured interview later coded in topics	-	control/interactivity	UX - Usability	system perceived control / interactivity
183	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	later coded	unstructured interview later coded in topics	-	enjoyment	UX - Emotion	amusement / fun
183	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	later coded	unstructured interview later coded in topics	-	flexibility	UX - Usability	system flexibility
183	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	later coded	unstructured interview later coded in topics	-	memorability	UX - Emotion	interest / attractiveness
183	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	later coded	unstructured interview later coded in topics	-	potential	Prototype focus	possible use / potentials of system
183	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	later coded	unstructured interview later coded in topics	-	usability	UX - Usability	usability - unspecified
183	3	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	enhanced Learning from video recordings (later coded in topics) + field notes	UX - Usability	perceived performance
183	3	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	human Interactivity from video recordings (later coded in topics) + field notes	interaction	interaction strategy and system use
183	3	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	initiations (by children) from video recordings (later coded in topics) + field notes	UX - Emotion	interest / attractiveness
183	3	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	positive/Negative Engagement from video recordings (later coded in topics) + field notes	UX - Emotion	arousal / engagement

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
183	3	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	usability issues from video recordings (later coded in topics) + field notes	Prototype focus	problem individuation
183	4	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (Control + Experiment groups)	-	-	remember items (learning performance)	Education specific	learning performance (error / score comparation)
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale polar terms	-	difficult	UX - Usability	perceived task/interaction difficulty
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale polar terms	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale polar terms	-	interesting	UX - Emotion	interest / attractiveness
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale polar terms	-	intuitiveness	UX - Usability	intuitiveness
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale polar terms	-	stimulating	UX - Emotion	arousal / engagement
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale polar terms	-	wonderful	UX - Emotion	arousal / engagement
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	effectiveness	UX - Usability	effectiveness
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived value	UX - Meaning	price / value
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	preference vs traditional hardware/software	UX - Usability	preference
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
184	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	want to recommend	UX - Usefulness	would recommend the use
184	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	completion time	Task performance	completion time
185	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments	Prototype focus	comments / suggestions
185	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
186	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher	-	-	learning performance	Education specific	learning performance (error / score comparation)
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived behavior	interaction	general interaction behavior
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived learning performance	UX - Usability	perceived performance
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived usefulness	UX - Usefulness	perceived usefulness
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	preference vs traditional hardware/software	UX - Usability	preference
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	want to use in future	UX - Usefulness	would use again in future
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	-	Fun	UX - Emotion	amusement / fun
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	-	interest in topic	Mixed background questions	subject interest / knowledge on topic
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	-	perceived competency	UX - Usability	understandability
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	-	perceived motivation	UX - Emotion	motivation
186	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
187	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Depth perception	Perception/Cognition	perceived (or evaluated) depth or distance
187	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	virtual objects perception	Perception/Cognition	virtual environment / object recognition
187	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	virtual objects quality	Perception/Cognition	virtual environment / object perceived quality
187	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	structured	-	possible pros/cons	Prototype focus	problem individuation
187	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	structured	-	possible use of tech	Prototype focus	possible use / potentials of system
187	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	structured	-	usefulness for teaching	UX - Usefulness	perceived usefulness
187	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Depth perception	Perception/Cognition	perceived (or evaluated) depth or distance
187	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	virtual objects perception	Perception/Cognition	virtual environment / object recognition
187	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	virtual objects quality	Perception/Cognition	virtual environment / object perceived quality
187	P	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	structured	-	describe perception	Perception/Cognition	virtual environment / object recognition
187	P	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	structured	-	interest in system	UX - Emotion	interest / attractiveness
187	P	2	Qualitative	Subjective	Empirical Inquiry	Interviews	with proxy users	structured	-	possible use of tech	Prototype focus	possible use / potentials of system
188	\	\	\	\	\	\	\	-	-	\	\	\
189	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + Post -> Control + Experiment group)	-	-	learning performance	Education specific	learning performance (error / score comparation)
190	1	1	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on prototype	-	-	behavior relative to learning with AR	interaction	learning / problem coping strategy
190	1	1	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on prototype	-	-	Interactions with system	interaction	interaction strategy and system use
190	1	1	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on prototype	-	-	subjects opinions/thoughts	Prototype focus	feedbacks / insights
190	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	behavior relative to learning with AR	interaction	learning / problem coping strategy
190	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	Interactions with system	interaction	interaction strategy and system use
190	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	subjects opinions/thoughts	Prototype focus	comments / suggestions
190	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	ISONORM part 10 - 5 Likert	Yes	affordance	UX - Usability	intuitiveness
190	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	ISONORM part 10 - 5 Likert	Yes	control	UX - Usability	system perceived control / interactivity
190	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	ISONORM part 10 - 5 Likert	Yes	ease of use	UX - Usability	ease of use
190	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	ISONORM part 10 - 5 Likert	Yes	efficiency	UX - Usability	efficiency
190	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	ISONORM part 10 - 5 Likert	Yes	Learnability	UX - Usability	learnability
190	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	ISONORM part 10 - 5 Likert	Yes	learning performance	UX - Usability	efficiency

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
190	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	ISONORM part 10 - 5 Likert	Yes			
190	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	ISONORM part 10 - 5 Likert	Yes	motivation	UX - Emotion	motivation
190	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	ISONORM part 10 - 5 Likert	Yes	Understandability	UX - Usability	understandability
191	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	effort	Ergonomics / Load / Comfort	task perceived effort
191	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
191	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	metal demand	Ergonomics / Load / Comfort	cognitive load
191	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived performance	UX - Usability	perceived performance
191	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	physical demand	Ergonomics / Load / Comfort	physical load
191	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	temporal demand	Ergonomics / Load / Comfort	cognitive load
191	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	attention focus	interaction	attention / focus
191	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	comments	Prototype focus	comments / suggestions
191	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	ease of use	UX - Usability	ease of use
191	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	missing/excessive features	Prototype focus	feature usefulness / importance
191	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	perceived problems	Prototype focus	problem individuation
191	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	solutions adopted	interaction	learning / problem coping strategy
191	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Santa Barbara Sense of Direction (SBSOD)	-	-	orientation	Perception/Cognition	sense of orientation / navigation
192	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	accuracy	Task performance	accuracy
192	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	angle	Task performance	field specific amount
192	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance	Task performance	distance
193	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	feature/visuals identification	Perception/Cognition	virtual environment / object recognition
193	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	comments/feedbacks	Prototype focus	feedbacks / insights
194	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	Attitude towards using (interest in topic w system)	UX - Emotion	motivation
194	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	ease of use	UX - Usability	ease of use
194	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	effectiveness	UX - Usability	effectiveness
194	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	Intention to use (in the future)	UX - Usefulness	would use again in future
194	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	Perceived enjoyment	UX - Emotion	amusement / fun
194	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
194	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	Unspecified	Yes	UI style preference	UX - Usability	aesthetic
195	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	Likert 7 scale	-	interest/enjoyment	UX - Emotion	interest / attractiveness

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
195	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory	Likert 7 scale	-			
195	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	Likert 7 scale	-	perceived competency	UX - Usability	understandability
195	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	Likert 7 scale	-	pressure/tension	Ergonomics / Load / Comfort	frustration / stress / anxiety
195	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	Likert 7 scale	-	value usefulness	UX - Usefulness	perceived usefulness
195	2	1	Quantitative	Objective	Empirical Experimental	User Measurements	Galvanic Skin Response (GSR)	-	-	Arousal	UX - Emotion	arousal / engagement
195	2	1	Quantitative	Objective	Empirical Experimental	User Measurements	Heart Rate Variability (HRV)	-	-	stress	Ergonomics / Load / Comfort	frustration / stress / anxiety
195	3	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	feature usefulness	Prototype focus	feature usefulness / importance
195	3	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Interaction patterns	interaction	interaction patterns
195	3	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usefulness	perceived usefulness
195	3	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
195	4	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	comparation with traditional	UX - Usability	preference
195	4	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	enjoy	UX - Emotion	amusement / fun
195	4	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	interest	UX - Emotion	interest / attractiveness
195	4	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	motivation	UX - Emotion	motivation
195	4	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
195	4	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived usability	UX - Usability	usability - unspecified
195	4	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	strain	Ergonomics / Load / Comfort	physical load
195	4	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	want to use in future	UX - Usefulness	would use again in future
196	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + Post -> Control + Experiment group)	-	-	learning performance	Education specific	learning performance (error / score comparation)
196	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow experience questionnaire by Chang et al. (2012)	5 Likert scale	Yes	interest in topic (education)	Mixed background questions	subject interest / knowledge on topic
196	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow experience questionnaire by Chang et al. (2012)	5 Likert scale	Yes	motivation (education)	Education specific	learning attitude (self-regulation / autonomy / motivation)
196	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Flow experience questionnaire by Chang et al. (2012)	5 Likert scale	Yes	problem identification (education)	Education specific	learning attitude (self-regulation / autonomy / motivation)
197	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	enjoyment	UX - Emotion	amusement / fun
197	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	randomness	Prototype focus	problem individuation
197	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	skill required	UX - Usability	perceived task/interaction difficulty
197	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	comments	Prototype focus	comments / suggestions
198	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception completion time
198	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	comments	Prototype focus	comments / suggestions

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
198	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-			
198	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	Easiest interface	UX - Usability	perceived task/interaction difficulty
198	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	most challenging	Perception/Cognition	virtual environment / object perceived quality
198	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	most realistic	Perception/Cognition	virtual environment / object perceived quality
198	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	preferred interface	UX - Usability	preference
198	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	presence/immersion	Perception/Cognition	sense of presence / immersion
198	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	social/presence	Collaboration/Communication	Social presence / interaction impact
199	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	interface usage time	Task performance	interaction time
199	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	time per level	Task performance	task completion time
199	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	interest in system (gaze)	interaction	attention / focus
199	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	reactions/emotions	UX - Emotion	reactions and emotion individuation / shifting
199	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	interaction behavior	interaction	general interaction behavior
199	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	environment focus	Perception/Cognition	real environment / object recognition
199	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	interface preferences	UX - Usability	preference
199	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	social Presence	Collaboration/Communication	Social presence / interaction impact
199	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usage of the system in the environment (intensive...)	Ergonomics / Load / Comfort	task perceived effort
199	1	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	location of utilization from (later coded in topics) + field notes	interaction	interaction strategy and system use
199	1	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	type of system audience from (later coded in topics) + field notes	interaction	interaction patterns
199	1	5	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	comments/feedbacks	Prototype focus	feedbacks / insights
200	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	Behavioral intention/interaction	interaction	common general live / interaction behavior
200	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	ease of use	UX - Usability	ease of use
200	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	effectiveness	UX - Usability	effectiveness
200	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	Perceived enjoyment	UX - Emotion	amusement / fun
200	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
200	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	tech usage	Mixed background questions	subject technological comfort / general use

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
200	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	tech usage	Mixed background questions	subject technological comfort / general use
200	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	Behavioral intention/interaction	interaction	common general live / interaction behavior
200	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	ease of use	UX - Usability	ease of use
200	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	effectiveness	UX - Usability	effectiveness
200	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	Perceived enjoyment	UX - Emotion	amusement / fun
200	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technology Acceptance Model (TAM)	7 Likert scale	Yes	perceived usefulness	UX - Usefulness	perceived usefulness
201	P1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	features importance	Prototype focus	feature usefulness / importance
201	P2	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Paper wireframe creation with users	-	-	features importance	Prototype focus	feature usefulness / importance
201	P2	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Paper wireframe creation with users	-	-	interaction flows/patterns	interaction	interaction patterns
202	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	problems individuation	Prototype focus	problem individuation
202	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	amusement	UX - Emotion	amusement / fun
202	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
202	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	problems individuation	Prototype focus	problem individuation
203	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	enjoyment	UX - Emotion	amusement / fun
203	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	fatigue	Ergonomics / Load / Comfort	physical load
203	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	game collaboration	Collaboration/Communication	ease of collaboration
203	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	game learnability	UX - Usability	learnability
203	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	virtual obj perception and searchability	Perception/Cognition	virtual environment / object recognition
203	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	tech usage	Mixed background questions	subject technological comfort / general use
203	1	2	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	feedbacks	Prototype focus	feedbacks / insights
203	1	2	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	level of social interaction	Collaboration/Communication	Social presence / interaction impact
203	1	2	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	opinions	Prototype focus	comments / suggestions
203	P	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	interactions behavior/patterns	interaction	interaction patterns
203	P	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	problems individuation	Prototype focus	problem individuation
204	\	\	\	\	\	\	\	-	-	\	\	\
205	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	accuracy orientation	Task performance	accuracy
205	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
205	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	n POIs individuated	Task performance	score
205	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	demographic and mixed background questions	Mixed background questions	mixed background questions
205	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	1 to 6 scale	-	perceived navigation skill (performance)	Perception/Cognition	sense of orientation / navigation
205	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	2 to 6 scale	-	experience with virtual environment (preference visualization)	UX - Usability	preference
206	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	average speed	Task performance	field specific amount
206	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
206	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance travelled	Task performance	distance
206	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	user feedbacks/opinions	Prototype focus	comments / suggestions
206	1	2	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on prototype	-	-	users paths (interaction behavior)	interaction	interaction patterns
206	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	comments/feedbacks	Prototype focus	feedbacks / insights
207	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	opinions	Prototype focus	feedbacks / insights
207	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Entertainment	UX - Emotion	amusement / fun
207	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	preference/performed location	UX - Meaning	meaning of context / place / interaction
207	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	recorded	-	preference/performed location (most meaningful)	UX - Meaning	meaning of context / place / interaction
207	2	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	recorded	-	preference/performed location (most meaningful) (narrative requirements)	UX - Meaning	meaning of context / place / interaction
208	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	games events	Task performance	score
208	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	interactions behavior/patterns	interaction	interaction patterns
208	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	users enjoyments	UX - Emotion	interest / attractiveness
208	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Ease of learning	UX - Usability	learnability
208	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	enjoyment	UX - Emotion	amusement / fun
208	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Perceived Engagement	UX - Emotion	arousal / engagement
208	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	social awareness	Collaboration/Communication	Social presence / interaction impact
208	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	social interaction	Collaboration/Communication	communication behavior
209	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	social behavior on video recordings (later coded in topics) + field notes	Collaboration/Communication	communication behavior
209	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	social event count and clustering on video recordings (later coded in topics) + field notes	Collaboration/Communication	ease of collaboration

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
209	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured	-	-			
210	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	correct judgments	Perception/Cognition	perception related errors
210	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	uncertain judgments	Perception/Cognition	perception related n. attempts
210	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	depth perception difficulty	Perception/Cognition	perceived (or evaluated) depth or distance
210	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness of method for depth perception	UX - Usability	intuitiveness
210	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	preference in sense used	UX - Usability	preference
210	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	sense used to judge depth	Perception/Cognition	perceived (or evaluated) depth or distance
210	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception completion time
210	2	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	impressiveness sensation	Perception/Cognition	sense of presence / immersion
210	2	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	perceived performance (identifications of objects)	UX - Usability	perceived performance
210	2	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	sense of presence	Perception/Cognition	sense of presence / immersion
210	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	social awareness	Collaboration/Communication	Social presence / interaction impact
210	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	social interaction	Collaboration/Communication	Social presence / interaction impact
211	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	ease of use	UX - Usability	ease of use
211	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	perceived collaboration with urban planners	Collaboration/Communication	ease of collaboration
211	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	tech usage	Mixed background questions	subject technological comfort / general use
211	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	usefulness	UX - Usefulness	perceived usefulness
211	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	Willingness of participate in planning with and without the system (want to use)	UX - Usefulness	would use again in future
211	1	2	Qualitative	Subjective	Empirical Experimental	Observation	comments collection during test	-	-	feedback	Prototype focus	feedbacks / insights
211	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	interaction behavior	interaction	general interaction behavior
212	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Task performance	errors
212	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
212	1	2	Qualitative	Subjective	Empirical Experimental	Observation	comments collection during test	-	-	expression/comments	Prototype focus	comments / suggestions
212	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	interaction behavior	interaction	general interaction behavior
212	1	2	Quantitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	errors/calls for help	Task performance	errors
212	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	Clarity and simplicity	UX - Usability	understandability
212	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	easiness of task	UX - Usability	ease of use
212	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
212	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	product agreeable (enjoyable)	UX - Emotion	amusement / fun
212	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	tech usage	Mixed background questions	subject technological comfort / general use
213	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	competition time	Task performance	completion time
213	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Task performance	errors
213	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	trials	Task performance	n. trails
213	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	order items	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort
213	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	order items	-	perceived performance	UX - Usability	perceived performance
213	1	2	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	order items	-	perceived speed	UX - Usability	efficiency
214	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	perceived text (readability)	Perception/Cognition	virtual environment / object perceived quality
214	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
214	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception completion time
215	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 7 scale	-	tech usage	Mixed background questions	subject technological comfort / general use
215	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors rate	Task performance	errors
215	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
215	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use
215	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
215	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
216	1	1	Quantitative	Objective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (Control + Experiment groups)	-	-	learning performance	Education specific	learning performance (error / score comparation)
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived increase in performance	UX - Usability	perceived performance
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived value of system	UX - Meaning	price / value
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	want to recommend	UX - Usefulness	would recommend the use
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	attention focus	interaction	attention / focus
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	clarity of instruction	UX - Usability	system status information and feedback
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	comfortable experience	Ergonomics / Load / Comfort	comfort / sickness
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	perceived difficulty	UX - Usability	perceived task/interaction difficulty
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	perceived learnability of task (efficiency)	UX - Usability	efficiency

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	perceived task completion efficiency	UX - Usability	efficiency
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	recoverability of mistakes	UX - Usability	system errors recovery, prevention and warning
216	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	system ease of use	UX - Usability	ease of use
217	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easiness of interaction	UX - Usability	perceived task/interaction difficulty
217	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	helpfulness of system	UX - Usefulness	perceived usefulness
217	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	system ease of use	UX - Usability	ease of use
217	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	system enjoy	UX - Emotion	amusement / fun
218	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	interaction behavior	interaction	general interaction behavior
218	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
218	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	device position	interaction	users movements / gestures / physical utilization of prototype
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	AttrakDiff	First Version - 5 item bipolar scale	-	Hedonic Identity	UX - Meaning	hedonic quality
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	AttrakDiff	First Version - 5 item bipolar scale	-	Hedonic Stimulation	UX - Meaning	hedonic quality
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	AttrakDiff	First Version - 5 item bipolar scale	-	Pragmatic Quality	UX - Meaning	pragmatic quality
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	-	Interest/Enjoyment	UX - Emotion	interest / attractiveness
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	5 Likert scale	-	value/usefulness	UX - Usefulness	perceived usefulness
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	mental demand	Ergonomics / Load / Comfort	cognitive load
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	perceived effort	Ergonomics / Load / Comfort	task perceived effort
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	perceived performance	UX - Usability	perceived performance
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	physical demand	Ergonomics / Load / Comfort	physical load
218	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	modify Likert	Yes	temporal demand	Ergonomics / Load / Comfort	cognitive load
219	\	\	\	\	\	\	\	-	-	\	\	\
220	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
220	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors rate	Task performance	errors
220	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
220	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction level	UX - Usability	satisfaction
220	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	simple to use	UX - Usability	ease of use
220	2	1	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on prototype	-	-	Idea generation of possible interfaces	Prototype focus	co-design
220	2	2	Quantitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	categorization of interactions techniques	interaction	interaction patterns

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
220	2	3	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Experts Interview	-	-	feedbacks on interactions	Prototype focus	feedbacks / insights
221	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	errors	Task performance	errors
221	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	head position	Task performance	accuracy
221	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	supporting task focus (head orientation)	interaction	attention / focus
221	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	task completion time	Task performance	task completion time
221	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	task localization time	Perception/Cognition	perception related accuracy
221	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments	Prototype focus	comments / suggestions
221	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use
221	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
221	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
221	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	intuitiveness	UX - Usability	intuitiveness
221	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preferred in use	UX - Usability	preference
222	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	alignment error between conditions	Task performance	accuracy
222	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	task completion time	Task performance	task completion time
222	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of use	UX - Usability	ease of use
222	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
222	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
223	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	After-Scenario Questionnaire (ASQ)	7 Likert scale	Yes	system useability	UX - Usability	system perceived control / interactivity
223	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	insecure/stressed	Ergonomics / Load / Comfort	frustration / stress / anxiety
223	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	mental demand	Ergonomics / Load / Comfort	cognitive load
223	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived effort to performance	Ergonomics / Load / Comfort	task perceived effort
223	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived successfulness	UX - Usability	perceived performance
223	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	physical demand	Ergonomics / Load / Comfort	physical load
223	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	temporal demand	Ergonomics / Load / Comfort	cognitive load
223	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	7 Likert scale	-	quality o interface design	UX - Usability	aesthetic
223	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Post-Study System Usability Questionnaire (PSSUQ)	7 Likert scale	-	quality of information	UX - Usability	system status information and feedback
223	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	task completion time	Task performance	task completion time
224	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
224	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	3D shapes created by user	Task performance	accuracy

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
224	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	able to create what the user want (control)	UX - Usability	efficiency
224	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy to learn	UX - Usability	learnability
224	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy to use	UX - Usability	ease of use
224	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	get tired	Ergonomics / Load / Comfort	physical load
224	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived control (precision/effectiveness)	UX - Usability	system perceived control / interactivity
224	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	want to use in future	UX - Usefulness	would use again in future
225	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	interaction behavior	interaction	general interaction behavior
225	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	utilization of device	interaction	interaction strategy and system use
225	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	comments	Prototype focus	comments / suggestions
225	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	feedbacks	Prototype focus	feedbacks / insights
225	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	opinions	Prototype focus	comments / suggestions
226	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception completion time
226	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Perception/Cognition	perception related errors
226	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	coordination	interaction	users movements / gestures / physical utilization of prototype
226	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	satisfaction	UX - Usability	satisfaction
226	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	usability	UX - Usability	usability - unspecified
226	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	RTLX version (Raw)- 100 scale	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
226	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	RTLX version (Raw)- 100 scale	-	mental demand	Ergonomics / Load / Comfort	cognitive load
226	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	RTLX version (Raw)- 100 scale	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort
226	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	RTLX version (Raw)- 100 scale	-	perceived performance	UX - Usability	perceived performance
226	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	RTLX version (Raw)- 100 scale	-	physical demand	Ergonomics / Load / Comfort	physical load
226	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	RTLX version (Raw)- 100 scale	-	temporal demand	Ergonomics / Load / Comfort	cognitive load
226	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	interaction behavior	interaction	general interaction behavior
226	1	3	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	utilization of device	interaction	interaction strategy and system use
227	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception completion time
227	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Perception/Cognition	perception related errors
227	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	head movement	Perception/Cognition	perception related accuracy
227	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	identification of info	UX - Usability	system status information and feedback
227	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived usability of info showed	UX - Usability	efficiency
227	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	unutterability of info visualization	Perception/Cognition	virtual environment / object perceived quality

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
227	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-			
227	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preferred visualization method	UX - Usability	preference
228	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	tech usage	Mixed background questions	subject technological comfort / general use
228	P	2	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	co-design/scenario exploration	Prototype focus	co-design
229	\	\	\	\	\	\	\	-	-	\	\	\
230	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	detection of info on real world background	Perception/Cognition	real environment / object recognition
230	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	reading of data on real world background	Perception/Cognition	virtual environment / object perceived quality
230	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	comments	Prototype focus	comments / suggestions
231	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Task performance	errors
231	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
231	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	opinions	Prototype focus	feedbacks / insights
232	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
232	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	error rate	Task performance	errors
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	comparation with traditional	UX - Usability	preference
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	coolness of system	UX - Emotion	perceived innovativeness / wow factor
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	interaction effectivity	UX - Usability	effectiveness
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived accuracy	UX - Usability	system perceived accuracy
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	tracking stability	Prototype focus	problem individuation
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	UI intuitiveness vs traditional	UX - Usability	intuitiveness
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	user support on task	UX - Usability	system perceived control / interactivity
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	utilization simplicity	UX - Usability	ease of use
233	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	visualization techniques	Perception/Cognition	virtual environment / object recognition
233	P	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	co-design	Prototype focus	co-design
233	P	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	feedbacks	Prototype focus	feedbacks / insights
233	P	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	specification	Prototype focus	requirements and missing features
234	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	5 Likert scale	-	ease of distance estimation	UX - Usability	system perceived control / interactivity

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
234	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	5 Likert scale	-	ease of navigation	UX - Usability	system perceived control / interactivity
234	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	5 Likert scale	-	ease of object manipulation	UX - Usability	system perceived control / interactivity
234	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	5 Likert scale	-	ease of object selection	UX - Usability	system perceived control / interactivity
234	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	5 Likert scale	-	ease of use	UX - Usability	ease of use
234	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	5 Likert scale	-	ergonomics	Ergonomics / Load / Comfort	ergonomic properties
234	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	5 Likert scale	-	navigational activity	UX - Usability	system perceived control / interactivity
234	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	5 Likert scale	-	precision of distance estimation	UX - Usability	system perceived control / interactivity
234	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology by D. Davis (10.2307/249008)	5 Likert scale	-	precision of object manipulation	UX - Usability	system perceived control / interactivity
234	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Cognitive Walkthrough	-	-	Interaction patterns	interaction	interaction patterns
234	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Cognitive Walkthrough	-	-	utilization	interaction	interaction strategy and system use
234	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Nielsen 10 - problems	Prototype focus	problem individuation
234	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Nielsen 10 - requirements	Prototype focus	requirements and missing features
234	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	Nielsen 10 - usability	UX - Usability	usability - unspecified
235	\	\	\	\	\	\	\	-	-	\	\	\

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
236	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Task performance	errors
236	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
236	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	usability problem cope strategy	interaction	learning / problem coping strategy
237	\	\	\	\	\	\	\	-	-	\	\	\
238	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
238	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	ergonomics problems	Ergonomics / Load / Comfort	ergonomic properties
238	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	position accuracy	Task performance	accuracy
238	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	position time spent	Ergonomics / Load / Comfort	ergonomic properties
238	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	visual impairment	Ergonomics / Load / Comfort	ergonomic properties
239	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	success rate	Task performance	accuracy
239	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
239	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	comments	Prototype focus	comments / suggestions
239	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	possible problems	Prototype focus	problem individuation
240	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	success rate	Task performance	accuracy
240	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
240	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	motivation of errors	Prototype focus	problem individuation
240	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	preferred method	UX - Usability	preference
240	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	want to use in future	UX - Usefulness	would use again in future
240	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	comments	Prototype focus	comments / suggestions
240	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	suggestions	Prototype focus	comments / suggestions
241	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	ease of data gathering	UX - Usability	ease of use
241	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	ease of use	UX - Usability	ease of use
241	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	enjoyment	UX - Emotion	amusement / fun
241	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	helpfulness of application	UX - Usefulness	perceived usefulness
241	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	perceived performance	UX - Usability	perceived performance
241	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	tasks standards / consistency	UX - Usability	system consistency / standards
242	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	position accuracy (w real word)	Perception/Cognition	perception related accuracy
242	1	2	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	eye point estimation	Perception/Cognition	perception related accuracy
243	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
243	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	success rate	Task performance	errors
243	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of use	UX - Usability	ease of use

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
243	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	fun and engaging	UX - Emotion	arousal / engagement
243	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
243	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	mentally stressful	Ergonomics / Load / Comfort	cognitive load
243	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived performance	UX - Usability	perceived performance
243	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	physically stressful	Ergonomics / Load / Comfort	physical load
243	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	usefulness	UX - Usefulness	perceived usefulness
244	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
244	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	easy to learn	UX - Usability	learnability
244	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	easy to use	UX - Usability	ease of use
244	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	fun and engaging	UX - Emotion	arousal / engagement
244	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	mentally stressful	Ergonomics / Load / Comfort	cognitive load
244	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	natural (expected behavior of interface)	UX - Usability	naturalness
244	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	physically stressful	Ergonomics / Load / Comfort	physical load
244	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	9 Likert scale	-	useful to complete the task	UX - Usefulness	perceived usefulness
245	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
245	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	success rate	Task performance	accuracy
245	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy to learn	UX - Usability	learnability
245	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy to use	UX - Usability	ease of use
245	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	mentally stressful	Ergonomics / Load / Comfort	cognitive load
245	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	natural (expected behavior of interface)	UX - Usability	naturalness
245	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	physically stressful	Ergonomics / Load / Comfort	physical load
245	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	useful to complete the task	UX - Usefulness	perceived usefulness
246	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
246	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	deviation from optimal	Task performance	accuracy
246	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	dizziness	Ergonomics / Load / Comfort	comfort / sickness
246	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	physical discomfort	Ergonomics / Load / Comfort	comfort / sickness
246	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	task difficultness	UX - Usability	perceived task/interaction difficulty
246	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	visualization version preference for search	UX - Usability	preference
246	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	visualization version preference for select	UX - Usability	preference
246	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	visualization version preference global	UX - Usability	preference

Evaluation methodologies and main HCI aspects investigated

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
247	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
247	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	error rate	Task performance	errors
248	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perception of virtual object size	Perception/Cognition	perceived (or evaluated) depth or distance
248	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	perception of virtual object distance	Perception/Cognition	virtual environment / object recognition
248	1	1	Quantitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perception of other person pointing (error rate)	Perception/Cognition	perception related accuracy
249	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
249	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	deviation from optimal	Task performance	accuracy
249	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	participants enjoyment	UX - Emotion	amusement / fun
250	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
250	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	number of clicks	Task performance	n. interactions
250	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
250	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	number of clicks	Task performance	n. interactions
250	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	fatigue	Ergonomics / Load / Comfort	physical load
250	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	learning	UX - Usability	learnability
250	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	preference	UX - Usability	preference
250	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	usability	UX - Usability	usability - unspecified
250	2	3	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	comments	Prototype focus	comments / suggestions
251	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	user interaction with app	interaction	interaction strategy and system use
251	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	easy of learn	UX - Usability	learnability
251	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	easy to use	UX - Usability	ease of use
251	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	overall feedback	Prototype focus	feedbacks / insights
252	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completed tasks	Task performance	n. trails
252	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
252	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Easy to control	UX - Usability	system perceived control / interactivity
252	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	fun to use	UX - Emotion	amusement / fun
252	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Move physically (method of interaction)	interaction	users movements / gestures / physical utilization of prototype
252	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	preference between versions	UX - Usability	preference
253	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time + time in menus	Task performance	task completion time

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
253	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	numbers of trials (comparation w seconds for learning effect)	Task performance	n. trails
253	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	wrong clicks	Task performance	errors
253	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	position of tracked cursor in 2D space	Task performance	accuracy
253	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	effort	Ergonomics / Load / Comfort	task perceived effort
253	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
253	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	mental demands	Ergonomics / Load / Comfort	cognitive load
253	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	own performance (satisfaction)	UX - Usability	satisfaction
253	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	physical demands	Ergonomics / Load / Comfort	physical load
253	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	temporal demands (pressure under task)	Ergonomics / Load / Comfort	frustration / stress / anxiety
254	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	attention to prototype	interaction	attention / focus
254	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	comparation with other techs	UX - Usability	preference
254	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	perceived social acceptability	Collaboration/Communication	Social presence / interaction impact
254	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	perceived use	UX - Usefulness	perceived usefulness
254	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	previous knowledge on topic	Mixed background questions	subject interest / knowledge on topic
254	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	reactions/emotions	UX - Emotion	reactions and emotion individuation / shifting
255	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	errors	Task performance	errors
255	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	on material recorded	-	completion time	Task performance	completion time
255	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	perceived usefulness of augmentation	UX - Usefulness	perceived usefulness
255	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	perceived utilization of augmentation	UX - Usefulness	perceived usefulness
256	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
256	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance travelled	Task performance	distance
256	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	ease of use	UX - Usability	ease of use
256	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	info amount on screen	UX - Usability	efficiency
256	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	usefulness	UX - Usefulness	perceived usefulness
256	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
256	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Experts Interview	-	-	semi-structured interview after test (comparation between interfaces)	UX - Usability	preference

Evaluation methodologies and main HCI aspects investigated

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
256	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Experts Interview	-	-	semi-structured interview after test (pros & cons)	Prototype focus	problem individuation
256	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Experts Interview	-	-	semi-structured interview after test (usability problems)	Prototype focus	problem individuation
257	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	rank items	-	comparation between visualizations	UX - Usability	preference
257	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	info amount on screen	UX - Usability	efficiency
257	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	perceived readability	UX - Usability	system status information and feedback
257	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	open ended question/s	-	comments	Prototype focus	comments / suggestions
258	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	on material recorded	-	completion time	Task performance	completion time
258	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	enjoyment	UX - Emotion	amusement / fun
258	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	feedbacks	Prototype focus	feedbacks / insights
258	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	preference	UX - Usability	preference
259	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	numbers of succeed tasks	Task performance	errors
259	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
259	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance from screen	interaction	users movements / gestures / physical utilization of prototype
259	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	comments	Prototype focus	comments / suggestions
259	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	subjects fun	UX - Emotion	amusement / fun
259	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	error from real target	Perception/Cognition	perception related accuracy
259	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Perception/Cognition	perception completion time
260	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
260	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	comfort	Ergonomics / Load / Comfort	comfort / sickness
260	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived speed	UX - Usability	perceived performance
260	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived stability	UX - Usability	system perceived robustness / stability
260	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	understanding	UX - Usability	understandability
261	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
261	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors rate	Task performance	errors
261	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	intuitiveness	UX - Usability	intuitiveness
261	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	satisfaction level	UX - Usability	satisfaction
261	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	simple to use	UX - Usability	ease of use
262	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
262	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of use	UX - Usability	ease of use
262	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	enjoyment	UX - Emotion	amusement / fun
262	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived performance	UX - Usability	perceived performance
262	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	visualization version preference	UX - Usability	preference
262	1	3	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
262	1	4	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	comments	Prototype focus	comments / suggestions
263	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
263	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of use	UX - Usability	ease of use
263	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	enjoyment	UX - Emotion	amusement / fun
263	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived accuracy	UX - Usability	efficiency
263	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived performance	UX - Usability	perceived performance
264	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
264	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	unweighted	-	effort	Ergonomics / Load / Comfort	task perceived effort
264	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	unweighted	-	mental demands	Ergonomics / Load / Comfort	cognitive load
264	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	unweighted	-	temporal demands (pressure under task)	Ergonomics / Load / Comfort	frustration / stress / anxiety
265	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
265	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Task performance	errors
265	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	ease of use	UX - Usability	ease of use
265	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived accuracy	UX - Usability	system perceived accuracy
266	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
266	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Task performance	errors
267	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Simulator Sickness Questionnaire (SSQ)	5 Likert scale	-	Fun	UX - Emotion	amusement / fun
267	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Simulator Sickness Questionnaire (SSQ)	5 Likert scale	-	immersiveness	Perception/Cognition	sense of presence / immersion
267	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Simulator Sickness Questionnaire (SSQ)	5 Likert scale	-	satisfaction	UX - Usability	satisfaction
267	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Simulator Sickness Questionnaire (SSQ)	5 Likert scale	-	sense of movement	Perception/Cognition	sense of presence / immersion
267	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Simulator Sickness Questionnaire (SSQ)	5 Likert scale	-	Sickness	Ergonomics / Load / Comfort	comfort / sickness
268	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	errors recover	UX - Usability	system errors recovery, prevention and warning
268	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	flexibility	UX - Usability	system flexibility

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
268	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	hand gesture intuitiveness	UX - Usability	intuitiveness
268	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	hand gesture learnability	UX - Usability	learnability
268	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	hand gesture response time	UX - Usability	system smoothness / response time
268	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	info readability	Perception/Cognition	virtual environment / object recognition
268	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	system learnability	UX - Usability	learnability
268	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	utilization effort	Ergonomics / Load / Comfort	task perceived effort
268	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	wearing comfort	Ergonomics / Load / Comfort	ergonomic properties
269	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	ease of completing	UX - Usability	perceived task/interaction difficulty
269	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	errors recover	UX - Usability	system errors recovery, prevention and warning
269	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	info context visualization/hierarchy	UX - Usability	system status information and feedback
269	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived time to task	UX - Usability	perceived performance
269	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	personalization	UX - Usability	aesthetic
269	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	physical effort	Ergonomics / Load / Comfort	physical load
269	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	system feedback	UX - Usability	system status information and feedback
269	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	info readability	Perception/Cognition	virtual environment / object recognition
269	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Heuristic evaluation	-	-	info usefulness	UX - Usability	efficiency
270	1	1	Qualitative	Subjective	Empirical Experimental	Observation	comments collection during test	-	-	feedbacks	Prototype focus	feedbacks / insights
270	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	satisfaction	UX - Usability	satisfaction
270	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	user success on task	Task performance	accuracy
270	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	perceived force on commands and location	Perception/Cognition	hepatics
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	clutterers of audio sources	UX - Usability	system status information and feedback
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	comfortable	Ergonomics / Load / Comfort	ergonomic properties
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy to learn	UX - Usability	learnability
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy to operate	UX - Usability	system perceived control / interactivity
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	efficiency of complete tasks	UX - Usability	efficiency
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	environment discretions	interaction	attention / focus
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	simple to use	UX - Usability	ease of use
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	usefulness of info source	UX - Usefulness	perceived usefulness
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	usefulness of system	UX - Usefulness	perceived usefulness

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-			
271	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	virtual obj quality	Perception/Cognition	virtual environment / object perceived quality
272	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	number of coded gestures	interaction	users movements / gestures / physical utilization of prototype
272	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	number of coded words	interaction	interaction strategy and system use
272	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	pattern of coded gestures during time	interaction	users movements / gestures / physical utilization of prototype
272	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	pattern of worlds during time	interaction	interaction patterns
272	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	on material recorded	-	speech and gesture timing	interaction	interaction patterns
272	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	ease of use	UX - Usability	ease of use
272	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	enjoyableness	UX - Emotion	amusement / fun
272	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	feedbacks	Prototype focus	feedbacks / insights
272	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	Preferences	UX - Usability	preference
272	1	3	Quantitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	interactions behavior	interaction	general interaction behavior
273	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	collision over time	Perception/Cognition	perception related errors
274	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	collision over time	Perception/Cognition	perception related errors
275	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
275	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	tracing error	Task performance	accuracy
276	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	errors	Task performance	errors
276	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	on material recorded	-	completion time	Task performance	completion time
276	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	cognitive demand	Ergonomics / Load / Comfort	cognitive load
276	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of use	UX - Usability	ease of use
276	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	naturalness of interface	UX - Usability	naturalness
276	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived interface effectiveness	UX - Usability	effectiveness
276	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived interface efficiency	UX - Usability	efficiency
276	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived interface satisfaction	UX - Usability	satisfaction
276	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	physical demand	Ergonomics / Load / Comfort	physical load
276	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	satisfaction with the interaction method	UX - Usability	satisfaction
276	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	open ended question/s	-	feedbacks on interactions	Prototype focus	feedbacks / insights
276	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	rank items	-	preferred interaction methods	UX - Usability	preference

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
276	1	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	commands counts	interaction	interaction patterns
276	1	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	commands sequences	interaction	interaction patterns
276	1	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	commands type	interaction	interaction strategy and system use
276	1	4	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	users reactions on errors	interaction	learning / problem coping strategy
276	P	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	system problems	Prototype focus	problem individuation
276	P	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
277	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	comments	Prototype focus	comments / suggestions
277	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	easy to learn	UX - Usability	learnability
277	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived accuracy	UX - Usability	system perceived accuracy
277	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived speed	UX - Usability	perceived performance
278	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
278	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Rating Scale for Mental Effort (RSME)	-	-	perceived mental demand	Ergonomics / Load / Comfort	cognitive load
279	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
279	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	Unspecified	-	effort	Ergonomics / Load / Comfort	task perceived effort
279	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	Unspecified	-	mental demands	Ergonomics / Load / Comfort	cognitive load
279	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	Unspecified	-	physical demands	Ergonomics / Load / Comfort	physical load
279	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	Unspecified	-	temporal demands (pressure under task)	Ergonomics / Load / Comfort	frustration / stress / anxiety
279	1	3	Quantitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	interactions behavior	interaction	interaction strategy and system use
279	1	4	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	feedbacks	Prototype focus	feedbacks / insights
280	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
280	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance of movements	Task performance	accuracy
280	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	errors	Task performance	errors
280	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy to interact	UX - Usability	ease of use
280	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy to understand	UX - Usability	understandability
280	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
280	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	mental demand	Ergonomics / Load / Comfort	cognitive load
280	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived performance	UX - Usability	perceived performance
280	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	physical demand	Ergonomics / Load / Comfort	physical load
280	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	want to use in future	UX - Usefulness	would use again in future

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
281	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Rico and Brewster. Usable gestures for mobile interfaces: evaluating social acceptability	-	social acceptability by audiences and applications	Collaboration/Communication	Social presence / interaction impact
281	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	adapted from previous/similar researches	Rico and Brewster. Usable gestures for mobile interfaces: evaluating social acceptability	-	Social acceptability rating by locations and applications	Collaboration/Communication	Social presence / interaction impact
281	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	gesture usability	UX - Usability	usability - unspecified
281	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	hardware comfort	Ergonomics / Load / Comfort	ergonomic properties
281	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	preference	UX - Usability	preference
282	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
282	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	errors	Task performance	errors
283	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
283	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	steps used	Task performance	n. trails
283	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy of use	UX - Usability	ease of use
283	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	information visualization usefulness	Prototype focus	feature usefulness / importance
283	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived accuracy	UX - Usability	system perceived accuracy
283	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived performance	UX - Usability	perceived performance
283	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	importance of factor	Prototype focus	feature usefulness / importance
283	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	Preferences	UX - Usability	preference
284	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
284	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	steps used	Task performance	n. trails
284	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy of use	UX - Usability	ease of use
284	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	information visualization usefulness	Prototype focus	feature usefulness / importance
284	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived accuracy	UX - Usability	system perceived accuracy
284	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived performance	UX - Usability	perceived performance
284	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	importance of factor	Prototype focus	feature usefulness / importance
284	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	Preferences	UX - Usability	preference
285	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
285	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	frame tracked errors	Task performance	errors
285	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	experience pleasantness	UX - Emotion	amusement / fun
285	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	how to use system	UX - Usability	ease of use
285	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived technology robustness	UX - Usability	system status information and feedback
286	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	time to respond (receiver incoming info amount performance)	Task performance	reaction time

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
286	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-			
286	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	number of detection by observer (how the receiver was detectable)	Collaboration/Communication	ease of communication
286	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	number of response by receiver subject (receiver incoming info amount performance)	Collaboration/Communication	ease of collaboration
286	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	number of world detection per list (how the receiver was detectable)	Collaboration/Communication	ease of communication
286	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	number of world insert during conversation (receiver incoming info amount performance)	Collaboration/Communication	ease of collaboration
286	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	Preferences	UX - Usability	preference
287	\	\	\	\	\	\	\	-	-	\	\	\
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - closed ended question/s	-	area of AR use	Mixed background questions	subject technological comfort / general use
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - closed ended question/s	-	subject use of AR	Mixed background questions	subject technological comfort / general use
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	disappointments	UX - Emotion	arousal / engagement
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	fits with mobile habits	UX - Usability	preference
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	innovation	UX - Emotion	perceived innovativeness / wow factor
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	opinions	Prototype focus	feedbacks / insights
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	want to recommend	UX - Usefulness	would recommend the use
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	want to use in future	UX - Usefulness	would use again in future
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	worth to use the app	UX - Meaning	price / value
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - open / closed ended question/s	-	App Strengths and Weaknesses	Prototype focus	problem individuation
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - open / closed ended question/s	-	expectative of AR use (works as intended)	UX - Usability	system perceived robustness / stability
288	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - open / closed ended question/s	-	motivation of use	UX - Emotion	motivation
289	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	environment perception	Perception/Cognition	real environment / object recognition
289	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	importance of activity	UX - Emotion	interest / attractiveness
289	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	need of info for task	Prototype focus	requirements and missing features
289	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	occurrence of technical problems	Prototype focus	problem individuation
289	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - Likert 7 scale	-	other people influence on user	Collaboration/Communication	individual action vs collaboration
289	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - open ended question/s	-	description of particular experience	Prototype focus	comments / suggestions

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
289	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - open ended question/s	-			
289	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - polar choice	-	user activity during narrative (utilization of APP)	interaction	interaction strategy and system use
290	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
290	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	time between inputs	Task performance	interaction time
290	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easy to identify buttons	UX - Usability	learnability
290	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	hepatic feedback satisfaction	Perception/Cognition	hepatics
290	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	usefulness of tech	UX - Usefulness	perceived usefulness
291	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	force quantification (stronger/weaker)	Perception/Cognition	hepatics
291	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	motivation of responses	Perception/Cognition	sense of presence / immersion
291	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	possible problems	Prototype focus	problem individuation
291	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	sensation description	Perception/Cognition	sense of presence / immersion
291	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	illusion evaluation questionnaire by Pusch, Martin, and Coquillart	1 to 7 scale	-	AR Experience correlation with real world	Perception/Cognition	sense of presence / immersion
292	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	force quantification (stronger/weaker)	Perception/Cognition	hepatics
292	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	motivation of responses	Perception/Cognition	sense of presence / immersion
292	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	possible problems	Prototype focus	problem individuation
292	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	sensation description	Perception/Cognition	sense of presence / immersion
292	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	illusion evaluation questionnaire by Pusch, Martin, and Coquillart	1 to 7 scale	-	AR Experience correlation with real world	Perception/Cognition	sense of presence / immersion
292	1	3	Quantitative	Objective	Empirical Experimental	User Measurements	Electromyography (EMG)	-	-	arm/hand muscles activity	Perception/Cognition	physical body responses
292	1	3	Quantitative	Objective	Empirical Experimental	User Measurements	gait tracking	Force plate balance	-	balance control	Perception/Cognition	physical body responses
293	\	\	\	\	\	\	\	-	-	\	\	\
294	\	\	\	\	\	\	\	-	-	\	\	\
295	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
295	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	error rate	Task performance	errors
295	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	item count	Task performance	score
296	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
296	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	error rate	Task performance	errors
296	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	item count	Task performance	score
297	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
297	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance from predefined path	Task performance	accuracy

Evaluation methodologies and main HCI aspects investigated

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
297	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-			
297	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	error rate	Task performance	errors
297	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	comments	Prototype focus	comments / suggestions
297	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	ease of understand	UX - Usability	understandability
297	1	2	Quantitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	visualization preferences	UX - Usability	preference
298	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
298	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance from predefined position	Task performance	accuracy
298	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	feedbacks	Prototype focus	feedbacks / insights
298	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
298	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance from predefined position	Task performance	accuracy
298	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	perceived best on overall demand	Ergonomics / Load / Comfort	task perceived effort
298	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	perceived best on performance	UX - Usability	perceived performance
298	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort
298	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
298	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived mental demand	Ergonomics / Load / Comfort	cognitive load
298	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived own performance	UX - Usability	perceived performance
298	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived physical demand	Ergonomics / Load / Comfort	physical load
298	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived temp demand	Ergonomics / Load / Comfort	cognitive load
299	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	Electroencephalography (EEG)	-	-	EEG deviation on base line	Task performance	accuracy
299	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
300	\	\	\	\	\	\	\	-	-	\	\	\
301	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
301	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	gesture accuracy	Task performance	accuracy
302	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
302	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	gesture accuracy	Task performance	accuracy
303	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	interaction techniques used	interaction	interaction strategy and system use
303	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	interactions behaviors	interaction	general interaction behavior
303	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	attitude towards system (interest)	UX - Emotion	interest / attractiveness
303	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured post-experiment discussion	-	-	attitude towards system (privacy)	UX - Meaning	Privacy

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
304	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	5 Likert scale	-	gestures suitability to command (preferences)	UX - Usability	preference
304	1	1	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	6 Likert scale	-	previous experience on platform	interaction	common general live / interaction behavior
304	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	gestures interaction	interaction	users movements / gestures / physical utilization of prototype
304	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	insight on system usability	Prototype focus	feedbacks / insights
304	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	10 Likert scale	-	ease of use	UX - Usability	ease of use
304	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	6 Likert scale	-	usefulness of interaction	Prototype focus	feature usefulness / importance
304	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	immersion	Perception/Cognition	sense of presence / immersion
304	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	8 Likert scale	-	arm fatigue	Ergonomics / Load / Comfort	physical load
304	1	3	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	9 Likert scale	-	sense of size	Perception/Cognition	virtual environment / object recognition
305	\	\	\	\	\	\	\	-	-	\	\	\
306	\	\	\	\	\	\	\	-	-	\	\	\
307	\	\	\	\	\	\	\	-	-	\	\	\
308	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	applied force	Perception/Cognition	hepatics
308	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
308	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	gesture accuracy	Task performance	accuracy
309	\	\	\	\	\	\	\	-	-	\	\	\
310	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
310	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	gesture accuracy	Task performance	accuracy
310	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	interaction problems	Prototype focus	problem individuation
310	1	2	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	pleasure/fun	UX - Emotion	amusement / fun
311	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance from edge point	Task performance	accuracy
312	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	observed engagement/emotions	UX - Emotion	arousal / engagement
312	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	play theme	interaction	general interaction behavior
312	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	players comments	Prototype focus	comments / suggestions
312	1	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	play behavior (frequency)	interaction	common general live / interaction behavior
312	1	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	play behavior (time)	interaction	common general live / interaction behavior
312	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert with proxy users	-	appropriateness of themes	Prototype focus	requirements and missing features
312	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert with proxy users	-	Cooperativeness	Collaboration/Communication	ease of collaboration

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
312	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert with proxy users	-	effectiveness/usefulness of tech	UX - Usefulness	perceived usefulness
312	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert with proxy users	-	Engagement	UX - Emotion	arousal / engagement
312	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert with proxy users	-	improvements	Prototype focus	comments / suggestions
312	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert with proxy users	-	Interest in general attentiveness	UX - Emotion	interest / attractiveness
312	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert with proxy users	-	smiling/enjoyment	UX - Emotion	amusement / fun
312	P1	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Experts Interview	-	-	psychology experts feedbacks	Prototype focus	feedbacks / insights
312	P2	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	play behavior	interaction	gaming style / behavior
312	P3	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	-	-	problems	Prototype focus	problem individuation
313	\	\	\	\	\	\	\	-	-	\	\	\
314	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived training properties	UX - Usefulness	perceived usefulness
314	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	realism and hepatics	Perception/Cognition	sense of presence / immersion
314	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	background knowledge on topic	Mixed background questions	subject interest / knowledge on topic
314	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
314	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	path length	Task performance	distance
315	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	clarity of system	UX - Usability	ease of use
315	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	hepatic feedback satisfaction	Perception/Cognition	hepatics
315	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived training properties	UX - Usability	perceived performance
315	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Realism	Perception/Cognition	sense of presence / immersion
315	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usefulness of system	UX - Usefulness	perceived usefulness
316	1	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Anxiety Disorders Interview Schedule (ADIS-IV)	-	Phobia Diagnosis	Treatment Specific	fears / phobias
316	1	2	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	Behavior Avoidance Test (Bat) (pre and post therapy)	-	measure the degree of overt avoidance	Treatment Specific	fears / phobias
316	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	-	-	Fear	Treatment Specific	fears / phobias
316	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Presence and reality judgment (open ended) (pre and post therapy)	-	Presence and reality judgment	Treatment Specific	fears / phobias
316	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Degree of belief in catastrophic thoughts (1 to 100 scale) (pre and post therapy)	-	(da belief in catastrophic thoughts)	Treatment Specific	fears / phobias

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
316	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Fear and avoidance scales (1 to 10 scale) (pre and post therapy)	-	Fear and advanced	Treatment Specific	fears / phobias
316	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Measures regarding expectations and-satisfaction with the treatment (1 to 7 scale) (pre and post therapy)	-	Expectations	Treatment Specific	fears / phobias
316	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Subjective units of discomfort scale (SUDS) (1 to 10 scale) (pre and post therapy)	-	Subjective units of discomfort	Treatment Specific	fears / phobias
317	1	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Anxiety Disorders Interview Schedule (ADIS-IV)	-	Phobia Diagnosis	Treatment Specific	fears / phobias
317	1	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Target Behaviors (adapted from Marks & Mathew 1979) (1 to 10 scale) (pre and post therapy)	-	Fear	Treatment Specific	fears / phobias
317	1	2	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	Behavior Avoidance Test (Bat) (pre and post therapy)	-	Avoidance	Treatment Specific	fears / phobias
317	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	modified The Fear of Spiders Questionnaire (8 Likert) (pre and post therapy)	Yes	Fear	Treatment Specific	fears / phobias
317	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Spider Phobia Beliefs Questionnaire (SPBQ) (1 to 100 scale) (pre and post therapy)	-	Presence and reality judgment	Treatment Specific	fears / phobias
317	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Subjective units of discomfort scale (SUDS) (1 to 10 scale) (pre and post therapy)	-	Subjective units of discomfort	Treatment Specific	fears / phobias
318	1	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Anxiety Disorders Interview Schedule (ADIS-IV)	-	Phobia Diagnosis	Treatment Specific	fears / phobias
318	1	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Target Behaviors (adapted from Marks & Mathew 1979) (1 to 10 scale) (pre and post therapy)	-	Fear	Treatment Specific	fears / phobias
318	1	2	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	Behavior Avoidance Test (Bat) (pre and post therapy)	-	Avoidance	Treatment Specific	fears / phobias
318	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	modified The Fear of Spiders Questionnaire (8 Likert) (pre and post therapy)	-	Fear	Treatment Specific	fears / phobias
318	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Spider Phobia Beliefs Questionnaire (SPBQ) (1 to 100 scale) (pre and post therapy)	-	Fear	Treatment Specific	fears / phobias
318	1	3	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Subjective units of discomfort scale (SUDS) (1 to 10 scale) (pre and post therapy)	-	Subjective units of discomfort	Treatment Specific	fears / phobias
319	1	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Presence and reality judgment (open ended) (pre and post therapy)	-	Presence and reality judgment	Treatment Specific	fears / phobias

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
319	1	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Anxiety Disorders Interview Schedule (ADIS-IV)	-	Phobia Diagnosis	Treatment Specific	fears / phobias
319	1	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Treatment / Rehabilitation specific tests Experts Evaluation	Subjective units of discomfort scale (SUDS) (1 to 10 scale) (pre and post therapy)	-	Subjective units of discomfort	Treatment Specific	fears / phobias
320	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	tasks completion time	Task performance	task completion time
320	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	total completion time	Task performance	completion time
321	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	deviation from path	Task performance	accuracy
321	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance from receptacle	Task performance	distance
321	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	multi-axis usage	interaction	users movements / gestures / physical utilization of prototype
321	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	path distance	Task performance	distance
321	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	reversal errors	Task performance	errors
321	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	tasks completion time	Task performance	task completion time
321	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	trails	Task performance	n. trails
321	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	deviation from path	Task performance	accuracy
321	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance from receptacle	Task performance	distance
321	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	multi-axis usage	interaction	users movements / gestures / physical utilization of prototype
321	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	path distance	Task performance	distance
321	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	reversal errors	Task performance	errors
321	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	tasks completion time	Task performance	task completion time
321	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	trails	Task performance	n. trails
322	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	3D localization precision	Task performance	accuracy
322	1	2	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	aided localization (task efficiency)	UX - Usability	efficiency
322	1	2	Quantitative	Subjective	Empirical Inquiry	Interviews	structured	7 Likert scale	-	perceived confidence	UX - Emotion	trust (perceived safety)
322	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort
322	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
322	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived mental demand	Ergonomics / Load / Comfort	cognitive load
322	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived own performance	UX - Usability	perceived performance
322	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived physical demand	Ergonomics / Load / Comfort	physical load
322	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	7 Likert	-	perceived temp demand	Ergonomics / Load / Comfort	cognitive load
323	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	gait velocity, stride length, stride cadence	Task performance	field specific amount

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
324	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	difference between projected and real target	Task performance	accuracy
325	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	difference between projected and real target	Task performance	accuracy
326	1	1	Quantitative	Objective	Empirical Inquiry	Self-Reported / Diaries	Self-reported data / Diaries	-	-	completion time	Task performance	completion time
326	1	1	Quantitative	Objective	Empirical Inquiry	Self-Reported / Diaries	Self-reported data / Diaries	-	-	n. scans	Task performance	n. interactions
326	1	1	Quantitative	Objective	Empirical Inquiry	Self-Reported / Diaries	Self-reported data / Diaries	-	-	Radiation Dose used	Task performance	field specific amount
327	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	force applied	Task performance	field specific amount
327	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	max force applied	Perception/Cognition	hepatics
327	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	total completion time	Task performance	completion time
328	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	force applied, max force area, max force applied, force volume	Perception/Cognition	hepatics
328	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	Path length/position	Task performance	accuracy
328	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	task completion time	Task performance	task completion time
329	1	1	Quantitative	Objective	Empirical Inquiry	Questionnaire	custom-made	1 to 100 scale	-	similarity between real and virtual	Perception/Cognition	virtual environment / object perceived quality
330	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	anxiety level	Ergonomics / Load / Comfort	frustration / stress / anxiety
330	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Slater et al. (1994) - 1 to 7 scale	-	perception of physical tokens	Perception/Cognition	real environment / object recognition
330	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Slater et al. (1994) - 1 to 7 scale	-	Perception of presence in virtual environment	Perception/Cognition	sense of presence / immersion
330	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Slater et al. (1994) - 1 to 7 scale	-	Perception of virtual objects	Perception/Cognition	virtual environment / object recognition
331	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	anxiety level	Ergonomics / Load / Comfort	frustration / stress / anxiety
331	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Slater et al. (1994) - 1 to 7 scale	-	perception of physical tokens	Perception/Cognition	real environment / object recognition
331	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Slater et al. (1994) - 1 to 7 scale	-	Perception of presence in virtual environment	Perception/Cognition	sense of presence / immersion
331	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Slater et al. (1994) - 1 to 7 scale	-	Perception of virtual objects	Perception/Cognition	virtual environment / object recognition
332	1	1	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	The Fugl-Meyer Upper Extremity Motor Performance Section Test (pre/post test)	-	arm motion performance	Treatment Specific	rehabilitation
332	1	2	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Treatment / Rehabilitation specific Questionnaire	DASH questionnaire (pre/post test)	-	arm motion performance	Treatment Specific	rehabilitation
332	1	3	Quantitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	Wolf Motor Arm Test (pre/post test)	-	arm motion performance	Treatment Specific	rehabilitation
332	1	4	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	concept validation	Prototype focus	co-design
332	1	4	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	ease of use	UX - Usability	ease of use
332	1	4	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	enjoyment	UX - Emotion	amusement / fun

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
332	1	4	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-			
332	1	4	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	motivation of use	UX - Emotion	motivation
332	1	4	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	problems	Prototype focus	problem individuation
332	1	4	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	requirements	Prototype focus	requirements and missing features
332	1	4	Qualitative	Subjective	Empirical Inquiry	Focus Group	Post test focus group	-	-	want to use in future	UX - Usefulness	would use again in future
333	1	1	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	Objective Structured Assessment Technical Skills (OSATS) (1 to 5 scale)	-	score given by doctor on tasks	Treatment Specific	rehabilitation
334	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	success rate	Task performance	errors
334	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	task completion time	Task performance	task completion time
334	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	graphics quality	Perception/Cognition	virtual environment / object perceived quality
334	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	hepatic feedback quality/Tactility	Perception/Cognition	hepatics
334	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived learning performance	UX - Usability	perceived performance
334	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	silicone mold quality	Perception/Cognition	real environment / object recognition
334	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	similarity between real and simulator syringe	Perception/Cognition	real environment / object recognition
334	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	usefulness of simulator	UX - Usefulness	perceived usefulness
335	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	grasping / press force	-	-	force applied during rehabilitations sessions	Perception/Cognition	hepatics
336	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	execution time	Task performance	completion time
336	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	maximum displacement	Task performance	accuracy
336	1	2	Quantitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	Standard functional tests (box & blocks, Rancho)	-	score given by doctor on tasks	Treatment Specific	rehabilitation
337	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	success rate	Task performance	errors
337	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	task completion time	Task performance	task completion time
338	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance from target	Task performance	accuracy
338	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	task completion time	Task performance	task completion time
339	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments	Prototype focus	comments / suggestions
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	amusement to use	UX - Emotion	amusement / fun
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	discomfort/dizziness	Ergonomics / Load / Comfort	comfort / sickness
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	easy to understand	UX - Usability	understandability
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	easy to use	UX - Usability	ease of use
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	perceived confidence in task	UX - Emotion	trust (perceived safety)

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	perceived control over system	UX - Usability	system status information and feedback
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	prefer real person interaction	UX - Usability	preference
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	system is clumsy	UX - Usability	system perceived robustness / stability
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	technical problems	Prototype focus	problem individuation
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	want to recommend	UX - Usefulness	would recommend the use
339	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	want to use in future	UX - Usefulness	would use again in future
339	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users interactions behavior	interaction	general interaction behavior
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	difficulty in reaching the tiles	Prototype focus	problem individuation
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	difficulty in tile selection	Prototype focus	problem individuation
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	ease of use	UX - Usability	ease of use
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	enjoyment/fun	UX - Emotion	amusement / fun
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	perceived virtual hand speed	UX - Usability	perceived performance
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	selection feedbacks	Prototype focus	feedbacks / insights
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	7 Likert	Yes	easy to learn	UX - Usability	learnability
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	7 Likert	Yes	effectiveness	UX - Usability	effectiveness
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	7 Likert	Yes	perceived comfort in using the system	Ergonomics / Load / Comfort	comfort / sickness
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	7 Likert	Yes	perceived performance	UX - Usability	perceived performance
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	7 Likert	Yes	perceived time to task	UX - Usability	effectiveness
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	7 Likert	Yes	satisfaction level	UX - Usability	satisfaction
340	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	Usability Satisfaction Questionnaires	7 Likert	Yes	simplicity of use	UX - Usability	ease of use
340	2	1	Qualitative	Subjective	Empirical Inquiry	Focus Group	workshop with students	-	-	uses possibilities	Prototype focus	possible use / potentials of system
340	3	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Experts Interview	-	-	possible features	Prototype focus	requirements and missing features
340	3	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Experts Interview	-	-	technological therapeutic pros/cons of system	Prototype focus	problem individuation
340	3	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Experts Interview	-	-	understand how to use the system	UX - Usability	understandability
340	3	1	Qualitative	Subjective	Empirical Inquiry	Experts Review / Evaluation	Experts Interview	-	-	usefulness of system	UX - Usefulness	perceived usefulness
341	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	hepatic perception	Perception/Cognition	hepatics

Evaluation methodologies and main HCI aspects investigated

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
341	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-			
341	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	realism of virtual elements	Perception/Cognition	real environment / object recognition
341	1	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	visual perception of monitor	Perception/Cognition	virtual environment / object recognition
341	2	1	Qualitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	realism of virtual elements	Perception/Cognition	virtual environment / object perceived quality
341	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	IPQ version -3 to +3 scale	Yes	realism of virtual elements	Perception/Cognition	virtual environment / object perceived quality
341	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	IPQ version -3 to +3 scale	Yes	sense of continue presence	Perception/Cognition	sense of presence / immersion
341	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	IPQ version -3 to +3 scale	Yes	sense of presence in real world	Perception/Cognition	sense of presence / immersion
341	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	IPQ version -3 to +3 scale	Yes	visual perception of hands	Perception/Cognition	virtual environment / object recognition
341	3	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	mental demand	Ergonomics / Load / Comfort	cognitive load
341	3	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	requirements	Prototype focus	requirements and missing features
341	3	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	technical problems	Prototype focus	problem individuation
341	3	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	usability of system	UX - Usability	usability - unspecified
341	3	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users comments	Prototype focus	comments / suggestions
342	1	1	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	clinical measurements on motor rehabilitation	-	rehabilitation performances measured by doctors	Treatment Specific	rehabilitation
343	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	path length	Task performance	accuracy
343	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	smoothness	Perception/Cognition	hepatics
344	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	incision accuracy	Task performance	accuracy
344	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	task completion time	Task performance	task completion time
345	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	easy to use	UX - Usability	ease of use
345	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	feature usefulness	Prototype focus	feature usefulness / importance
345	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived learn performance	UX - Usability	perceived performance
345	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	preference vs traditional hardware/software	UX - Usability	preference
345	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	visualization performances	UX - Usability	system perceived robustness / stability
345	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	open ended question/s	-	comments	Prototype focus	comments / suggestions
346	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	scutter points (3D coordinate of operation)	Task performance	accuracy
346	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	task completion time	Task performance	task completion time
347	1	1	Quantitative	Subjective	Empirical Inquiry	Conventional Test (Written/Oral)	test with evaluation give by teacher (PRE + POST evaluation)	-	-	treatment score/pass/fail %	Education specific	learning performance POST (error / score comparation)

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
348	1	1	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	Behavior Avoidance Test (Bat) (pre and post therapy)	-	measure the degree of overt avoidance	Treatment Specific	rehabilitation
348	1	1	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	Working Alliance Inventory (WAI)	-	score given by doctor	Treatment Specific	rehabilitation
349	1	1	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	Berg Balance Scale (BBS)	-	Balance Ability	Treatment Specific	rehabilitation
349	1	2	Qualitative	Subjective	Empirical Experimental	User Measurements	gait tracking	GAITRite system	-	Spatiotemporal parameters (gait velocity, cadence, step length, stride length)	Treatment Specific	rehabilitation
349	1	3	Qualitative	Subjective	Empirical Experimental	Observation	Treatment / Rehabilitation specific tests Experts Evaluation	short Falls Efficacy Scale-International (FES-I)	-	Fall efficacy	Treatment Specific	rehabilitation
350	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	success rate (after use)	Task performance	errors
350	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	success rate (pre use)	Task performance	errors
350	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	overall satisfaction with system	UX - Usability	satisfaction
350	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived performance	UX - Usability	perceived performance
350	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived usefulness	UX - Usefulness	perceived usefulness
350	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived virtual information	UX - Usability	efficiency
350	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	want to recommend	UX - Usefulness	would recommend the use
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	Acceptance	UX - Meaning	acceptance
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	Disorientation	Perception/Cognition	sense of orientation / navigation
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	ease of use	UX - Usability	ease of use
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	familiarity	UX - Usability	preference
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	Privacy	UX - Meaning	Privacy
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	System Trust	UX - Emotion	trust (perceived safety)
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	usefulness	UX - Usefulness	perceived usefulness
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	6 Likert	-	visibility	UX - Usability	system status information and feedback
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived mental demand	Ergonomics / Load / Comfort	cognitive load
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived own performance	UX - Usability	perceived performance
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived physical demand	Ergonomics / Load / Comfort	physical load
351	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived temp demand	Ergonomics / Load / Comfort	cognitive load

Evaluation methodologies and main HCI aspects investigated

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
351	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	percentage preferred walking speed (how the normal walking speed is disrupted by system)	Task performance	interaction time
351	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Technical self-efficacy (TSE) Questionnaire	-	Yes	subject technological comfort	Mixed background questions	subject technological comfort / general use
351	1	4	Qualitative	Objective	Empirical Inquiry	Self-Reported / Diaries	Factor-Referenced Cognitive Tests (Paperfolding test)	-	-	Spatial visualization ability	Perception/Cognition	real environment / object recognition
352	\	\	\	\	\	\	\	-	-	\	\	\
353	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	number of tags found	Task performance	score
353	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	taps on screen	Task performance	n. interactions
353	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	task completion time	Task performance	task completion time
353	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	ease of use of method used	UX - Usability	ease of use
353	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preferred method	UX - Usability	preference
354	\	\	\	\	\	\	\	-	-	\	\	\
355	\	\	\	\	\	\	\	-	-	\	\	\
356	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
356	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	position errors	Task performance	accuracy
356	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	effort	Ergonomics / Load / Comfort	task perceived effort
356	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived accuracy	UX - Usability	system perceived accuracy
356	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived performance	UX - Usability	perceived performance
356	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived speed	UX - Usability	efficiency
356	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	satisfaction of use	UX - Usability	satisfaction
357	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
357	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	path taken	interaction	users movements / gestures / physical utilization of prototype
357	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	success rate	Task performance	errors
358	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
358	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	difference w baseline/number of points interacted	Task performance	accuracy
358	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	comfort	Ergonomics / Load / Comfort	comfort / sickness
358	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easiness	UX - Usability	perceived task/interaction difficulty
358	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived accuracy	UX - Usability	system perceived accuracy
358	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived speed	UX - Usability	perceived performance
358	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Understandability	UX - Usability	understandability
358	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
358	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-			
358	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	effective width	Task performance	distance
358	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	movement distance	Task performance	distance
358	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	number of clicks	Task performance	n. interactions
358	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	traced path	Task performance	accuracy
358	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	comfort	Ergonomics / Load / Comfort	comfort / sickness
358	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	easiness	UX - Usability	perceived task/interaction difficulty
358	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived accuracy	UX - Usability	system perceived accuracy
358	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived speed	UX - Usability	perceived performance
358	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Understandability	UX - Usability	understandability
359	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	compass orientation	Task performance	accuracy
359	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	path taken	interaction	users movements / gestures / physical utilization of prototype
359	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	-	adjust to virtual environment	Perception/Cognition	sense of presence / immersion
359	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	-	concentration on task being performed	Perception/Cognition	sense of presence / immersion
359	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	-	naturalness of experience	Perception/Cognition	sense of presence / immersion
359	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	-	perceived localization performance	Perception/Cognition	sense of presence / immersion
359	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	-	perceived space movement	Perception/Cognition	sense of presence / immersion
359	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	-	responsivities of system	UX - Usability	system smoothness / response time
359	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	-	stability of sound space	UX - Usability	system perceived robustness / stability
359	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	by Witmer and Singer (1998) - 7 Likert	-	time perception	Perception/Cognition	sense of presence / immersion
360	1	1	Qualitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	usage insights	Prototype focus	feedbacks / insights
360	1	2	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on prototype	-	-	Interactions with system	interaction	interaction strategy and system use
360	1	2	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Think aloud on prototype	-	-	subjects opinions/thoughts	Prototype focus	comments / suggestions
360	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	comments	Prototype focus	comments / suggestions
360	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	week long interaction logging	interaction	long period interactions studies with system
360	2	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	comments	Prototype focus	comments / suggestions
360	3	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	month long interaction logging	interaction	long period interactions studies with system
360	3	2	Qualitative	Subjective	Empirical Inquiry	Interviews	remote interview	semi-structured phone interview	-	comments	Prototype focus	comments / suggestions
361	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	attention drawing of the visualization method	interaction	attention / focus
361	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	convenient of the visualization method	UX - Usability	system status information and feedback

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
361	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-			
361	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	distractibility of the visualization method	interaction	attention / focus
361	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	perceived accuracy	UX - Usability	system perceived accuracy
361	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	preferred visualization method	UX - Usability	preference
361	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	want to use in future	UX - Usefulness	would use again in future
361	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	preferred method	UX - Usability	preference
362	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
362	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	attention drawing of the visualization method	interaction	attention / focus
362	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	convenient of the visualization method	UX - Usability	system status information and feedback
362	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	distractibility of the visualization method	interaction	attention / focus
362	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	perceived system accuracy	Task performance	accuracy
362	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	preferred method	UX - Usability	preference
362	1	3	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	position of the phone	Task performance	accuracy
363	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	players game strategy	interaction	gaming style / behavior
363	1	2	Qualitative	Subjective	Empirical Inquiry	Self-Reported / Diaries	Participants artefacts (notebooks, emails, drawings, produced materials etc.)	-	-	photos taken by participants	interaction	general interaction behavior
363	1	3	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	communications strategies between players	Collaboration/Communication	organization behavior and strategies between users
363	1	3	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	Embodied interaction (use of hands and body to communicate)	Collaboration/Communication	gestures / hands / body communication
363	1	3	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	game performances	interaction	gaming style / behavior
363	1	3	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	utilization of tools	interaction	interaction strategy and system use
363	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	GameFlow questionnaire	Likert Ordinal scale	-	how the flow of the game changed (from easy to difficult/how subjects interacted with other players...)	interaction	gaming style / behavior
363	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Intrinsic Motivation Inventory (IMI)	Likert Ordinal scale	-	motivation (interest/perceived performance)	UX - Emotion	interest / attractiveness
363	1	4	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	MEC-SPQ - Likert Ordinal	-	presence	Perception/Cognition	sense of presence / immersion
363	1	5	Qualitative	Subjective	Empirical Inquiry	Interviews	structured	-	-	experience description recurrent adjectives	Prototype focus	comments / suggestions
364	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	average acceleration	Task performance	field specific amount

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
364	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	distance between car and virtual objects	Perception/Cognition	perception related accuracy
364	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	maneuver completion time	Perception/Cognition	perception completion time
364	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	driving comfort	Ergonomics / Load / Comfort	ergonomic properties
364	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	HMD comfort	Ergonomics / Load / Comfort	ergonomic properties
364	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	motion sickness	Ergonomics / Load / Comfort	comfort / sickness
364	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	opposing vehicles realism	Perception/Cognition	virtual environment / object perceived quality
364	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	opposing vehicles visibility	Perception/Cognition	virtual environment / object recognition
364	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	safety perceived during drive	UX - Emotion	trust (perceived safety)
364	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	scene realism	Perception/Cognition	virtual environment / object perceived quality
364	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	scene visibility	Perception/Cognition	real environment / object recognition
365	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
365	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	steps walked	Task performance	distance
365	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort
365	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
365	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived mental demand	Ergonomics / Load / Comfort	cognitive load
365	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived own performance	UX - Usability	perceived performance
365	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived physical demand	Ergonomics / Load / Comfort	physical load
365	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived temp demand	Ergonomics / Load / Comfort	cognitive load
365	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	experience errors/issues encounter count	Prototype focus	problem individuation
365	1	4	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	errors recover strategies	interaction	learning / problem coping strategy
365	1	4	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	navigation strategy	interaction	interaction strategy and system use
365	1	4	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	system utilization	interaction	interaction strategy and system use
366	1	1	Qualitative	Subjective	Empirical Experimental	User Action Logging	system logs	-	-	average duration of session	Task performance	interaction time
366	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	on material recorded	-	session activity (system use during task)	interaction	interaction strategy and system use
366	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	feedbacks	Prototype focus	feedbacks / insights
367	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	perceived depth	Perception/Cognition	perceived (or evaluated) depth or distance
367	P1	1	Qualitative	Subjective	Empirical Experimental	Think aloud / Shadowing	Shadowing	-	-	user observations of common problems/experience/ habits/concerns while driving	interaction	common general live / interaction behavior

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
367	P2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	users reactions	UX - Emotion	reactions and emotion individuation / shifting
367	P2	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	comments	Prototype focus	comments / suggestions
367	P2	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
367	P2	3	Qualitative	Subjective	Empirical Experimental	Observation	evaluators coded/structured observations	-	-	waiting time before crossing	Task performance	task completion time
368	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
368	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	error rate	Task performance	errors
368	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	omission of targets	Task performance	accuracy
368	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	viewing time per target	Task performance	task completion time
368	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - with only one Fatigue category (7 Likert)	Yes	fatigue	Ergonomics / Load / Comfort	physical load
368	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - with only one Fatigue category (7 Likert)	Yes	force required for operation	Ergonomics / Load / Comfort	physical load
368	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - with only one Fatigue category (7 Likert)	Yes	mental effort required for operation	Ergonomics / Load / Comfort	cognitive load
368	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - with only one Fatigue category (7 Likert)	Yes	operation	Ergonomics / Load / Comfort	task perceived effort
368	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - with only one Fatigue category (7 Likert)	Yes	perceived accuracy	UX - Usability	system perceived accuracy
368	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - with only one Fatigue category (7 Likert)	Yes	perceived comfort	Ergonomics / Load / Comfort	comfort / sickness
368	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - with only one Fatigue category (7 Likert)	Yes	perceived speed	UX - Usability	perceived performance
368	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	ISO 9241	part 9 - with only one Fatigue category (7 Likert)	Yes	smoothness	UX - Usability	system smoothness / response time
368	1	3	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	traced path on map (search strategies)	interaction	interaction strategy and system use
369	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
369	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	error rate	Task performance	errors
369	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	traced path on map (search strategies)	interaction	interaction strategy and system use
369	1	2	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	% eyes on background (attention focus/search strategies)	interaction	attention / focus
369	1	2	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	gaze shifts (attention focus/search strategies)	interaction	attention / focus
369	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	condition preference	UX - Usability	preference

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
369	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	control	UX - Usability	system status information and feedback
369	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	efficiency	UX - Usability	efficiency
369	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	helpfulness	UX - Usability	ease of use
369	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	learnability	UX - Usability	learnability
369	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	liking the application (affect/want to suggest)	UX - Emotion	arousal / engagement
369	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Task performance	completion time
369	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	error rate	Task performance	errors
369	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	omission of targets	Task performance	accuracy
369	2	2	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	% eyes on background (attention focus/search strategies)	interaction	attention / focus
369	2	2	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	gaze shifts (attention focus/search strategies)	interaction	interaction strategy and system use
369	2	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	condition preference	UX - Usability	preference
369	2	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	control	UX - Usability	system status information and feedback
369	2	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	efficiency	UX - Usability	efficiency
369	2	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	helpfulness	UX - Usability	ease of use
369	2	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	learnability	UX - Usability	learnability
369	2	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Software Usability Measurement Inventory (SUMI)	1 to 3 scale	Yes	liking the application (affect/want to suggest)	UX - Emotion	arousal / engagement
370	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	Reaction time	Task performance	reaction time
370	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	Response rate (count)	Task performance	accuracy
371	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	Reaction time	Task performance	reaction time
371	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	Response rate (count)	Task performance	accuracy

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
372	\	\	\	\	\	\	\	-	-	\	\	\
373	\	\	\	\	\	\	\	-	-	\	\	\
374	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	counted distractions	interaction	attention / focus
374	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	counted fixation objects	interaction	attention / focus
374	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	fixation time on objects	interaction	attention / focus
374	1	2	Qualitative	Subjective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	error rate	Task performance	errors
374	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	Reaction time	Task performance	reaction time
374	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	opinion on position of visualization	Prototype focus	feedbacks / insights
374	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	perceived difference between methods	Perception/Cognition	virtual environment / object recognition
374	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	position of augmentation acceptability	Perception/Cognition	virtual environment / object perceived quality
374	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	size of augmentation acceptability	Perception/Cognition	virtual environment / object perceived quality
374	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed response multi item	-	preferred visualization method	UX - Usability	preference
375	\	\	\	\	\	\	\	-	-	\	\	\
376	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	accuracy	Perception/Cognition	perception related accuracy
376	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	response time	Perception/Cognition	perception related response time
376	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	signed error (perceived distance)	Perception/Cognition	perceived (or evaluated) depth or distance
377	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	signed error (perceived distance)	Perception/Cognition	perceived (or evaluated) depth or distance
377	2	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	signed error (perceived distance)	Perception/Cognition	perceived (or evaluated) depth or distance
377	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	depth estimation confidence	Perception/Cognition	perceived (or evaluated) depth or distance
377	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived accuracy	UX - Usability	system perceived accuracy
377	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived difficulty	UX - Usability	perceived task/interaction difficulty
377	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived performance	UX - Usability	perceived performance
378	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	errors	Perception/Cognition	perception related errors
378	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	response time	Perception/Cognition	perception related response time
379	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	errors	Perception/Cognition	perception related errors

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
379	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	response time	Perception/Cognition	perception related response time
380	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	errors	Perception/Cognition	perception related errors
380	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	response time	Perception/Cognition	perception related response time
381	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	errors	Perception/Cognition	perception related errors
381	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	response time	Perception/Cognition	perception related response time
382	\	\	\	\	\	\	\	-	-	\	\	\
383	1	1	Qualitative	Subjective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	distance walked	Perception/Cognition	perception related errors
384	X	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	comments	Prototype focus	comments / suggestions
384	X	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
385	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	feedbacks	Prototype focus	feedbacks / insights
385	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	possible uses/potentiality	Prototype focus	possible use / potentials of system
385	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	-	-	usefulness	UX - Usefulness	perceived usefulness
386	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	errors	Perception/Cognition	perception related errors
386	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	response time	Perception/Cognition	perception related response time
386	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	preferred solution	UX - Usability	preference
387	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	preferred solution	UX - Usability	preference
387	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	reading errors	Perception/Cognition	perception related errors
387	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception completion time
387	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert polar terms scale	-	aesthetics	UX - Usability	aesthetic
387	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	7 Likert	Yes	distractibility of the visualization method	interaction	attention / focus
387	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	7 Likert	Yes	easiness to read	Perception/Cognition	virtual environment / object recognition
387	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	7 Likert	Yes	font quality	Perception/Cognition	virtual environment / object perceived quality
387	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	Questionnaire for User Interface and Satisfaction (QUIS)	7 Likert	Yes	visibility	Perception/Cognition	virtual environment / object recognition
388	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	grasping / press force	-	-	force used	Perception/Cognition	hepatics

Evaluation methodologies and main HCI aspects investigated

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
389	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perceived stiffness	Perception/Cognition	hepatics
390	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	judged distance	Perception/Cognition	perceived (or evaluated) depth or distance
391	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	judged distance	Perception/Cognition	perceived (or evaluated) depth or distance
392	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	distance walked	Perception/Cognition	perception related errors
392	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	distance walked	Perception/Cognition	perception related errors
392	3	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	distance walked	Perception/Cognition	perception related errors
392	4	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	distance walked	Perception/Cognition	perception related errors
393	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	virtual obj judged distance	Perception/Cognition	perceived (or evaluated) depth or distance
393	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	virtual obj judged size	Perception/Cognition	virtual environment / object recognition
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Interface (efficiency of interaction)	UX - Usability	efficiency
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Interface (effort required)	Ergonomics / Load / Comfort	task perceived effort
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Involvement (Concentration)	Ergonomics / Load / Comfort	cognitive load
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Involvement (info satisfaction)	UX - Usability	satisfaction
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Involvement (motivation)	UX - Emotion	motivation
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Involvement (real time awareness)	Perception/Cognition	sense of presence / immersion
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	real environment recognition/distraction	Perception/Cognition	sense of presence / immersion
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Sensory (interaction w system/how the system was used)	interaction	interaction strategy and system use
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Spatial accuracy	Perception/Cognition	virtual environment / object recognition
394	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Spatial recognition	Perception/Cognition	virtual environment / object recognition
395	\	\	\	\	\	\	\	-	-	\	\	\
396	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	position of phantom sensations (closed positions)	Perception/Cognition	virtual environment / object recognition
396	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	confidence of perception	Perception/Cognition	virtual environment / object recognition
396	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	immersion	Perception/Cognition	sense of presence / immersion
396	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived recognition time	Perception/Cognition	sense of presence / immersion
396	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	spatial perception	Perception/Cognition	sense of orientation / navigation
396	2	1	Quantitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	position of phantom sensations (closed positions)	Perception/Cognition	virtual environment / object recognition

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
396	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	confidence of perception	Perception/Cognition	virtual environment / object recognition
396	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	immersion	Perception/Cognition	sense of presence / immersion
396	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived recognition time	Perception/Cognition	sense of presence / immersion
396	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	spatial perception	Perception/Cognition	sense of orientation / navigation
396	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	strength perception	Perception/Cognition	virtual environment / object recognition
397	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	questions on environment	Perception/Cognition	real environment / object recognition
397	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	questions on information provided	Perception/Cognition	perception related errors
398	\	\	\	\	\	\	\	-	-	\	\	\
399	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	eye accommodation	-	-	accommodation response	Perception/Cognition	physical body responses
399	1	2	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	closed response (during evaluation)	-	-	perceived depth during test	Perception/Cognition	perceived (or evaluated) depth or distance
399	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	closed ended question/s	-	perceived depth after test (on questionnaire)	Perception/Cognition	perceived (or evaluated) depth or distance
400	1	1	Qualitative	Subjective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Task performance	errors
400	1	1	Qualitative	Subjective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	Reaction time	Task performance	reaction time
400	1	1	Qualitative	Subjective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
401	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	error	Perception/Cognition	perception related errors
401	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	perceived depth	Perception/Cognition	perceived (or evaluated) depth or distance
402	\	\	\	\	\	\	\	-	-	\	\	\
403	\	\	\	\	\	\	\	-	-	\	\	\
404	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception completion time
404	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	distance of virtual object (deviation from real)	Perception/Cognition	perception related errors
404	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	user position when task completed	Perception/Cognition	perception related accuracy
404	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	10 Likert scale polar terms	-	perceived task performance	UX - Usability	perceived performance
404	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived effort	Ergonomics / Load / Comfort	task perceived effort
404	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
404	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived mental demand	Ergonomics / Load / Comfort	cognitive load
404	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived own performance	UX - Usability	perceived performance
404	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived physical demand	Ergonomics / Load / Comfort	physical load
404	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived temp demand	Ergonomics / Load / Comfort	cognitive load
404	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	NASA TLX	100 scale	-	perceived workload	Ergonomics / Load / Comfort	task perceived effort

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
405	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	Virtual element finding / matching	-	-	target perception	Perception/Cognition	virtual environment / object recognition
405	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
405	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception related completion time
405	2	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	Virtual element finding / matching	-	-	perceived color	Perception/Cognition	virtual environment / object recognition
406	\	\	\	\	\	\	\	-	-	\	\	\
407	1	1	Quantitative	Objective	Empirical Experimental	Observation	evaluators observations	on material recorded	-	position errors	Perception/Cognition	perception related errors
408	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	Virtual element finding / matching	-	-	target perception	Perception/Cognition	virtual environment / object recognition
408	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
408	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception completion time
408	1	3	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	Virtual element finding / matching	-	-	target perception	Perception/Cognition	virtual environment / object recognition
408	1	4	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors
408	1	4	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception completion time
409	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	Electroencephalography (EEG)	-	-	brain activity	Perception/Cognition	physical body responses
409	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Clarity	UX - Usability	naturalness
409	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Comprehensibility	UX - Usability	understandability
409	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	innovation	UX - Emotion	perceived innovativeness / wow factor
409	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	motivation	UX - Emotion	motivation
409	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Originality	UX - Meaning	price / value
409	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Simplicity	UX - Usability	perceived task/interaction difficulty
410	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - 7 Likert scale	-	opinions on AR use	Prototype focus	comments / suggestions
410	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - 7 Likert scale	-	perceived usefulness	UX - Usefulness	perceived usefulness
410	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - 7 Likert scale	-	possible context of use	Prototype focus	comments / suggestions
410	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - 7 Likert scale	-	possible use of tech	Prototype focus	possible use / potentials of system
410	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - 7 Likert scale	-	privacy concerns	UX - Meaning	Privacy
410	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - 7 Likert scale	-	satisfaction	UX - Usability	satisfaction
410	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - 7 Likert scale	-	subject general tech use	Mixed background questions	subject technological comfort / general use
410	P	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	remote survey	online survey - open ended question/s	-	feedbacks	Prototype focus	feedbacks / insights
411	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	information perception	Perception/Cognition	virtual environment / object recognition
411	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	errors	Perception/Cognition	perception related errors

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
411	1	2	Quantitative	Objective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Perception/Cognition	perception completion time
411	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Concentration problems	Ergonomics / Load / Comfort	cognitive load
411	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Confusing task	UX - Usability	ease of use
411	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	Neck pain, Headache, Eye strain	Ergonomics / Load / Comfort	comfort / sickness
411	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	visibility problems	UX - Usability	system status information and feedback
412	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Perception/Cognition	perception completion time
412	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	path deviation	Perception/Cognition	perception related accuracy
412	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	order items	-	preferred method	UX - Usability	preference
413	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	feedbacks	Prototype focus	feedbacks / insights
413	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 10 scale	-	perceived difficulty	UX - Usability	perceived task/interaction difficulty
413	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	ability to perform tasks	interaction	learning / problem coping strategy
413	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	adaptation to new perception methods	interaction	learning / problem coping strategy
413	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	interactions strategies	interaction	interaction strategy and system use
414	\	\	\	\	\	\	\	-	-	\	\	\
415	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	difference w real	Perception/Cognition	virtual environment / object perceived quality
415	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perceived distance	Perception/Cognition	perceived (or evaluated) depth or distance
416	1	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	difference w real	Perception/Cognition	virtual environment / object perceived quality
416	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perceived distance	Perception/Cognition	perceived (or evaluated) depth or distance
417	1	1	Quantitative	Objective	Empirical Experimental	User Measurements	Heart Rate Variability (HRV)	-	-	real time cardiovascular feedback	Perception/Cognition	physical body responses
417	1	2	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perceived position of occluded hand	Perception/Cognition	real environment / object recognition
417	1	2	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	sync/async perception of cardiac feedback	Perception/Cognition	physical body responses
417	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	perceived sensation on real hand	Perception/Cognition	physical body responses
417	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	perceived virtual hand as own	Perception/Cognition	virtual environment / object recognition
417	1	3	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	perception of sync between feedback and video	Perception/Cognition	physical body responses
418	1	1	Qualitative	Subjective	Empirical Experimental	User Action Logging	evaluators timing	-	-	completion time	Task performance	completion time
418	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	tech problems/requirements	Prototype focus	problem individuation

Evaluation methodologies and main HCI aspects investigated

Evaluation methodologies and main HCI aspects investigated

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
418	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	visibility problems	Perception/Cognition	virtual environment / object recognition
418	2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	tech problems/requirements	Prototype focus	problem individuation
418	2	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	tech problems/requirements	Prototype focus	requirements and missing features
419	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	preferred visualization method	UX - Usability	preference
419	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	real world perception	Perception/Cognition	real environment / object recognition
419	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	-3 to +3 scale	-	virtual world perception	Perception/Cognition	virtual environment / object recognition
420	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	naturalness of experience	Perception/Cognition	sense of presence / immersion
420	1	2	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	find differences in images	Perception/Cognition	virtual environment / object recognition
420	2	1	Qualitative	Objective	Empirical Experimental	User Measurements	eye tracking	-	-	attention drawing of the visualization method	interaction	attention / focus
420	3	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	recall objects post video	Perception/Cognition	perception related accuracy
420	3	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	naturalness of experience	Perception/Cognition	sense of presence / immersion
420	3	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	task perceived difficulty	UX - Usability	perceived task/interaction difficulty
420	P1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	naturalness of experience	Perception/Cognition	sense of presence / immersion
420	P2	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	find differences in images	Perception/Cognition	virtual environment / object recognition
421	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	desired features/changes	Prototype focus	feature usefulness / importance
421	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	usefulness	UX - Usefulness	perceived usefulness
421	1	1	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	want to use in future	UX - Usefulness	would use again in future
421	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	completion time	Task performance	completion time
421	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	errors	Task performance	errors
421	2	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	time spent in section/task	Task performance	task completion time
421	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	favorite visualization method	UX - Usability	preference
421	2	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	separation between virtual and real in map	Perception/Cognition	sense of presence / immersion
422	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	3D avatar experience improve	Prototype focus	feature usefulness / importance
422	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	3D avatar friendliness	UX - Emotion	trust (perceived safety)
422	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	3D avatar realism	Perception/Cognition	virtual environment / object recognition
422	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	3D avatar realism w real world	Perception/Cognition	real environment / object recognition
422	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	3D avatar usefulness	Prototype focus	feature usefulness / importance
422	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	enjoyment	UX - Emotion	amusement / fun
422	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	Interface ease of use	UX - Usability	ease of use

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
422	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived learning performance	UX - Usability	perceived performance
422	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	task difficultness	UX - Usability	perceived task/interaction difficulty
422	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	encounter problems	Prototype focus	problem individuation
422	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	feedbacks	Prototype focus	feedbacks / insights
422	1	2	Qualitative	Subjective	Empirical Inquiry	Interviews	unstructured	-	-	suggestions	Prototype focus	comments / suggestions
423	1	1	Qualitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	difference w real	Perception/Cognition	real environment / object recognition
423	1	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perceived distance	Perception/Cognition	perceived (or evaluated) depth or distance
423	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	visualization learnability	UX - Usability	learnability
423	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	visualization quality	Perception/Cognition	virtual environment / object recognition
424	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	angle and rotation of device	interaction	users movements / gestures / physical utilization of prototype
424	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	tracking logs	-	-	completion time	Perception/Cognition	perception related completion time
424	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	efficiency	UX - Usability	efficiency
424	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	favorite visualization method	UX - Usability	preference
424	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	more visual appealing condition	UX - Usability	aesthetic
424	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	perceived presence of info in real world	Perception/Cognition	sense of presence / immersion
424	2	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	7 Likert scale	-	quality of info presentation	UX - Usability	efficiency
424	2	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	encounter problems	Prototype focus	problem individuation
424	2	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	feedbacks	Prototype focus	feedbacks / insights
424	2	2	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	suggestions	Prototype focus	comments / suggestions
425	1	1	Qualitative	Subjective	Empirical Experimental	User Action Logging	evaluators count/measure	-	-	distance walked	Perception/Cognition	perception related errors
425	2	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	difference w real	Perception/Cognition	real environment / object recognition
425	2	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perceived distance	Perception/Cognition	perceived (or evaluated) depth or distance
425	3	1	Qualitative	Subjective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	difference w real	Perception/Cognition	perception related accuracy
425	3	1	Quantitative	Objective	Empirical Experimental	Question-answer-Protocol	open response (during evaluation)	-	-	perceived distance	Perception/Cognition	perceived (or evaluated) depth or distance
426	1	1	Qualitative	Subjective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	errors	Task performance	errors
426	1	1	Qualitative	Subjective	Empirical Experimental	User Action Logging	evaluators count/measure	on material recorded	-	gesture counts	Task performance	n. trails
426	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	interface performance with task	UX - Usability	perceived performance

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
426	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	interface usability	UX - Usability	usability - unspecified
426	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived interaction quality	UX - Usability	aesthetic
427	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	difficulty comigration with other technologies	UX - Usability	perceived task/interaction difficulty
427	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	enjoy in learning with system	UX - Emotion	motivation
427	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	enjoyment	UX - Emotion	amusement / fun
427	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	enjoyment compared with other interfaces	UX - Emotion	amusement / fun
427	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	features usefulness	Prototype focus	feature usefulness / importance
427	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	interacted with features	Prototype focus	feature usefulness / importance
427	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	interest in topic after AR	Mixed background questions	subject interest / knowledge on topic
427	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	Interface ease of use	UX - Usability	ease of use
427	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	1 to 5 scale	-	perceived learning performance	UX - Usability	perceived performance
428	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	enjoyment	UX - Emotion	amusement / fun
428	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	general acceptance	UX - Meaning	Privacy
428	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	Unspecified	-	personal preference	UX - Usability	preference
428	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	frustration	Ergonomics / Load / Comfort	frustration / stress / anxiety
428	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	interest	Mixed background questions	subject interest / knowledge on topic
428	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	reactions	UX - Emotion	reactions and emotion individuation / shifting
428	1	2	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	use of the system	interaction	interaction strategy and system use
429	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	count of item explored	Task performance	n. interactions
429	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	number of interactions with system	Task performance	n. trails
429	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	variety of topics explored	Task performance	n. interactions
429	1	1	Quantitative	Objective	Empirical Experimental	User Action Logging	system logs	-	-	variety of topics explored	Task performance	n. trails
429	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	audio quality	UX - Usability	system smoothness / response time
429	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	headphones comfort	Ergonomics / Load / Comfort	ergonomic properties
429	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	navigation and control impression	UX - Usability	system status information and feedback
429	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	overall reaction/satisfaction	UX - Usability	satisfaction
429	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived information quality	UX - Usability	efficiency
429	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived system learnability	UX - Usability	learnability
429	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	perceived system performance	UX - Usability	perceived performance

ref. paper	ref. Study	n. Method Used	Quantitative / Qualitative	Subjective/ Objective	Methods Type (1st and 2nd level)	Method Used (3rd level)	Methods / Tool Names (4th level)	Method specification (5th level)	Modify /Adapted	Measured Parameters Name	Investiaged HCI Aspect	Investiaged HCI Aspect subgroup
429	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-			
429	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	5 Likert scale	-	tangible user interface comfort(easy to use)	UX - Usability	ease of use
429	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	encounter problems	Prototype focus	problem individuation
429	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	feedbacks	Prototype focus	feedbacks / insights
429	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	interactions meanings	UX - Meaning	meaning of context / place / interaction
429	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	playfulness of system	UX - Emotion	amusement / fun
429	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	suggestions	Prototype focus	comments / suggestions
429	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Experts Interview	-	-	depth of the content	UX - Meaning	meaning of context / place / interaction
429	P	1	Qualitative	Subjective	Analytical Inspections	Experts Review / Evaluation	Experts Interview	-	-	interaction meaningfulness	UX - Meaning	meaning of context / place / interaction
430	\	\	\	\	\	\	\	-	-	\	\	\
431	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	effectiveness of interfaces	UX - Usability	effectiveness
431	1	1	Qualitative	Subjective	Empirical Experimental	Observation	evaluators observations	-	-	general visitor's behavior	interaction	general interaction behavior
431	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposite adjectives (1 to 4 scale)	-	emotional reactions (quality of topic)	Mixed background questions	subject interest / knowledge on topic
431	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposite adjectives (1 to 4 scale)	-	experience captivating/dull	UX - Emotion	arousal / engagement
431	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposite adjectives (1 to 4 scale)	-	immensities and involvement in interaction	Perception/Cognition	sense of presence / immersion
431	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposite adjectives (1 to 4 scale)	-	innovation impression	UX - Emotion	perceived innovativeness / wow factor
431	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposite adjectives (1 to 4 scale)	-	perceived aesthetic quality	UX - Usability	aesthetic
431	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposite adjectives (1 to 4 scale)	-	quality feel (cheep/premium)	UX - Meaning	price / value
431	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposite adjectives (1 to 4 scale)	-	usability (practical/complicated/challe nging)	UX - Usability	usability - unspecified
431	1	2	Quantitative	Subjective	Empirical Inquiry	Questionnaire	custom-made	opposite adjectives (1 to 4 scale)	-	utilization confusion	UX - Usability	learnability
431	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	encounter problems	Prototype focus	problem individuation
431	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	feedbacks	Prototype focus	feedbacks / insights
431	1	3	Qualitative	Subjective	Empirical Inquiry	Interviews	semi-structured	open ended question/s	-	suggestions	Prototype focus	comments / suggestions
432	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	Regenbrecht and Schubert (2002) - 7 Likert scale	-	intuitiveness of the system	UX - Usability	intuitiveness
432	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	Regenbrecht and Schubert (2002) - 7 Likert scale	-	naturalness of control and interaction	UX - Usability	naturalness
432	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	Regenbrecht and Schubert (2002) - 7 Likert scale	-	perceived task performance	UX - Usability	perceived performance
432	1	1	Quantitative	Subjective	Empirical Inquiry	Questionnaire	presence questionnaire	Regenbrecht and Schubert (2002) - 7 Likert scale	-	quality of immersion	Perception/Cognition	sense of presence / immersion

Evaluation methodologies and main HCI aspects investigated