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M.Sc. Thesis

Improving User Experience
in Urban Design using Visual Simulation

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Abstract

User Experience is a broad term used to describe design processes in which end users influence how a design evolves. UX designers have introduced new requirements for design with a user-centered approach. In urban design also, new focuses are on the transformation of the urban environment into a place that is usable by many people. The current study focuses on the final stage of the design process, prototyping, which allows designers to test the usability of their designs. As a result, the study attempts to determine which elements designers should prioritize in order to provide the best user experience.

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1. Introuduction

Since the definition of the User Experience (UX) was clarified in the last decade, UX designers have introduced new requirements for design with a user-centered approach. The term 'human-centered design' originated in Donald Norman's research laboratory at the University of California San Diego (UCSD) in the 1980s (Lillemaa, 2004). It is a broad term to describe design processes in which end-users influence how a design takes shape. It is both a broad philosophy and a variety of methods (Lillemaa, 2004). Involving users in the design process helps designers to achieve to important characteristics of good design. Two of the most important characteristics of good design are discoverability and understanding (Norman, 1988).

It mainly begins with Human-Com-

puter Interaction (HCI) in Norman's books User Centered System Design (1986) and The Design of Everyday Things (1988). However, Donald Norman brings various examples which go beyond HCI design, including architectural examples in our daily lives.

This idea was also expressed in Jan Gehl's book, Cities for People (2010). His work focuses on the transformation of the urban environment into a place that is usable by many people. He explains the methods and tools he uses to reconfigure unworkable cityscapes into the cities for people.

This thesis tries to find how we can use "User Experience" term in Urban Design firstly by studying design thinking frameworks and then adapting user experience criteria in urban design using User Experience approaches. The main focus is on the last phase of the design process, Prototyping, which provides designers with possibilities to test the usability of their design. There is evidence in research, showing that urban designers use visual simulations to evaluate their designs before construction. This method could enable designers to conduct lots of tests of the User Experience, including usability tests for evaluating architectural solutions.

Lastly, visual simulations can serve as a valid support for design thinking and evaluation. At the same time, they can provide useful support when communicating urban design projects, both for professionals and the lay public. (Piga, 2018). In a nutshell, it is relevant, and now possible, to analyze human behaviour before implementing the design and evaluate how it can encompass user needs. The current attempt tries to figure out which elements designers could focus on to achieve the best user experience.

2. Applying User Experience in Urban Design

2.1. User Experience Definition

The first urban design and architecture appeared in Mesopotamia ten thousand years ago. It appears that interior design and furniture design evolved along with them. The development of cuneiform in Sumeria was five thousand years before graphic design and typography made their appearance (Manzini, 2015). Following that, things quickly progressed. There is a similar factor that is present in every type of design, nowadays, to solve problems and satisfy human needs. Due to this fact, designers often evaluated their designs to determine whether they succeeded in solving human needs. The cycle process of design can be viewed from this perspective. The cycle process allows designers to go back in time and revise their designs based on new findings.

A common mistake made by designers was that they made all decisions themselves or in a team that included other designers, which prevents them from understanding human needs, since they don't experience the problem themselves. As a result of this top-down approach, there are a lot of design issues after implementation. Numerous examples show how users have encountered design issues, issues that came with simple solutions, even provided by the users since the beginning. Don Norman in his book "The design of everyday things" brings some examples of a bad design which are complex, useless, and lost its main goal of the design. He mentioned "The design of the door should indicate how to work it without any need for signs, certainly without any need for trial and error." (Norman, 1988, p. 2).

User Experience (UX) definitions cover a wide range of topics that mostly focus on Human Computer Interaction (HCI). There are many variables associated with UX, including emotional, behavioral, cognitive, psychological, and visual variables. Because of this, it makes it difficult to give a comprehensive definition. According to Nielsen-Norman Group, "User experience encompasses all elements of the end-user's interaction with the company, its services, and its products."

Additionally, Donald Norman focuses on human interactions in his book, "The Design of Everyday Things", rather than just computer operations. He noted that "All artificial things are designed. Whether it is the layout of furniture in a room, the paths through a garden or forest, or the intricacies of an electronic device, some person or group of people had to decide upon the layout, operation, and mechanisms." (Norman, 1988, p. 4).

Norman gives designers a set of principles that can assist them in communicating products' purpose, usefulness, and how to use them effectively. Norman doors are an example that often comes up in conversation, a door or a set of doors whose design indicates they swing one way, and the attached handles indicate they swing the other way. While intentionally installing labels on doors in order to reduce people's misunderstanding of their functions can exacerbate confusion.

In addition, the following authors define user experience in their own ways, although some of them use different terms:

Lauralee Alben:

By “experience” we mean all the aspects of how people use an interactive product: the way it feels in their hands, how well they understand how it works, how they feel about it while they’re using it, how well it serves their purposes, and how well it fits into the entire context in which they are using it. If these experiences are successful and engaging, then they are valuable to users and noteworthy to the interaction design awards jury. We call this “quality of experience.” (Alben, 1996, p. 12).

Marc Hassenzahl and Noam Tractinsky:

UX is a consequence of a user’s internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g. complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g. organisational/social setting, meaningfulness of the activity, voluntariness of use, etc.). Obviously, this creates innumerable design and experience opportunities (Hassenzahl & Tractinsky, 2006, p. 95).

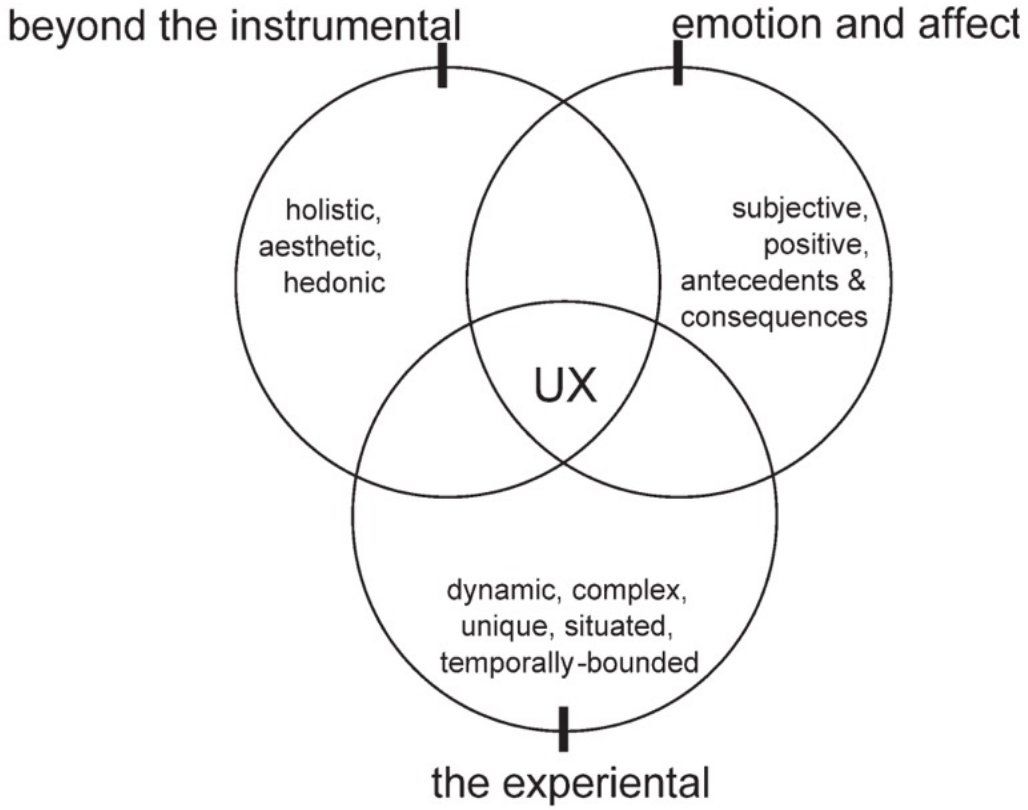

Figure 2-1-1 Facets of UX (Hassenzahl & Tracti sky, 2006, p. 95)

Jesse James Garrett discusses examples of designs without paying attention to the user experience, and in the following, he describes:

User experience is not about the inner workings of a product or service. User experience is about how it works on the outside where a person comes into contact with it (Garrett, 2010, p. 6).

Katja Battarbee & Ilpo Koskinen, focus on three approaches to user experience, The measuring approach, The empathic approach and The pragmatist approach:

These three approaches propose divergent methodologies for studying user experience, but imply different things. The measuring approach focuses on emotional responses, the empathic approach on user-centred concept design, while the pragmatic approach links action to meaning. The measuring approach is useful in development and evaluation, but is more difficult to apply at the fuzzy front end of design. The pragmatist approach concentrates on the embodied nature of experience and interaction (Battarbee & Koskinen, 2005, p. 7).

In conclusion, UX definitions need to be reconsidered on a broader scale to encompass all kinds of design, such as urban design. Therefore, based on the above definition, UX in the current exploration should be defined by author as follows:

The term user experience refers to the human's experience and satisfaction with a design's outcome.

2.2. User Experience Elements

According to Donald Norman (Norman, 1988) User Experience in Human-centered design (HCD) is the process of ensuring that people's requirements are satisfied, that the resultant product is clear and useable, it performs the necessary tasks, and that the user experience is good and joyful. *Shape and form, cost and efficiency, dependability and effectiveness, understandability and usability, the pleasure of appearance, pride of ownership, and the joy of real usage* are only a few of the restrictions and considerations that must be addressed by good design. HCD is a technique for meeting these standards, but with a focus on two things: solving the proper problem and doing so in a way that is compatible with human needs and capabilities.

The fundamental and most significant component of the UX, based on the factors mentioned above, is usability. According to ISO 9241:1998 The term "usability" refers to "Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use".

Whitney Quesenbery expanded the ISO 9241 characteristics of usability (efficient, effective, and satisfying) to five dimensions: effective, efficient, engaging, error-tolerant, and easy to learn (Albers & Mazur, 2003).

Effectiveness is the completeness and accuracy with which users achieve specified goals. *Efficiency* can be described as the speed (with accuracy) in which users can complete the tasks for which they use the product. *Engaging* refers to an interface which engaging if it is pleasant and satisfying to use. *Error Tolerant* means the ultimate goal is a system which has no errors. And *Easy to Learn* backs to an easy-to-learn design which helps users to expand their knowledge without making a conscious effort. This extends beyond basic utility to include built-in teaching for difficult or advanced activities, access to just-in-time training components, and linkages to domain knowledge sources, all of which are essential for effective usage (Albers & Mazur, 2003).

In usability, easy to learn and efficacy are both crucial, and they work together to decide if something is

useful. It doesn't matter whether something is simple or if it's not what you want. It's also ineffective if it is theoretically possible what users want to do they can't make that happen because they don't know how to do that.

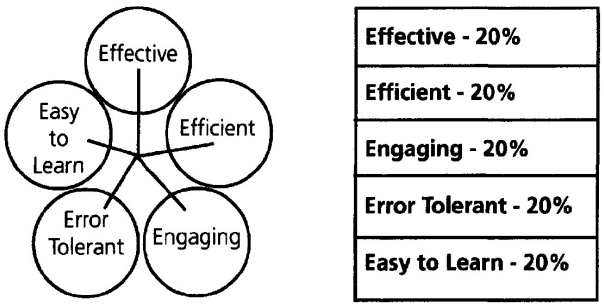

Figure 2-2-1 Usability dimensions in balance (Albers & Mazur, 2003, p. 84)

The five characteristics in Figure 2-2-1 above clearly define distinct elements of usability.

This figure represents them in balance. However, in most designs, some dimensions take priority over others. The usability problem is to produce a design that successfully fits all dimensions (Albers & Mazur, 2003). A usability dimension balance chart is created after creating a goal for the project and testing it. This approach could be used to achieve the best design outcome, with a test that demonstrates the most balance between all of these dimensions. Figure 2-2-2, represent design approaches to meet key usability requirements.

The 5 E's continue to be useful components of the process of developing usability goals for a product. They ensure that the usability goals adequately express user needs by connecting the original user requirements to the goals themselves.

A design objective that is usability focused, unambiguous, and measurable is called a usability goal. The design process is directed by usability goals, which define the most essential aspects of a product and the requirements that it must fulfill. It is essential that they are accepted by the entirety of the development team; otherwise, they will have merely postponed the inevitable conflicts, possibly to the point where they cannot be resolved successfully.

There are four aspects that make up a well-written goal(Albers & Mazur, 2003):

User Definition: Which users does this goal apply to?

Task: What should they be able to do?

Context: Under what conditions does the goal apply?

Criteria: How will the success of this goal be measured?

Dimension	Key needs	Design tactics
Effective	Accuracy	- Consider how many places in the interface are opportunities for error, and protect against them. - Look for opportunities to provide feedback and confirmations.
Efficient	Operational speed	- Place only the most important information in front of the user. - Work on navigation that moves as directly as possible through a task. - Be sure the interaction style minimizes the actions required.
Engaging	Draw users in	- Consider what aspects of the product are most attractive and incorporate them into the design.
Error Tolerant	Validation	- Look for places where selection can replace data entry. - Look for places where calculators can support data entry. - Make error messages include opportunities to correct problems.
Easy to Learn	Just-in-time instruction	- Create step-by-step interfaces to help users navigate through complex tasks. - Look for opportunities to provide small chunks of training.

Figure 2-2-2 Design approaches to meet key usability requirements (Albers & Mazur, 2003, p. 95)

It is critical to creating specific metrics rather than using broad criteria. For example, if a user says, "It has to be quick," we know that efficiency is essential. But do they mean that they have to finish the task in seconds or minutes?

In a chapter of the book "Content & Complexity: information design in technical communication", Whitney Quesenbery presents a case study of this method.

To complement an exhibition, a photographic institution established a website including image examples and information about the artist and the exhibition. The museum intended to attract more people while also serving as a long-term educational resource. Tourists seeking exhibitions, those already interested in the artist, and casual visitors linked from the museum site for further information were the key target users.

The museum also has a general website where visitors may learn about its

exhibitions, educational programs, awards, and other events. The larger site's user base is more diversified than that of the exhibit, including the same tourists, individuals buying in the museum store, job seekers, and art industry colleagues keeping up with the institution. All of these people are looking for information on the museum, however, the specifics may differ. Their requirements for usability are all the same. The table below (Figure 2-2-3) demonstrates the target of the five usability aspects for both cases.

Dimension	Usability requirements of the exhibition	Usability requirements of the website
Effective	The content of the site must be effective in communicating the exhibition material. Questions about the artist and the museum exhibit must be easily answered.	The site must include content that answers users' questions in an easy to-find location.
Efficient	This is not a primary concern. People browsing photographs are less interested in how quickly they can move around the site than in the richness of the experience. However, the size of the images might be a problem and long download needed to be avoided.	Attention spans are relatively short. The site structure must be straightforward and direct to minimize navigation time. Writing should be concise and easily scanned.
Engaging	The site needs to be engaging in several ways: to encourage those unfamiliar with the artist to stay and explore; to provide new and interesting information for researchers; and to create a compelling experience in its own right as an exhibition.	For the users, the site provides their first impression of what the museum is like. The degree to which the site can delight the visitor (and by extension convince them to visit the actual museum) is a measure of success.
Error Tolerant	Any content errors are unacceptable. In addition, the rich media used on the site created several opportunities for problems.	Errors are not acceptable in any form, especially those caused by a failure to meet user expectations.
Easy to Learn	One of the goals of the site is to encourage discovery. It must therefore invite exploration.	Users do not expect to have to learn to use a site. This site must allow for "zero-trial learning"—the ability to just walk up and use a product successfully the first time.

Figure 2-2-3 The usability requirements of museum exhibition in relation with the five elements (Albers & Mazur, 2003, p. 90)

The 5 E's for the Online Museum Exhibition are represented in Figure 2-2-4. When one dimension is clearly more essential than the others, it is hard to keep track of the others. Efficiency and error tolerance require special consideration in this design to guarantee that failures in these dimensions do not affect the site's overall performance.

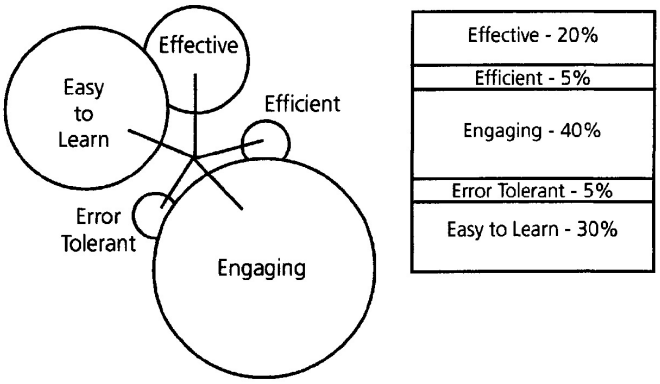

Figure 2-2-4 The 5 E's for the Online Museum Exhibition (Albers & Mazur, 2003, p. 92)

The 5Es for the General Museum Site are seen in Figure 2-2-5. The museum site, in contrast to the exhibition, has more balanced usability requirements. Although fault tolerance is a low user priority, this frequently implies that users just expect it to be there, rather than that it may be neglected in the site's design and development.

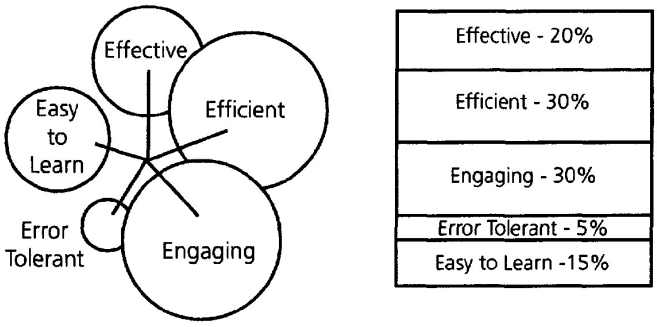

Figure 2-2-5 The 5E's for the General Museum Site (Albers & Mazur, 2003, p. 93)

2.3. Human-Centered approach in Urban Design

Defining problems and needs is the first step in all kinds of design. Phycology, or the study of human behavior, is an important factor in designing for humans.

Designing for specific human needs and experiences with expressive languages, such as inclusive design, universal design, design for all, and so on reflects the rise of a new set of values (Myerson, 2017).

A broad range of making and planning disciplines constitute the work of the service professions that meet human needs. Among these are industrial design, graphic design, textile design, furniture design, information design, process design, product design, interaction design, transportation design, educational design, systems design, urban design, design leadership, and design management, in addition to architecture, engineering, information technology, and computer science. There are a variety of subjects and objects covered by these fields. Throughout the world, there are many professional groups with distinct practices, methods and vocabularies. Each of these groups implements its methods and vocabularies in unique ways different with others. (Manzini, 2015). All forms of design have one thing in common, to meet user needs and solve a problem. In some cases, design requires human interaction, for example, furniture design, industrial design, HCI design, urban design, architecture, etc. To fulfill human needs and to be useful, these forms require more research in terms of human physiology. As a result of a centralized, top-down approach design, local communities' needs, wants, and aspirations are often not taken into account during the early stages of planning and design (Clare & McConnell, 2016).

Participatory design enables us to learn about the needs of communities. The benefits of participatory design outweigh the risks of pointing designers toward extreme ideals that may never be achievable, which may lead to unrealistic expectations from communities. Creating hypotheses, concepts, and prototypes, and putting them to the test with people, lets designers make sure users meet diverse needs without losing sight of your vision (Clare & McConnell, 2016).

A variety of new techniques and theories have been developed by the urban planning profession since the

1960s regarding how and why citizens should participate in planning processes. This democratic decision-making process was followed by most countries and policymakers. Nowadays, it is nearly impossible to plan or design without considering or involving citizens. Citizens are the only ones who are aware of problems during the years. Designers only understand small parts of the problem during their design process, while users, experience a wide range of different issues and situations. Only those with a deep understanding of the situation can come up with the best solutions and brainstorms.

In this case, designers play the role of experts and facilitators, who know how to solve different problems and how to move into actual implementation from brainstorming concepts. This collaboration adds great value to every project. There is a hard responsibility on designers, to create a common understanding between them as experts and citizens or general users as ordinary people. Such a process should be controlled and taught to prevent misunderstandings and data loss. This would be more difficult since the design is a conceptual and visual process.

As the world becomes more urbanized and connected, common design methods—such as creative problem solving, prototyping, and testing with people—can be applied to help cities, allowing civic stakeholders and commercial interests to meet the rising expectations of citizens and to improve infrastructure, management, and quality of life (Clare & McConnell, 2016).

In the thesis I define a new process to draw on the collective knowledge of all actors to provide greater opportunities for more inclusive and collaborative community engagement processes (Fredericks et al., 2016).

It is also important to note that the world, technology, and human needs change over time, so urban design must change as well.

3. Design Thinking Framework

3.1. Design Thinking Definition

Design Thinking History

Two decades before design thinking became a popular innovation concept, an international research group had defined and studied its cognitive nature. These studies aimed to gain more insight into the important features of Design Creativity. Rather than attempting to discover universal design methods (as the movement of the 1970s did), research in design thinking aims to identify the essential mental strategies designers use when working on a project. It was the purpose of this research to improve designers' thinking abilities in individual and collective design processes, both in education and in practice. More recently (2005 - 2012), design thinking has been extended beyond its traditional boundaries. Nowadays, Design Thinking (in upper case) is viewed as a way of conceiving new realities, expressing the introduction of design culture and its methods into areas such as business innovation (Tschimmel, 2012).

Design process

Designers engage in multiple cognitive processes during the design process. Kolodner and Wills (1996) identified three design thinking processes: (a) preparation, (b) assimilation, and (c) strategic control. Design professionals must learn what to focus on and what is important during the preparation process. In this phase, the specifications and constraints of the problem are reinterpreted, ideas are visualized, problems are reformulated (such as elaboration and assessment of the current situation) and other steps are implemented. In the assimilation process, the proposed solution, data, and observations from the design environment, such as feedback from prototype experiments, are made sense of. Strategic control involves many decisions over the course of a design (e.g., which idea to develop next, which constraints to relax, how to set priorities). Furthermore, they move between a variety of tasks, subproblems, and design processes in a flexible and highly opportunistic manner. The map below (Figure 3-1-1) is defined by two axes. The horizontal axis divides the map into left and right halves, classifying fields by process, how they operate. The left side of the axis is more concerned with "finding" or "discovering", while fields on the right are more concerned with "making" and "inventing". The vertical axes divides the map into half based on content or sphere of action. Fields in the top half of the map are primarily concerned with the abstract, symbolic world, as well as the structures, policies, and linguistic tools that en-

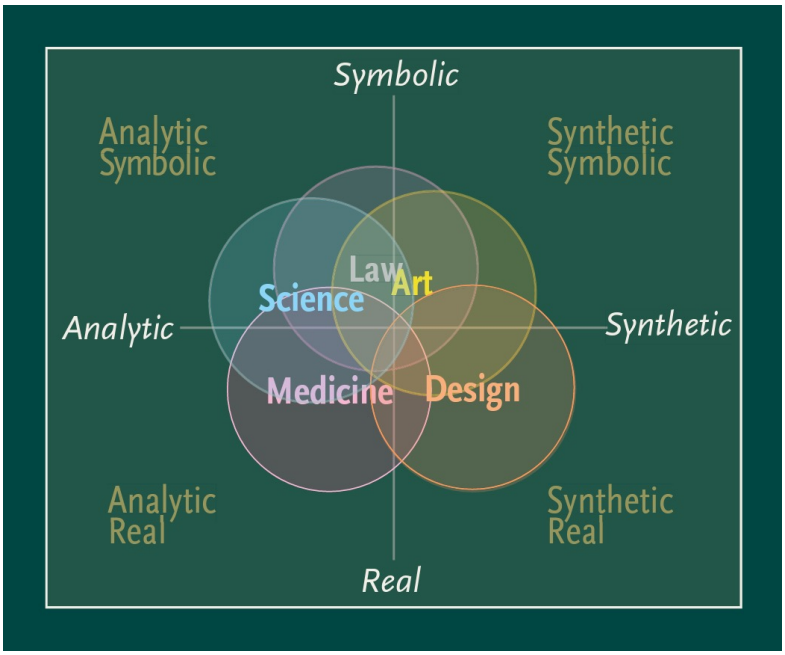

Figure 3-1-1 The 5 E's for the Online Museum Exhibition (Albers & Mazur, 2003, p. 92)

able individuals to manipulate information, communicate, and coexist. Those in the lower half deal with the physical world and the systems and artifacts that control it (Owen, 2017).
The five picked fields are instantly recognized, with well-defined disciplines and well-understood distinctions. Each field has items in each of the four quadrants. What separates one field from another is the degree to which a field shifts its 'center of gravity' away from the center and towards the quadrants, as well as the direction in which that shift occurs. Fields near the center are more 'generalized' in relation to the axes, whereas fields farther from the center are more 'specialized.' This mapping's design is extremely synthetic and heavily concerned with the real-world subject matter. Design includes a symbolic component since disciplines of design deal with communications and symbols, and design involves analysis to conduct synthesis, thus there is an analytic component—but design is a very specialized profession. However, design is a rather specialized discipline, and it is specialized roughly in the opposite direction as the science (Owen, 2017).

Design thinking definition

In many respects, design thinking is the polar opposite of scientific thinking. Whereas a scientist sifts through data to find patterns and insights, a designer creates new patterns and ideas to meet facts and possibilities. In a world where there is a rising demand for knowledge and insight, there is also a significant need for ideas that can combine that insight into innovative new solutions (Owen, 2017).
Design thinking is generally defined as an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign. Several characteristics (e.g., visualization, creativity) that a good design thinker should possess have been identified from the literature (Razzouk & Shute, 2012).

Among the fundamental characteristics of Design Thinking is its human-centered approach, where designing "for users" gives way to designing "with users". This can be seen in designers' collaborative working styles and in their participation in the co-creation process.
An entire design process, including defining a problem, brainstorming, and ideating, prototyping, testing,

and evaluating results are conducted by designers through collaboration with other designers and colleagues, researchers, and stakeholders, as well as working closely with the final customers and users who will use their design.

Traditional design aspects were expressed mostly in words, but sometimes they could also be presented in diagrams and tables. Design Thinking, however, is mainly visual and involves prototyping and sketching. There is mainly a difference in the outcome. Since we have a high-fidelity prototype, we could have a Test step, and see the result of the problem-solving before we build and implement it.

Iterative, experimental, and even chaotic processes define the design process (Braha & Reich, 2003). There are four basic elements of design thinking: generation, exploration, comparison, and selection. Generation and exploration widen a set of problems, then comparison and selection narrow it. The process of widening a problem helps find solutions. These solutions are then evaluated against the goal. Iteratively, solutions can be modified or new solutions can be developed until an optimal solution is found (Stempfle & Badke-Schaub, 2002).

A key element of design thinking is a designer's capability to consider multiple factors at the same time

1- Human needs and a new vision of living well,

2- availability of material and technical resources, and

3- opportunities and constraints of a project or business.

Designers are required to integrate these three factors in a way that is both analytical and empathic, rational and emotional, methodical and intuitive, oriented by plans and constraints, but spontaneous (Pombo & Tschimmel, 2005).

Therefore, Design Thinking is not only a new model for innovation, it is also a new toolkit that aims to improve, accelerate and visualize every creative process, applied not just by designers, but also in multidisciplinary teams within an organization of any kind. Today, Design Thinking has become more than a mental model or mental state, it has become an effective toolkit for all innovation processes, bridging creative design to conventional business thinking based on planning and rational problem-solving (Tschimmel, 2012).

3.2. Design Thinking Frameworks

There have been a lot of process models published in the business and innovation areas of Design Thinking; however, user experience designers are the ones who use these models to get the best possible results for the user experience. The 3I's model and the HCD model, which were both developed by the IDEO design agency, are two of the most well-known models. The Double Diamond model developed by the British Design Council is yet another option. Another well-known model of design thinking is that which was developed by the Hasso-Plattner-Institute (Tschimmel, 2012). In the meantime, there are a few other design thinking models that focus on other types of design. The following study will focus on these models that are most particularly focused on urban design. In the end, this helps to compare and determine whether or not this is the key to achieving the best possible user experience in urban design.

3I's model

The 3 I's model (Inspiration, Ideation, Implementation) was developed by

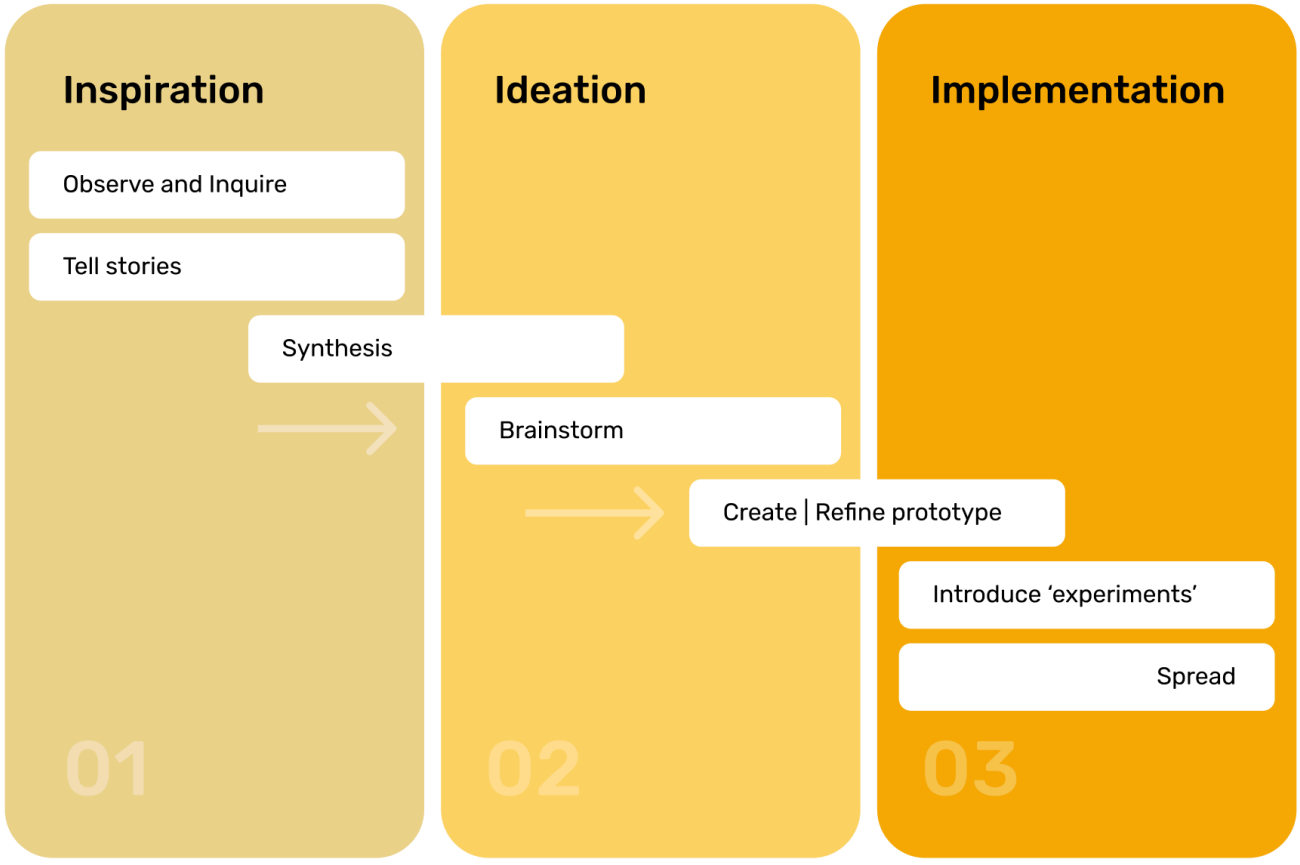

Figure 3-2-1 The Design Thinking model of 3 I's (Tschimmel, 2012, p. 6)

IDEO in 2001.

IDEO, the world's largest design company, began marketing itself as a "innovation company" instead of a design company: its practical expertise made it credible, while its collaboration with Stanford University offered educational qualifications. This, along with a sense of a more complicated reasoning than strategy could provide, increased design interest in the innovation discourse (Johansson-Sköldberg et al., 2013).

Inspiration is the first space in this model. This includes identifying the problem or opportunity, developing the design brief to provide a framework for the team, and observing the behavior of the target group.

Then, after the context is identified by observation and design research, the ideation phase begins. Through this process, an interdisciplinary team distills what they have observed and learned into insights that lead to either opportunities for change, or immediate solutions to problems. To simplify the brainstorming process, visual representations of concepts are encouraged, so others can understand complex ideas better.

Implementation is the third space, where great ideas are turned into action plans. Through the prototyping process, ideas and materials are tested, iterated, and improved. The final activity of the third space is to develop a communication strategy that will help the solution become known inside and outside of the organization (Tschimmel, 2012).

HCD

IDEO developed another Design Thinking model to be used by NGOs and social enterprises working with impoverished communities in the developing world. This model was created at the request of the Bill & Melinda Gates Foundation. This toolkit is based on the 3 spaces that IDEO's designers deem essential to an effective human-centered design process, and referred to as HCD: Hearing, Creating and Delivering. The process entails leading the user through a participatory design process, supporting it with activities such as training, workshops, and implementation of ideas (Tschimmel, 2012).

Hear (H): During the Hear phase, the design team collects stories and inspiration from people through field research.

Create (C): In the Create phase, the team translates what they hear from people into framework, opportunities, solutions and prototypes. During this phase, the team moves together from abstract thinking in identifying themes and opportunities to concrete solutions and prototypes.

Deliver (D): The Deliver phase begins to realize solutions, through rapid revenue and cost modeling capability assessment and implementation planning. This helps to launch new solutions into the world (Bandyopadhyay et al., 2013).

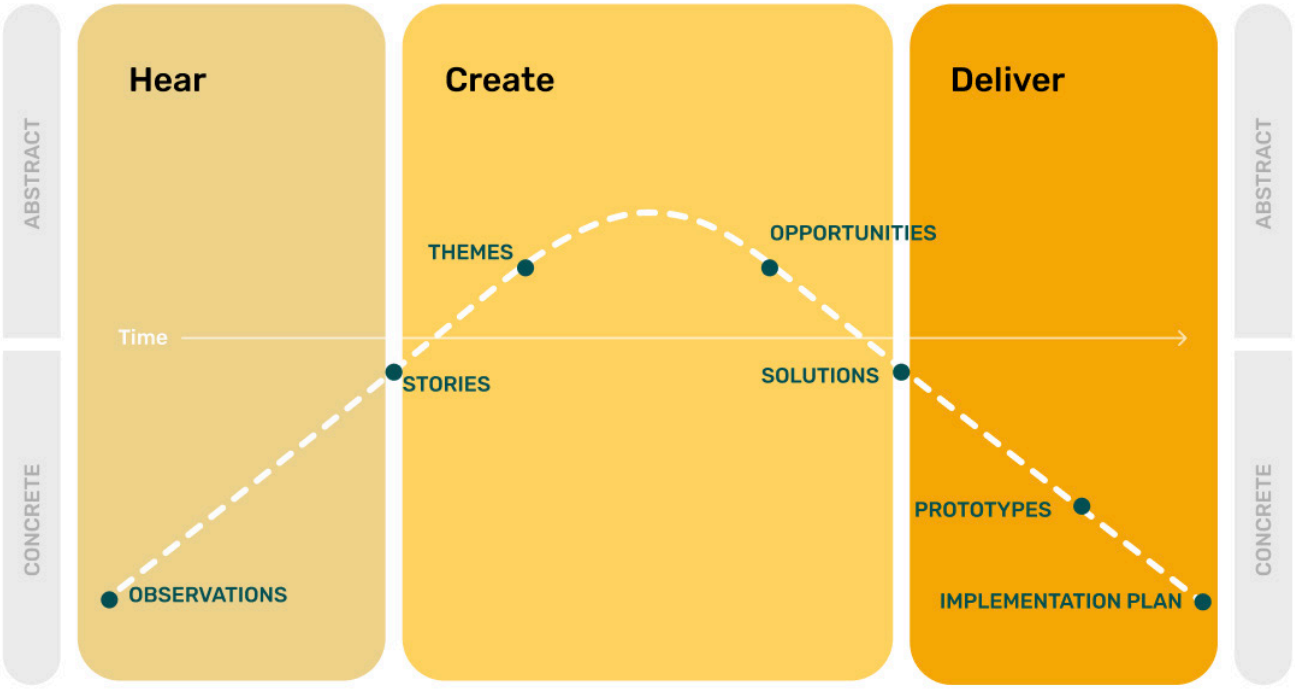

Figure 3-2-2 The Hear, Create, Deliver phases of the IDEO Design Thinking process (Bandyopadhyay et al., 2013, p. 5)

IDEO developed and wrote Field Guide to Human-Centered Design. The book evolved from the Human-Centered Design Toolkit, a book originally published by IDEO in 2011. Since the first publication of the HCD Toolkit, IDEO worked a lot on the power of design to work against poverty. The HCD process starts with a Concrete phase, then becomes Abstract during the Create phase, and finally returns to Concrete as it must be implemented in real life.

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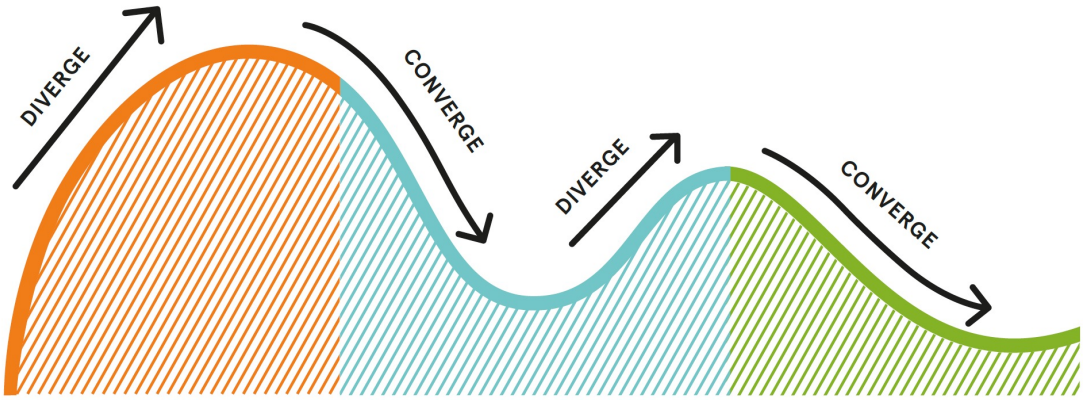

Figure 3-2-3 The 3I's Diverge and Converge process (IDEO, 2015)

The 4D or Double Diamond Model

A Double Diamond design process model was developed by the Design Council in 2005 using a simple diagram to describe divergent and convergent stages of the process. For that reason, the model appears as a double diamond. This model is also called the 4D model because each phase begins with the letter 'D': Discover, Define, Develop, and Deliver.

Discovery is the first phase of the Double Diamond, which represents the first diverging aspect of the project. In this phase of the process, the designer searches for new opportunities, new markets, new information, new trends, and new insights. During the second quarter, which is the Definition stage, insights are processed, selected, and discarded. During the Define stage, the designer is required to engage with the wider context of the opportunity identified as part of the initial development of the project idea. Development is the third quarter of the Double Diamond. In the Develop stage, the project went through corporate and financial approval, so we are once again in a divergent phase. The company develops, iterates, and tests design-led solutions using tools such as brainstorming, sketches, scenarios, renderings, and prototypes by multidisciplinary teams. During the fourth and final stage of the 4D model, the convergent Deliver stage, the final concept is tested, signed-off, produced and launched (Tschimmel, 2012).

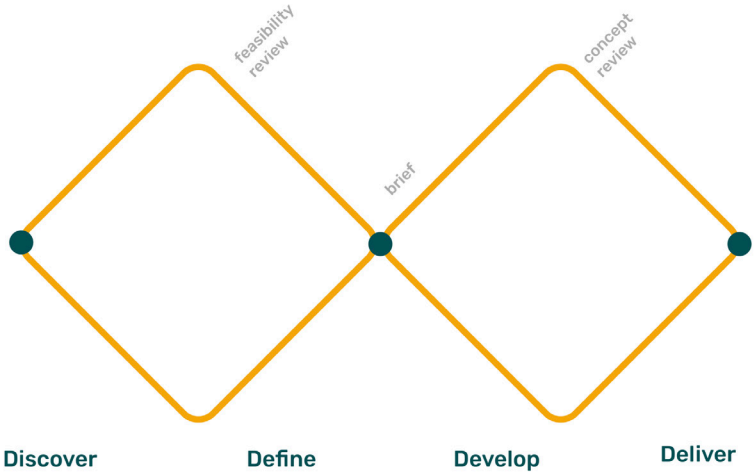

Figure 3-2-4 The 4D or Double Diamond Model (Tschimmel, 2012, p. 9)

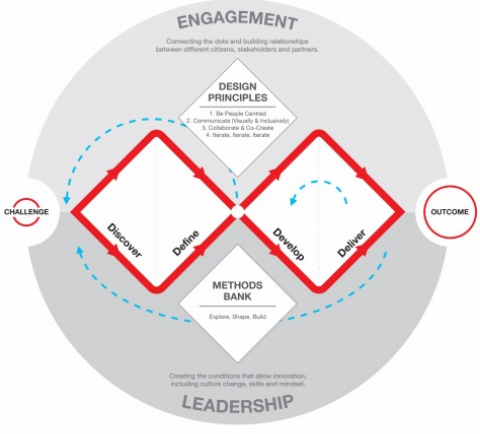

Figure 3-2-5 Double Diamond model with iterations (Nguyen, 2020, p. 10)

The Model of the Hasso-Plattner Institute

Another Design Thinking model, based on the 3I's model of IDEO, developed in an educational setting is the D-school model of the Hasso-Plattner-Institute at the University of Potsdam in Germany, a school directly connected with Stanford University and IDEO. A design thinking process is visualized in their model, which is based also on IDEO process experiences, as six steps, which are connected by curved lines to indicate that each step is performed in an iterative loop (Tschimmel, 2012).

In this model the design thinking process consists of six steps. These steps are visually connected by curved lines. This indicates that these steps can and should be performed in iterative loops, if it appears necessary to go back to a previous step. This model is quite rough and bears resemblance to the typical design process as it is known in the design community since decades. The concept of design thinking, however, is to transfer designerly methods, tools, and processes to other areas (Thoring & Müller, 2011).

In the first step, Understanding, existing information about the topic is gathered through secondary research. In the second step, Observe, is based on a qualitative research approach involving interviews and observations. During this step, the design thinker collects insights about users' problems and needs, of which users are usually unaware, but must be identified by the designer. Through storytelling, these insights are then shared within the group and gathered into Point of View (POV), which reflects the user's perspective and is like a micro theory about the problem. Next, the Ideation phase

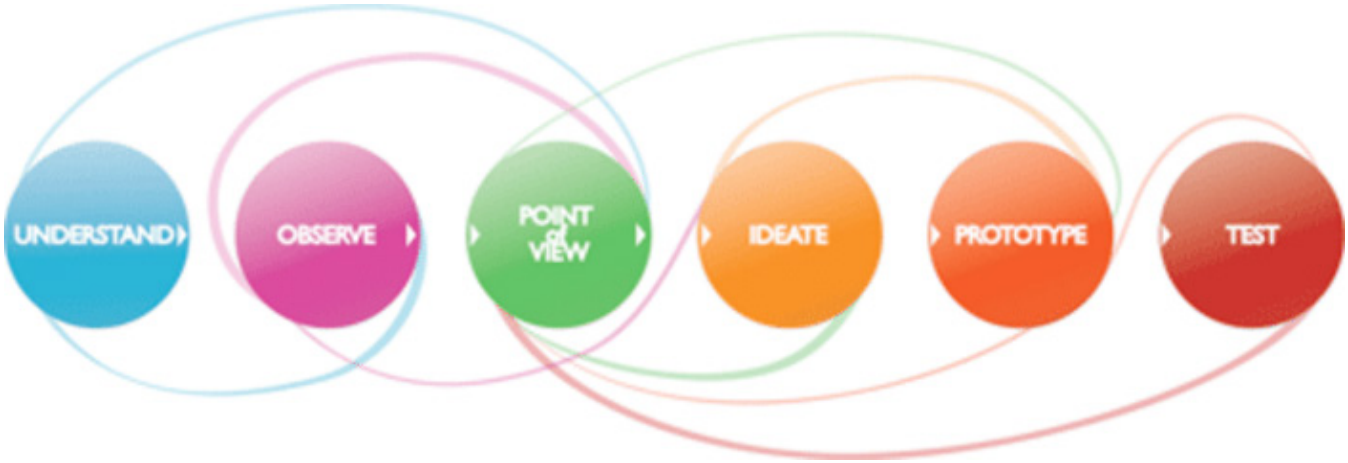

Figure 3-2-6 The Design Thinking Model of the Hasso-Plattner-Institute (Tschimmel, 2012)

begins with creating a brainstorming question. When the brainstorming is complete, team members vote on the best ideas. A prototyping process involves building the selected idea very quickly, e.g., with Legos, cardboard, or existing objects; by paper prototyping; or as a role-play (for service concepts). The testing phase involves taking the prototype back to the users to get feedback on the concept. Finally, Test results are then changed in one or more iteration loops where either the prototype is revised or the whole concept is reconsidered. There may even be a need to revisit the research phase (steps 1 and 2 of the process) to gather additional insights or to interview a different target group (Thoring & Müller, 2011).

Clare & McConnell Model

Clare & McConnell in "Designing for Cities" 2016, argues that by understanding diverse populations within cities and prototyping solutions to address civic challenges, designers can create experiences that deliver value to citizens, governments, and commerce. The book outlines leading civic-centered efforts as a result of working with the Intersection partner teams in New York City.

This method combines Design Thinking with Lean Start-Up and Agile practices. The design process was adjusted for efficiency and cross-disciplinary collaboration. In general, the alignment process is followed by iterative design sprints of concepting, prototyping, and testing, which eventually culminates in a pilot and then a full-scale deployment.

Through this iterative approach, which includes concepting, prototyping, and testing, we are able to move from understanding users' needs and values to designing fea-

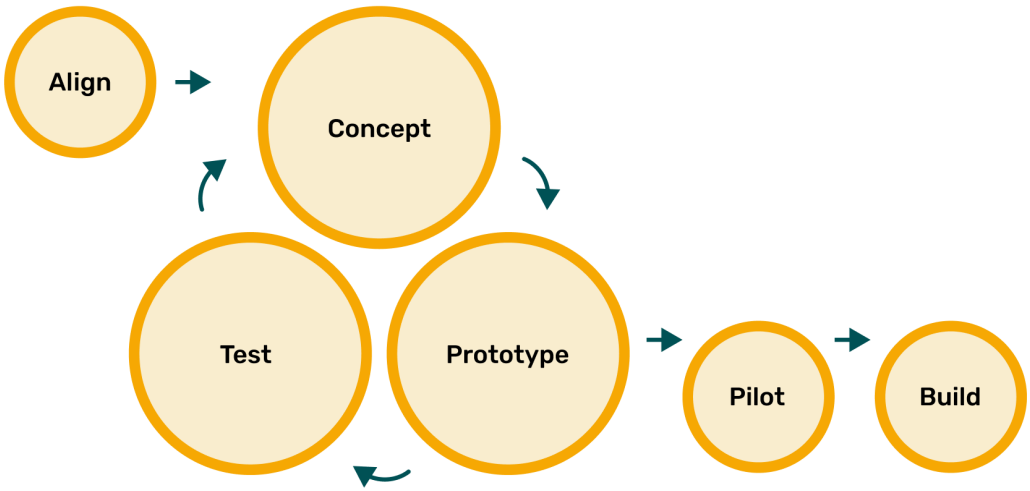

Figure 3-2-7 Oversimplified visualization of Clare & McConnell approach (Clare & McConnell, 2016)

tures that fulfill those needs and values, then designing the interactions and interfaces that make those features work. With prototyping and reviewing with collaborators, we're able to address the needs of each group and align the team around a central vision. Alignment, Assuming that the entire team is on the same page with the project's definition and goals is entirely common. People often have different interpretations of the project, and if left uncorrected, the teammates will head in different directions. Alignment ensures that everyone is moving in the same direction. During concepting, engage members across the team and from outside the design whenever possible. It is possible for you to facilitate the creation of diverse ideas as well as understand the underlying desires of the extended team. It's okay to start hypothesizing and generating initial ideas even if you haven't been able to get feedback from users yet. "Prototyping brings form to the intangible, opens up the process to enable collaboration across disciplines, and moves your project forward." As we go through the concepting, prototyping, and testing phases, our prototypes become more refined. "Testing means taking your assumptions to the people who are meant to use your solution. Testing ensures that what you plan to build will be valuable to people." (Clare & McConnell, 2016).

A number of significant contributions to design have been made in explorations that seem to have relied heavily on rigid-state theories from behaviorism. The logical structure of overt activities that appear to take place during the 1950s and 1960s was used to describe the creative problem-solving process at work in design. As a result, design was seen as a series of stages characterized by dominant forms of activity, such as analysis, synthesis, and evaluation (Rowe, 1991).

The book "Design Thinking" (1991) by Peter Rowe describes some of these models. The following two models "Asimow" and "Archer", also seem worth adding here from that book. Moreover, there are some other design thinking models focused mainly on the urban design process.

Asimow's Model

Asimow distinguished two sequential phases of the design process: a vertical structure that involves phasing activities sequentially, and a horizontal structure composed of a decision-making cycle that is common to all phases.

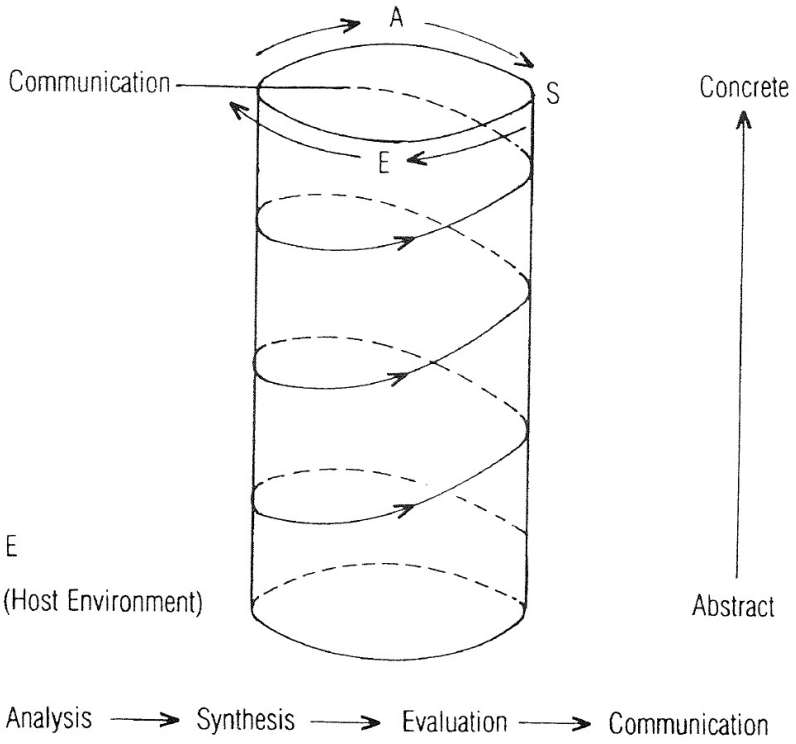

Figure 3-2-8 An iconic model of an design process (Rowe, 1991, p. 48)

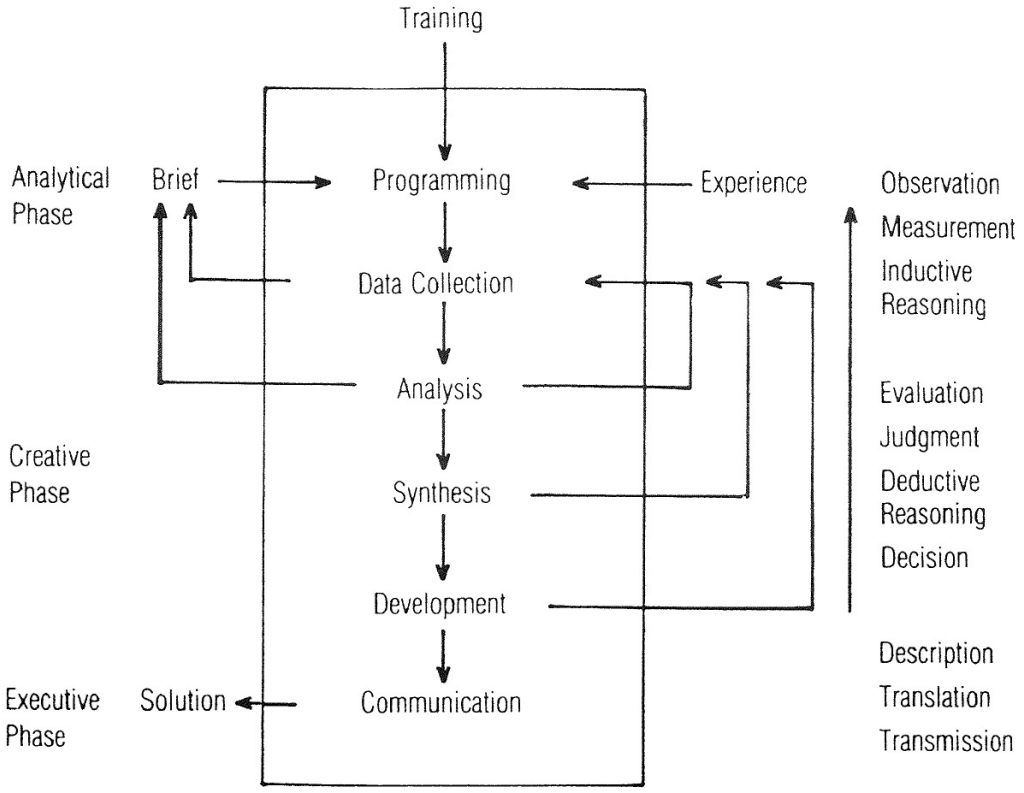

Figure 3-2-9 Archer's model of the stages of a design process (Rowe, 1991, p. 50)

There were numerous feedback loops built into the design process, which comprised relationships between phases, along which information about the design situation flowed, in order to allow for tracing back through the steps to respond to newly found difficulties or new information. In Asimov's diagram, the horizontal sequence is represented as a cycle that starts with analysis, moves through synthesis, evaluation, and ends with communication. Both within and between phases of activity, he saw this cycle as repeating, or iterative (Rowe, 1991).

Archer's Model

The industrial designer Bruce Archer, of the Hochschule für Gestaltung in Ulm and the Royal College of Art, introduced a similar "operational" approach to design, although in slightly different terms. Once again, design is seen as a sequence of activities defined by their orientation and the general type of task involved. A general description of the process is possible, regardless of the particular circumstances. There are feedback loops between activities, resulting in activities being staged less discretely as a result (Rowe, 1991).

Simulation Model

Additionally, to the previous models, it is worth mentioning that the simulation model should be added to the design thinking models, again with a major focus on urban design, simulation, and prototyping.

Using Peter Bosselmann (1998, 2008) work, Barbara Piga in "Experiential Simulation for Urban Design: From Design Thinking to Final Presentation (2017)" propose to highlight the constitutive methodological key-actions of environmental design and simulation as follow: to observe & to interpret, to measure & to compare, to model & simulate, to strategize, to design, to communicate; She consider the process of evaluation & decision-making transversal to all the categories. Even if the design process is not linear and is rather a recursive process of trial and errors or generate-and-test procedures, it is profitable to present these key-actions, that occur along the design phases, in a sequential way for describing the approach, as shown in the matrix below.

Synthesis matrix describes key-actions and recursive design phases. Darker to lighter blue and white, the cells indicate a stronger to a weaker relationship among the elements. An evaluation and decision making pro-

cess is transversal to all phases of the process and guides their development (Piga, 2017).

Rational process of planning

Andrea Faludi in the early 1970s made significant contributions to elucidating the procedural elements of planning. Faludi saw planning as a decision-making process aimed at resolving some of the numerous challenges that planners encounter. He stated that planning should be reasonable by completely analyzing all potential actions in light of their implications; and that these considerations should include alternate aims; and that planning should also adjust flexibly to changing conditions. Efforts must also be made in planning to link operational decisions (Faludi, 1986).

To achieve rational comprehensive planning, proponents specified the following operational procedures (Hobbs & Doling, 1981):

1. Goals and objectives must be specified.
2. Development and evaluation of all viable alternatives available to a decision maker for reaching the defined goals and objectives.
3. The prediction of all effects that would result from the adoption of

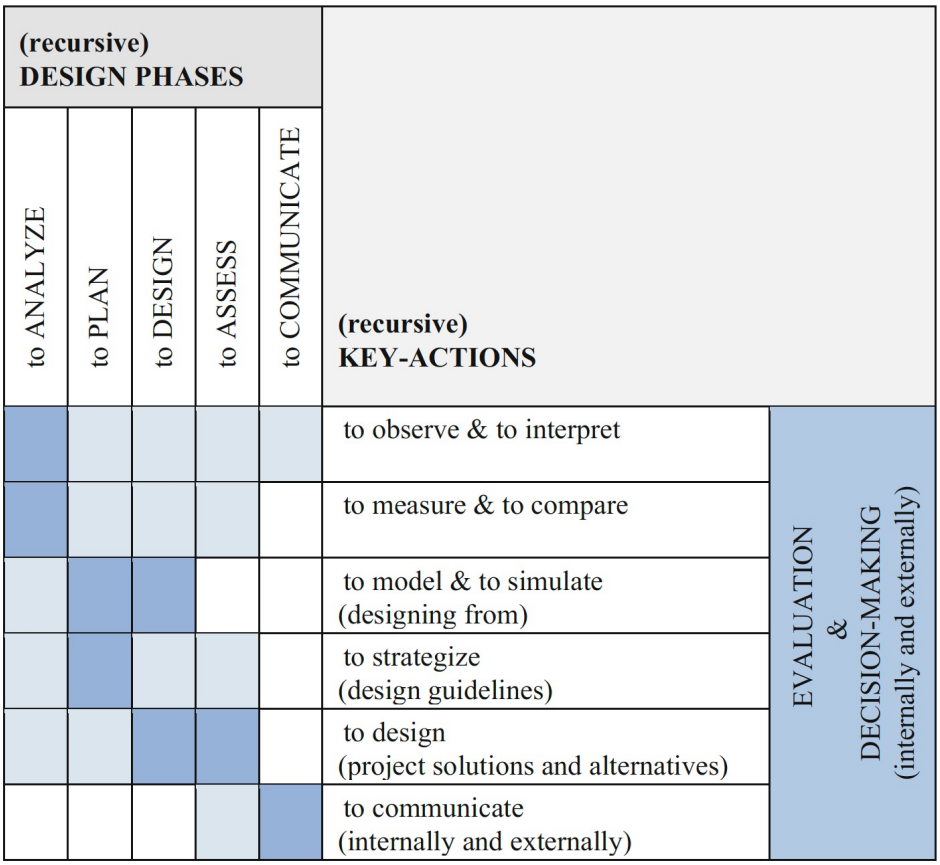

Figure 3-2-10 Schematization of the proposed method for an environmental urban design approach. (Piga, 2017)

each alternative.

4. A comparison of the outcomes regarding the agreed-upon set of goals and objectives.

5. Choosing the alternative whose effects are more closely aligned with the aims and objectives.

6. Implement the selected alternative.

7. Monitor of and assess outcomes and results.

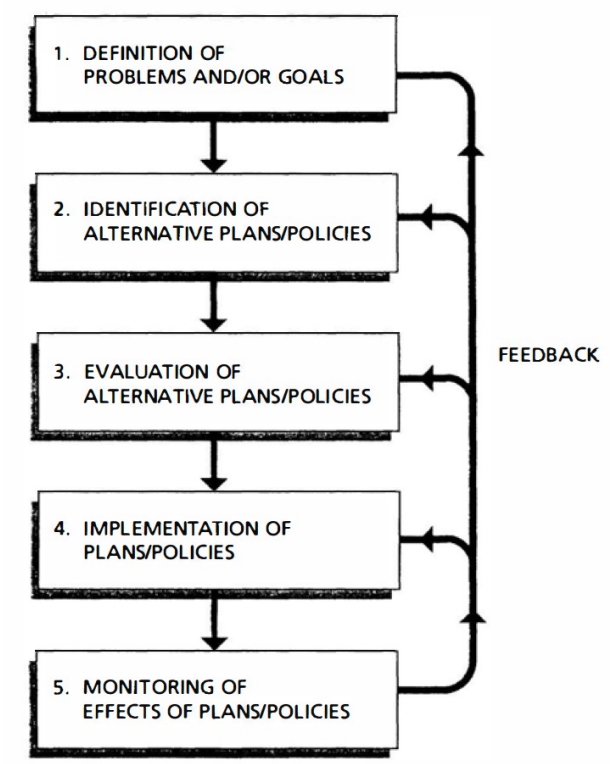

Figure 3-2-11 Planning as a process of rational action (Taylor, 1998, p. 68)

The planning process does not end when a decision is taken; the chosen policy or strategy must subsequently be implemented. As a result, Figure 3-2-11 depicts 'implementation' as a subsequent (fourth) stage in this process. A fifth step involves monitoring the plan's effectiveness to evaluate if it delivers the expected results. A rational planning process is thus continual or continuous (Taylor, 1998).

Despite the fact that rational comprehensive planning was the dominant and effective planning paradigm for a long period, its opponents leveled a number of criticisms at it.

The approach has been criticised of being abstract, providing only an extended definition of planning and stating nothing about how planning actually worked or what its impacts were (Taylor, 1998).

No matter how rational we want to be, no one can gather all of the data and take into account all of the factors.

Critics restrict thorough logic when it comes to the necessity to establish alternative approaches. Because of the nature of the challenges and the complexity of the ecosystem, there would be an insurmountable amount of possibilities to evaluate. It is nearly hard to be completely comprehensive due to the limited time and resources available for making a decision and examining all other possibilities (Campbell & Fainstein, 2003). The environment's uncertainty and ambiguity would likewise weaken any confidence in predicting the effects of a given choice. Critics claim that all choices are made with

no knowledge of the future and are instead dependent on assumptions. Planners are unable to anticipate unexpected changes and new expectations that occur between decision making and execution. Only the near future can be anticipated with certainty (Ledgerwood, 1985).

Strategic planning framework

Strategic plans should follow the path "from city strategy to action planning," in which, after establishing city priorities and objectives—"the strategic direction"—on the basis of a recognized urban situation—"the strategic situation," a set of strategic actions required to achieve each specific goal—"the strategic action"—is specified (UN-Habitat, 2007).

The strategic plans are divided into two sections: the first is connected to the so-called Strategic Planning Framework (SPF), which contains the strategic situation and direction, and the second is related to the Lo-

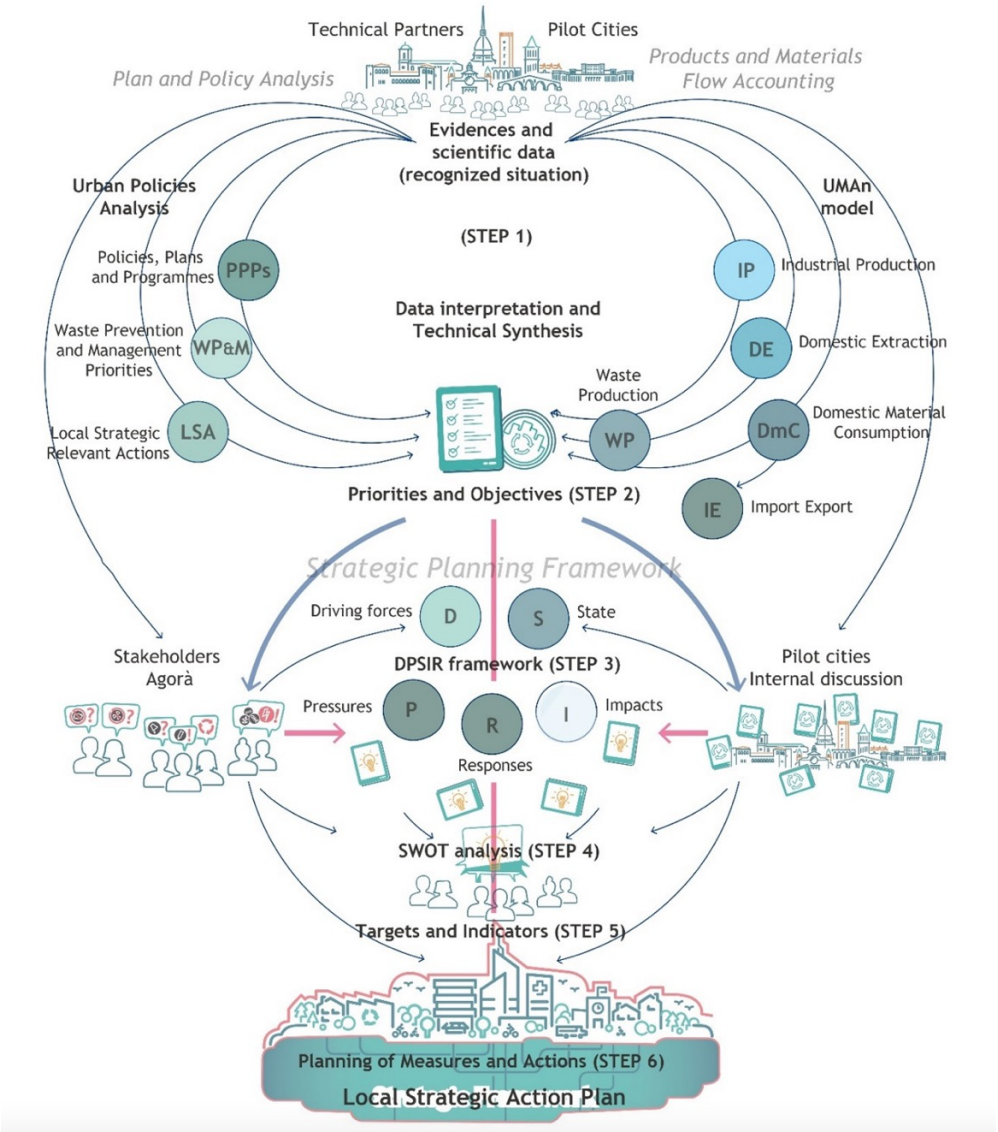

Figure 3-2-12 The various steps of the planning process proposed for the formulation of the strategic plans (Longato et al., 2019, p. 5)

cal Strategic Action Planning (LSAP), which contains the strategic action. The SPF section is intended to assist policymakers in developing a vision for their city and identifying relevant goals and objectives. The LSAP component is intended to aid in the implementation of the SPF. It is made up of particular measures and actions that must be carried out in order to achieve the city strategy by planning and prioritizing them based on the city's primary challenges and demands (Longato et al., 2019).

The current framework is a strategic framework that has been developed for the Urban Wins project. UrbanWINS was a European project financed by the Horizon 2020 Research and Innovation Program that investigated how cities use resources and goods, as well as how they eliminate trash, in order to design and test novel waste prevention and management strategies and solutions. The framework's goal is to provide creative urban strategic planning based on the concept of urban metabolism while also fostering the circular economy. It contains all of the activity clusters that the Urban Wins partners and target groups will do throughout the strategic planning process, beginning with the study of urban policies and ending with the redaction of the Strategic Planning Framework.

They are organized in phases that are produced through a participative approach. The process for involving local authorities and stakeholders in the entire planning process is designed to involve them from the very beginning of the strategic plan's definition (Longato et al., 2019).

By using a bottom-up approach in which the city strategy is built by decision and policy-makers with the support of relevant stakeholders and citizens, public participation in urban strategic planning improves the chances of developing solutions that are sustainable and feasible, as well as which residents are willing to implement (UN-Habitat, 2007).

Step one is mainly about the development of quantitative and qualitative knowledge about resource consumption and waste generation in the urban system aims to provide helpful information and data to begin the development of an urban plan based on a recognized scenario. The analysis of current policies entails gathering all of the information contained in plans, documents, reports, and so on that are required to construct the state-of-the-art of urban and territorial strategies and initiatives that have an impact on resource consumption and waste production

within the urban system. Step Two is the formulation of urban priorities and associated objectives which formed on the basis of quantitative and qualitative knowledge in order to respond to/improve the present condition (Longato et al., 2019).

The environmental and socioeconomic evaluation of the existing situation in the Third step, in terms of social and environmental concerns which produced the need to define priorities and objectives, is carried out in order to lay forth potential responses using the Driver-Pressure-State-Impact-Response (DPSIR) framework. The DPSIR framework is effective in urban planning practice because it focuses on supporting the design of the link between society, activities, and the urban environment; carrying out the consequences of decisions; and developing information on environmental impacts and challenges (Ioppolo et al., 2019). The Organization for Economic Cooperation and Development and the European Environment Agency created the DPSIR framework, which is described as a "causal framework for explaining the connections between society and the environment" (Longato et al., 2019).

In the step Four, the formation of the set of responses, a SWOT analysis is required to further discuss, approve, and detail the prospective responses based on the results of the study. SWOT analysis is one of the most commonly utilized approaches by practitioners; it has previously been applied effectively in a participative process in the waste management industry. In step Five, Particular time-bound measurable targets, as well as the indicators used to assess them, are created in order to identify a succession of time frames for monitoring the different steps for achieving the objectives and priorities through specific actions and measures. The final step, is to create and plan appropriate measures and activities within the LSAP section to achieve the objectives and priorities stated in the SPF part. Starting with the knowledge gathered during the analytical phases, strategies are transformed into real programs or activities for execution. Stakeholders must participate in the decision-making process collaboratively, just as they did in the previous phases, in order to reduce or eliminate disputes and oppositions (Longato et al., 2019).

References	Proposed by	Model's name	DISCIPLINE UX	UD	Data Collection	Priorities
		Total	**50,0**	**50,0**	**4**	**0**
Tschimmel, 2012	IDEO	3I	1		1 Inspiration	0
Tschimmel, 2012 / Bandyopadhyay et al., 2013	IDEO	HCD	1		1 Hear	0
Tschimmel, 2012 / IDEO, 2015 / Nguyen, 2020	Design Concil	4D	1		1 Discover	0
Thoring & Müller, 2011 / Tschimmel, 2012	Hasso-Plattner-Institute	Hasso-Plattner	1		1 Understanding / Observe	0
Clare & McConnell , 2016	Clare & McConnell	Clare & McConnell	1		0	0
					3	**1**
Asimow, 1962	Morris Asimow	Asimow		1	0	0
Rowe, 1991	Leonard Bruce Archer	Archer		1	1 Data Collection	0
Piga, 2017	Barbara E.A. Piga	Simulation		1	1 Analyze	0
Taylor, 1998	Andrea Faludi	Rational process of planning		1	0	0
Longato et al., 2019	UrbanWINS	Strategic Planning Framework		1	1 Evidences and scientific data	1 Prioritiese and Objectives / DPSIR Framework

Figure 3-2-13 Design Thinking frameworks comparison, by author

DESIGN PHASES							
Analyse	Problem definition	Ideate	Create	Prototype	Test	Build	Monitoring
1	**5**	**5**	**5**	**5**	**5**	**4**	**0**
0	1	1	1	1	1	1	0
		Ideation		Implementation			
0	1	1	1	1	1	1	0
	Create				Deliver		
1	1	1	1	1	1	1	0
Define		Develop				Deliver	
0	1	1	1	1	1	0	0
	POV	Ideate		Prototype	Test		
0	1	1	1	1	1	1	0
	Align	Concept		Prototype		Build	
4	**5**	**3**	**4**	**2**	**4**	**1**	**1**
1	1	1	0	1	1	0	0
Analysis	Synthesis			Evaluation	Communication		
1	1	1	1	0	1	0	0
Analysis	Synthesis		Development		Communication		
1	1	1	1	1	1	0	0
	Plan		Design	Assess	Communicate		
0	1	0	1	0	1	1	1
	Definition of problems and/or goals		Identification of alternative plans/policies		Evaluation of alternative plans/policies	Implementation of alternative plans/policies	Monitoring of Effects of Plans/Policies
1	1	0	1	0	0	0	0
SWOT	Target and Indicators		Planning of measures and Actions				

Frameworks in common

To compare these design processes, I made a table and listed the common phases across all models, for example almost all start with data collection and understanding of the problem. After examining each framework's process, I assigned a value of 0 or 1 to each step. These numbers indicate the presence of the step in the framework. If a step is labeled with the number 1, it indicates that the step exists or is among the primary steps or techniques of the framework. Obviously, a value of 0 indicates that the step did not exist or was never noted down in the framework process. Previous Figure 3-2-13 shows the table.

It is evident that "Problem definition" and "Create" are present in almost all models in the design frameworks. This shows the importance of defining the problem during the design process. Throughout this comparison, "Create" refers to all activities designers perform in order to create design guidelines, rules, or drawings and designs on any level. In this phase all the ideas come to life and change to become a visual concept, and then a prototype is created as realistic and interactive as possible before the "Build" phase begins, so that the cost can be reduced, and design mistakes avoided. Creation is also a key step in the design process, which is the designer's answer to the problem already defined.

As previously stated, there are four types of basic elements in design thinking. The first two elements (creation and exploration) broaden a problem space, while the latter two (comparison and selection) narrow it. When widening a problem, solutions are created and then evaluated in respect to the goal. Then, in an iterative process, solutions can be adjusted or new ones created until an ideal solution is identified. Narrowing a problem includes evaluating two or more ideas and then choosing the best solution based on specified and relevant target criteria. These pieces constitute a model that may be used to understand the thinking of designers when working in a team. Designers who work in groups must explain what they are thinking, revealing their underlying thought processes (Razzouk & Shute, 2012).

"Test" is another stage that exists almost in all models; it is also necessary because all models have iterative processes; it is a key step in those processes. In addition to "Test", "Prototype" is another crucial phase that gives designers an opportunity to see their solution in action before

building anything.

Between all stages, “Build” has a minor role. This is more understandable to urban designers because they usually deliver the complete design to the stakeholders or other experts on urban projects. This type of design makes it impossible to have different sprints or iterations after constructing a project. In contrast, for HCI user experience designers, this phase may seem different since they work closely with developers during the implementation and development phase.

Additionally, iteration and phase length are two other aspects that make each model unique. Depending on the model, different design activities are carried out at each stage. For instance, in the 3Is model, the Data Collection and Problem Definition activities are part of the Inspiration stage.

In the 4D model, the Ideate, Create, Prototype and Test activities are all included in the “Develop” phase, which means that designing in this model may require internal iterations that take place over one phase. As an example, there is one iteration after the “Define” stage to the previous point “Discover”

Iteration, can happen either internally or externally. Internal iterations refer to activities inside each phase, whereas external iterations refer to returning to the previous stage.

According to the bar chart in Figure 3-2-14, “Prototype” and “Build” are the least commonly used UD design

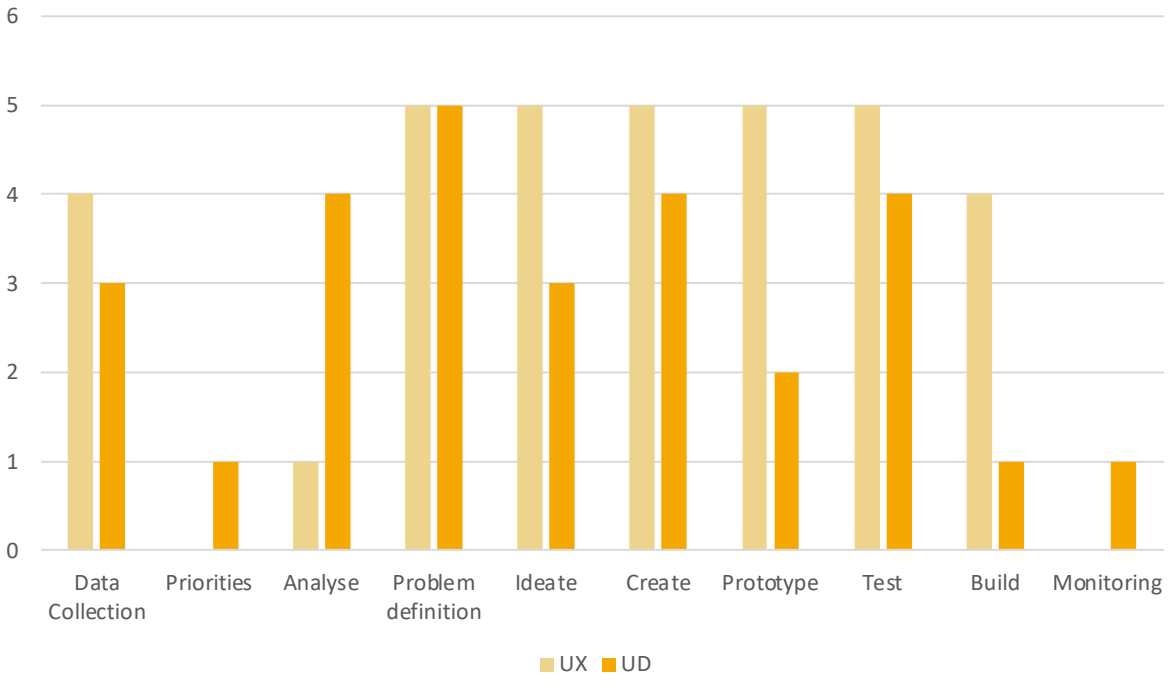

Figure 3-2-14 Design Thinking Phases in Comparison. by author

thinking frameworks as compared to other stages. On the one hand, it is evident that in Urban Design, "Build" requires a separate process that is impossible to have it parallel with the design process, due to a difference in scale. It is also difficult to iterate during or after the implementation process considering the scale. Monitoring after construction, Moreover, assists designers in correcting some of the mistakes with new ideas or, at the very least, preventing the same mistakes in future comparable scenarios.

"Prototype," on the other hand, tells a different tale. Although the scale is a significant limitation, it appears that urban designers did not take it as seriously in their design process as they should have. A simple study displayed that for a long time, designers in this industry have tended to test their designs using a prototype, but they have not made it a part of their design process, or at least they have not used and tested it for human-centered goals. In this discipline, prototyping is mostly used to constructing possibilities rather than as a stage in the decision-making process. When we examine the UX design thinking process, we see that several ways emerge to assist designers in testing their prototypes and the various viable alternatives they have.

Conclusion

To conclude, after reviewing and comparing User Experience design thinking frameworks to other design thinking models, the crucial thing to remember is that designers should only use these design frameworks as a reference. As a result, the first step that designers must take is to adjust the model to their own case requirements and needs. In terms of UX design, adapt depending on the user's needs and goals. For instance, because of the variety of users involved and the complexity of the problems a project may require more attention to data collection and analysis. The other project may not even need to spend much time collecting data because it is widely available.

Another significant aspect of the present comparison is that User Experience design thinking and today's Urban Design thinking frameworks are completely compatible. It is apparent that both types of designers currently use a similar decision-making process. Although Urban Design and Urban Planning has a long history going back to top-down design techniques and traditional approaches, the current approach is a result of

this history. Such achievement may demonstrate to current research that increasing user experience in urban design is not entirely due to variations in the decision-making process that designers go through, and it must be another significant difference that we can gain from UX design.

It is important to point out that, when looking at the proposed years of each framework, it is clear that architecture and urban design pay insufficient attention to the design process. This is something that should be mentioned here. As was noted, there are a few institutes in recent years that are working on the UX design process in order to keep it up to date and to make it more technically advanced. This not only helps to cultivate new designers and students in this field, but it also contributes to the creation of a pattern that is based on human behaviour, with the goal of achieving good design and determining how good it is.

A deeper look at each framework reveals that, while they may go through the same process, they do it in different ways with different approaches. This means that different approaches were used for different stages, resulting in different outcomes and results.

Furthermore, as previously mentioned, “Prototype” is the best stage to focus on and begin working on. As noted in the preceding chapter, it is also an excellent starting point for urban designers to incorporate various user experience techniques to urban design, such as usability elements.

3.3. Introduction to design thinking in Urban design

Until now, architecture, and urban design were among the only design disciplines that did not deal with interactive prototypes. Indeed, emerging technologies are allowing architects and designers to more effectively portray their designs, particularly through visual simulation and augmented reality. The growing use of such technologies is influencing how designers develop and present their ideas. At the moment, this modification mostly affects the final result of the design process.

In order to assess results, architectural and urban design do not use of realistic prototypes in the same way that industrial design does. Despite this, simulation is used in a variety of forms and with varying scopes in study and professional activity (Piga & Morello, 2015). In particular, "perceptual simulation attempts to provide tangible, concrete replicas or isomorphs of environments - often future environments - that can be displayed to observers for their evaluation or other response" (McKechnie, 1977, p. 174).

There are two key reasons why designers might reject simulation: First, skilled designers may argue that they have a clear understanding of the visual mental picture and intricacy of envisioned future settings (Kavakli & Gero, 2001). Second, in order to restore the atmosphere of places, they may want to extract the significant characteristics of their design schemes through more synthetic forms of representation, which restores the atmosphere they imagine through their synthesis (Piga & Morello, 2015). Simulated results are a reliable way of validating design outcomes in, and designers could benefit from this tool, since they can assess the cumulative impact of different design choices and the interactions that occur.

3.4. The history of Visual Simulation in Urban design

Using Visual Simulation in bult environment and urban projects is nothing new. Peter Bosselmann, director of the Environmental Simulation Laboratory (ESL) at the Institute of Urban and Regional Development at the University of California, Berkeley discusses in his book "Representation of Places: Reality and Realism in City Design" about the history of representation in city design.

Almost 150 years after photography was invented, we assume that photography records the world accurately. Despite this, photography is based on a convenient geometries fiction called "central projection", which represents reality in a somewhat limited way. We have been aware of these limitations since Filippo Brunelleschi (1377-1466) developed linear perspective as a method to represent a space in a way that approximates reality (Bosselmann, 1998).

The architect who designed Florence's cathedral dome (1420-1436) was this artisan engineer. Before the dome's construction, Brunelleschi had painted from the portal of the Cathedral of Santa Maria del Fiore the view of San Giovanni Baptistery in Florence. Although there is much speculation in art-historical literature about both of these, it is known that he painted the picture on a wooden panel (Bosselmann, 1998).

Brunelleschi did not record the method he used or the date he finished it until after his death. There is no record of his method of creating the work until after his death, and the painting is lost. Brunelleschi had made a hole in the panel In which his painting was framed. On the painting side of the window there was a hole about the size of a lentil. As for the back, it opened pyramidically, like a straw hat, to the size of a ducat or a little bit larger. In his vision, the eye should be placed at the back, where it would be large, with one hand holding the painting and the other holding a mirror opposite, so that there the painting could be reflected back to him. When seen, it looked as if they were real (Bosselmann, 1998)!

Brunelleschi's view tries to capture the world as the eye sees it. Along with this historical use of the representation, there are other facts that show how representations of the space are useful and important

to urban designers.

Gordon Cullen or Edmond Bacon have taught urban designers that movement can be read and understood as a pictorial sequence. According to critics, the use of serial vision has led to overly picturesque designs. In the case of cities, eye-level perspectives might be the most common representation, and maps combined with this technique could help designers to understand the scale and sense of the design.

3.5. Mixed Reality as Urban Design Prototype tools

It was the 1972, Appleyard and Craik received funding from the National Science Foundation to update what had been a rather simple environmental simulator purchased from Yale. The creation of very detailed maquettes was followed by the design of the environmental simulation equipment: Karl Mellander, a mechanical and optical engineer, created a modelscope with a tiny set of movable prisms and lenses that can be walked, driven, or flown through a very small scale physical model with attached cameras. The movie of a walkthrough was used as a validation of the simulator as a research tool (Bosselmann, 1984).

The creation of urban stage in physical maquettes started by taking photos of existing buildings. These facades were pasted on the vertical surfaces of a physical maquette, more recently it is done in a computer by creating a texture and mapping it on 3D models.

A rather simple environmental simulator obtained from Yale was updated by Appleyard and Craik with funding from the National Science Foundation in 1972. In addition to the creation of detailed maquettes, Karl Mellander, an optical and mechanical engineer, designed a modelscope. This device can be walked, driven, or flown through a very small scale physical model with attached cameras. In order to validate the simulator's value as a research tool, a movie of a walkthrough was produced (Bos-

selmann, 1984).

The process of creating urban maquettes began with the taking of photos of existing buildings. As a result, these facades are pasted on vertical surfaces of a physical maquette, and more recently a texture is created on a computer and is mapped on a 3D model. This laboratory created urban simulations that were specific types of simulation in terms of the connection between the human and the environment (Bosselmann, 1984). Exploring such a relationship, varying the focus according to the circumstances, has been done from a human perspective, with the objective of representing the environment.

In response to this simulation presented in the book, many planning agencies cannot afford to hire an engineer, filmmaker, computer programmer, model builder, and urban designer who can assist in developing a simulation. It is only suitable for very large engineering or planning projects that simulation can justify its cost. Nevertheless, with new technology in our hands, Virtual Reality (VR) and Augmented Reality (AR), could be more beneficial than ever, and with affordable hardware available today, we are no longer limited by cost.

Since the 1980s, the term “virtual reality” has been around. According to the Oxford English Dictionary (1989), it is a technology that synthesizes a shared reality using a computerized clothing.

The concept of virtual reality can be defined as the systems and technologies that create the illusion of being present within a three-dimensional computer-generated world. By interacting directly and in real-time with the virtual environment, the user is able to perceive this sense of presence and experience the feeling of the environment. In virtual reality, design objects can be directly manipulated and controlled by hand movements that are coordinated with the user’s movements. This encourages a much higher level of engagement with the design object. By doing so, digital models can be generated in a similar way that free-hand sketches or physical models are created (Okeil, 2010).

Virtual and augmented reality are forms of mixed reality; they describe a continuum between experiences that represent the real world and those that are fabricated or augmented.

In augmented reality, virtual images are dynamically overlayed on real-world images, so that the real world remains visible to the viewer;

when the viewer moves in the AR environment, information changes accordingly.

By definition, VR creates realities that do not yet exist or are largely inaccessible and therefore contain more created (synthetic) parts than AR (Portman et al., 2015).

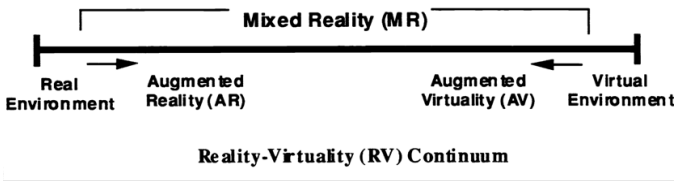

Figure 3-5-1 Simplified representation of a RY Continuum (Milgram et al., 1995, p. 2)

The case on the left of the continuum in Fig. 3-5-1 defines any environment consisting solely of real objects, and includes anything that can be seen when viewing a real-world scene in person, through a window, or via a (video) display. The case on the right defines environments made up entirely of virtual objects, such as traditional computer graphics simulations, either monitor-based or immersive. Within this framework, an ageneric Mixed Reality (MR) environment is easily defined as one in which real world and virtual world objects are presented together within a single display, that is, anywhere between the extremes of the RY continuum (Milgram et al., 1995).

3.6. Validation of visual simulation

Several studies have been conducted on the validity of the visual simulation.

The correct localization of the environmental futures in space, a simulation's quality is measured by the way features are described and represented (level of detail and resolution; materials and textures; lighting and colours; shapes; etc.).

Uniformity of the representation of environmental features (e.g. current condition vs. design scheme).

The readability of the simulation in relation to human eyes, including considerations of the resolution, fo-

veal, and peripheral vision.
The inclusion of features that recall the atmosphere of a place (like the weather, clues to economic and social aspects, like the level of maintenance) can unconsciously influence our perception of places.
The inclusion of dynamic features in the depicted setting can also affect our assessment of it (Piga & Morello, 2015).
In order to achieve the best results with an urban design prototype, the factors mentioned above may be considered.

4. Urban Design Prototype

4.1. Methodology

As noted in the previous chapter, adapting the model to suit the designer's requirements is a crucial step for all designers. Users' needs and goals are taken into account when adapting the model.

As a result, the concept is a combination of all frameworks. Therefore, the designer can select each step depending on what is required for their design. The proposed framework is derived from this idea and is based on research of design thinking frameworks comparison in the previous chapter.

This model inspired other design thinking models already mentioned, This is not a new design framework,

but rather a combination of the most important design thinking phase that designers must consider. As previously stated, it is critical that designers adopt the design frameworks based on their case requirements. This model attempts to show the main focuses, which are nearly identical to all studied models. Designers could use various methods to achieve the best design result within each phase of this model.

The model is divided into two main phases. The two first top parts are “Observe” and “Analyse” which are more related to the research and understanding. The two bottom parts “Create” and “Prototype” are more related to designing and creating. The process starts with “Observe” and then continues with “Analyse”, which at the beginning are understanding the problems, data collection and analysing data, and ends with the same two phases but this time with a prototype in hands to observe and test the design in real-world and analyse human behaviours, the process could continue until getting the best result in the first two parts “Observe” and “Analyse”.

Additionally, it is always recommended to repeat and iterate the previous stage if necessary during the whole framework. It could be a result of new observations and findings or an issue with problem-solving stage.

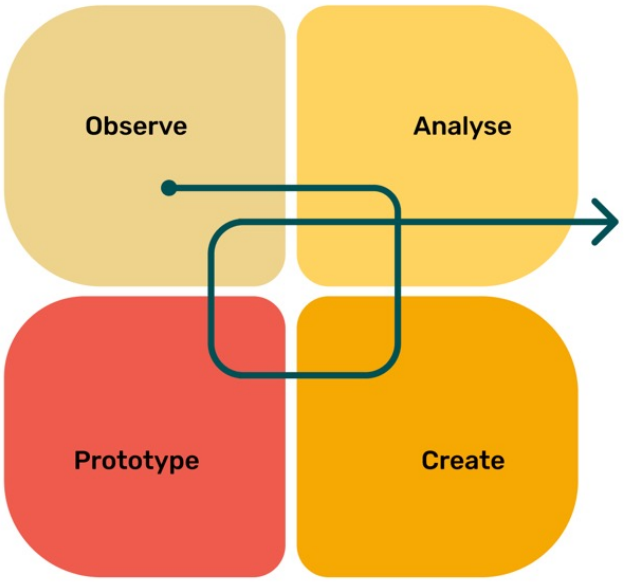

Figure 4-1-1 Clover Design Thinking Model, Proposed by author

Observe

is the first step in the problem-solving process. This is where you go and see the project site. During this phase, the most significant task is collecting raw data using observation, interview, photographing, and shadowing methods (to observe and document current human behavior at the site), as well as other similar techniques which could also be used. Bellow, there are some recommended methods for this phase which is used in some of design thinking studied in the second chapter.

What, How, Why

One of the recommended ways in this phase is, considering the what, how, and why of your users' behavior. By using this method, designer can translate observations into more abstract user motivations. Using these questions brings attention to abstract motivations beyond concrete observations.

"What?" – Describe what you observed.

"How?" – Analyze how users behave (e.g., with difficulty).

"Why?" – Guessing the users' emotions and motivations. This way is observing real user behaviors.

As part of observation and note taking, it is also a good idea to ask users for permission to record their video or take photos of them while they are solving a problem or using a space. It's also possible to ask them to record a video by themselves.

According to Jan Gehl's book Cities for people (2013), designing cities where people can live effectively begins with the concept of mobility and senses, as they form the biological basis for activity, behavior, and communication. The designer must also collect this type of data during the Visit phase.

Interview

The other common method is having interview with users. It is possible to directly ask users for their insights in an environment where they are able to provide honest answers to open-ended questions.

A user interview gives insight into their opinions about a site, a project, or a process. Site visitors can provide insight into what they find most memorable, what they find most important, and what ideas for improvement they may have. It is important to note that this method could be used also in "Prototype" phase to test the design.

It is better to begin by learning about the person's life, values, and habits, and then ask more specific questions that relate directly to the problem that exists.

Analyse

"Analyse" is the next step. Here, the recommended things to do are related to defining the problem and analyzing the raw data. Creating mind maps, brainstorming sessions, creating user personas based on the data collected during the previous phase, etc. are some of the methods that can be used in this phase. This is actually the most crucial phase because it is the time to understand citizens as users and develop empathy with them.

Emphasize

"Empathy is the capacity to step into other people's shoes, to understand their lives, and start to solve problems from their perspectives."(IDEO, 2015, p. 22) By empathizing with users, we can understand their immediate frustrations, as well as their hopes, fears and other feelings. By knowing the user, we can create solutions that not only address their needs, but also remove unnecessary friction or pain

from their lives.

Here it is worth mentioning, Participatory design is another similar term but different with Empathy design. In addition to getting to know your users, empathy maps are a great way to share this knowledge across the team.

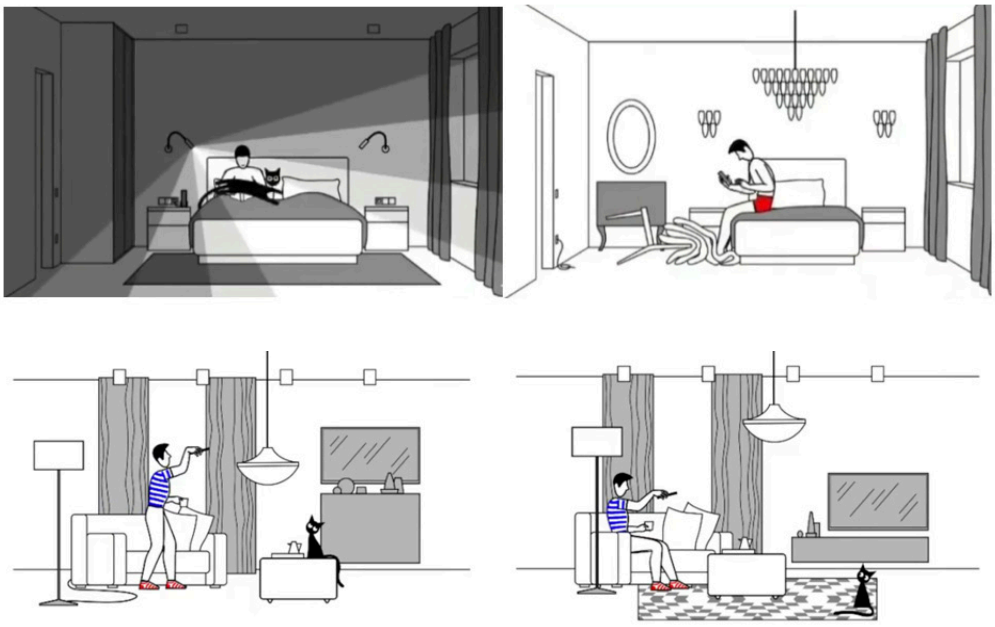

Figure 4-1-2 There is lack of Empathy with user in the right photos (Bon Ton Studio)

Steen (2011) outlines the different orientations within these two approaches. Empathic Design moves the designer towards the user, while Participatory Design moves the users closer to the designer. Urban design projects such as those discussed here require the designer to go beyond observing, that is, he or she must be able to understand the living conditions of people within different cultural and social contexts.

Users personas are archetypal users whose goals and characteristics are representative of a larger group of users. The purpose of user personas is to establish accurate portraits of the people who will interact with your design. It is essential to understand a target audience deeply before

designing anything exceptional. A user persona helps a design team discover the answer to one of their most critical questions, "Who do we design for?" By understanding the expectations, concerns, and motivations of target users, we can create engaging designs that fulfill users' needs and therefore be successful.

The use of personas allows designers to gain an understanding of the user's perspective. Users' personas are useful because they allow designers to step outside of themselves and recognize that different people have different expectations and needs.

Create

"Create" is the third step. It is the most familiar and common step for urban designers and architects, during which they draw lines and prepare designs. Throughout this design thinking step, it is highly recommended that designers design based on the data they collected in the previous phases and the user empathy they've gained.

Prototype

"Prototype" is the last phase. While it is highly recommended to finish the design process with the "Observe" phase after the "Prototype." Design thinking frameworks have all been finished with the Test phase, but since the visual model in the real world cannot be tested, prototype could help designers, so it is suggested to visit the site again using interactive prototype and having interview with people as a test.

Prototyping in the real world may be a challenge, but visual simulations are the best way to get the best prototype, which is the basis of the current research in the following chapters.

Architects and urban designers do not use realistic prototypes to test outcomes as industrial designers do. Although simulations are used in many ways and for different purposes in research and professional work.

It does not only serve as a method for assessing and anticipating design outcomes. This method transforms the way in which people look at and approach their work. In a manner that considers the human perception of space, design pays more attention to the experiential and physical aspects of space, thus placing people at the center of attention (Piga & Morello, 2015).

4.2. Urban Design Simulation Usability

On one hand, as mentioned in the second chapter, Usability is the most important element in user experience design. In order for a design to succeed, people's needs must be met, that the end result is clear, usable, performs the basic functions, and the user experience must be satisfactory. Usability has five dimensions, according to the 5Es: effective, efficient, engaging, error-tolerant, and easy to learn. When these elements are present in a design, we have a usable design and, as a result, a good design with a good user experience.

On the other hand, as checked design thinking frameworks, there is not much difference between design models, the most important thing to remember is that designer must adopt the framework based on the needs and case requirements. The point is, whatever you design, meet all requirements and have iterations between phases.

Moreover, "Prototype" is a crucial phase to achieve the best design, as makes it possible to test the design and see if the outcome is usable or not. To urban designers prototyping while has a long history, needs more attention and focus. This neglection could be because of the urban scales which makes it difficult to build a prototype and test it in the real world. Technology and virtual reality these days come forward to make this thought process easier. Urban designers from now on have to take it into consideration during their design framework.

Based on the above, urban designers require a method to test their prototype, and if the goal is to achieve a human-centred design and the best user experience, it is critical to meet usability elements and requirements. In this case, the 5E's method could be modified to meet this requirement.

The following effort attempts to make it possible by taking into account the visual simulation of urban design as a result of the design framework's prototype phase.
The table bellow (Figure 4-2-1) notes some design tactics and recommendation as the proposed of the current research to be considered during urban design visual simulation testing. This inspired the 5E's usability model.

Dimension	Key needs	Design tactics
Effective	Accuracy	- Consider how many places in the design are opportunities for people's mistakes or confusion, and protect against them. - Look for opportunities to provide feedback and confirmations.
Efficient	Operational speed	- Place the most important information in front of the user such as signs, urban elements and direction guides. - Work on navigation and circulation and make it simple based on human behaviour.
Engaging	Draw users in	- Consider what aspects of the design are most attractive and incorporate them into the design. - Use urban elements which need people interaction. - Let people try the space sometimes, they will have something new to discover every time they visit an urban space.
Error Tolerant	Validation	- Allow people to retrieve their mistakes or wrong choices easier, for example considering multiple exits from an urban space or multiple cycle path choices to reach a specific point.
Easy to Learn	Just-in-time instruction	- Always consider urban elements in your project to let people remember the spaces, repeating similar design increase confusion and learnability of the space. - Keep the balance between open and closed spaces to help users understand the space easier. - Do not use complicated shapes in your drawing! People always choose the easiest and shortest path to get anywhere.

Figure 4-2-1 The usability requirements of the urban visual simulation prototype by author

Thanks to visual stimulation as a design prototype, the proposed method and design tactics help designers make the 5E's balanced chart (see figure 2-2-1). Once the focus point is found, all activities based on the design thinking process would focus on improving the product usability.

Only two factors will be considered in the current study: Engaging and Easy to learn. The reason that we should put our attention on these two is that both of their main goals are comparable. Easy to Learn works toward the goal of simplifying everything in order to increase learnability, while Engaging strives to maintain users' interaction and interest. The important takeaway from this is that there needs to be a balance within both of these aspects. On the one hand, a design needs to be straightforward and easy to understand, and on the other, it can't be so simple that it becomes boring and repetitive and loses its ability to engage users. Therefore, for users to continue being engaged and to have a sense of achievement and uniqueness, there must always be something new to learn and secret parts.

There are a variety of qualitative and quantitative UX Design evaluation methods available, which can assist designers in testing their prototypes with regard to the usability dimensions.

4.3. Urban Design Simulation Usability

A product is seen to be engaging if it has the ability to draw in the user and encourage interaction. In terms of its five dimensions, this is the most subjective of them all.

Questioner is a useful method for evaluating participants' level of engagement in the design. When it comes to actually writing down the questions that they need to ask their participants, researchers almost never have an easy time of it. It is true that this becomes less difficult with time and experience, but the act of writing an interview guide or test-plan is something that will never be considered "easy." In the end, we are all human, which means that we are susceptible to our own frailties and constraints. When you don't know what questions need to be answered, it's difficult to conduct research on

the topic. To begin any research endeavor, you will first need to determine why something occurs, what people do when faced with particular challenges, and how they carry out fundamental activities. Finding people to talk to and formulating our questions in such a way as to get to the heart of the matter is necessary if we are going to get answers to these questions.

Understanding how questions should be asked is the first and most important step in developing a useful questionnaire. Let's examine how to construct questions that will elicit the desired responses. To begin, we are going to discuss the structure of a question in its entirety as well as the various forms questions can take in order to drive conversations (Nunnally & Farkas, 2016).

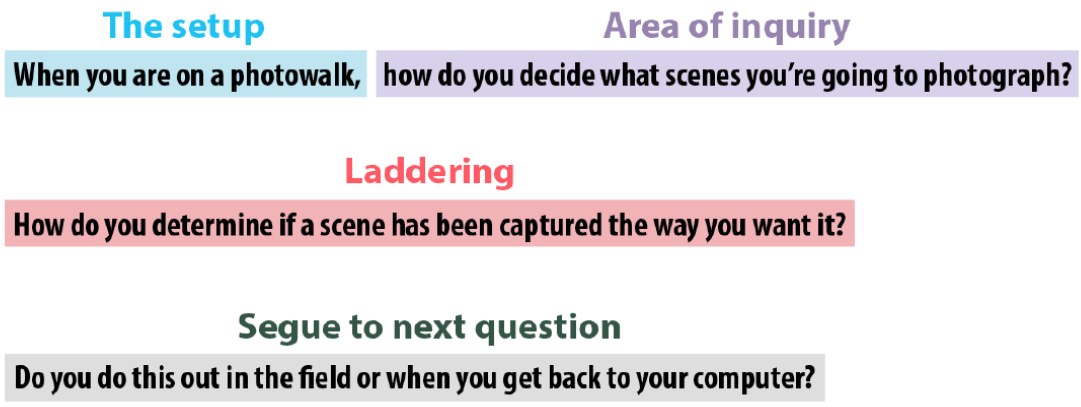

Figure 4-3-1 The structure of a standard question (Nunnally & Farkas, 2016, p. 44)

The Setup

Every question has a specific goal in mind, or setup. This takes the form of what (description), why (explanation), how (process), when (situation), and where (context). It provides the participant with a sense of the type of response you anticipate from them and, more importantly, the length of response that you anticipate from them (Nunnally & Farkas, 2016).

Area of Inquiry

The topic of your investigation is the topic that you want to learn more about, such as how the use of your design affects or has an influence on the life of someone (Nunnally & Farkas, 2016).

Laddering

Some of the answers to your questions will come with the question

"Why?" already linked to them. Laddering is an aspect of a question that helps you get to deeper information and potentially impactful stories by asking a participant to go into more detail or to explain the rationale behind their response. It's a running joke within us that this is the point at which we get to behave like two-year-olds and start asking "Why?" to find out more information regardless of the response. However, the trick is to ask enough questions without coming across as annoying.

Segue to Next Question

The best research sessions consist of in-depth discussions between the researcher and a participant. If you want an interview or study session to feel more like a conversation, the best way to do that is to string questions together in a way that gives the whole thing a beginning, middle, and end. It is important to keep the discussion fluid. While it is helpful to think about how each question could set up the following question, it is also important to keep this in mind.

Writing Questions

It is imperative that each and every one of the interview questions you prepare be directly related to the purpose of your research. Make sure that every question you ask is focused on a few relevant topics or events. As soon as a question doesn't seem to be able to help you understand these goals, it's time to stop asking it and move on to another.

We've discussed the importance of research sessions that feel more like conversations than a verbal questionnaire. In order to accomplish this, the questions you ask should build on one another and aid in the participant's progression through topics at a natural pace.

Looking back on the fundamental structure of a question. There is a distinct purpose served by each of these, and you should plan to include a healthy variety of them throughout the interview guide.

Using Various Types of Questions

Remember the fundamental structure of a question: what (description), why (explanation), how (process), when (situation), and where (context). Each of these serves a different purpose, and you should plan a balanced mix for the interview guide (Nunnally & Farkas, 2016).

Process-oriented questions are not only helpful as topic transitions but also make excellent openers for research sessions. They provide the participants with an open forum in which to discuss something they have done and how they carried it out.

> Example: How do you design a photo album for a friend or family member?
>
> Nunnally & Farkas, 2016, p. 27
>
> Revised: How do you get to work or pick up your child from school each day?
>
> Author

People are capable of saying the most fascinating things, and most of the time they have no idea why they are saying them. You will have a more in-depth understanding of the participants' world if you ask them to explain their comments using the laddering method, which was described earlier. In this location, you will find information that is useful to you.

> Example: Why do you feel that photo albums are still a treasured keepsake in today's world, where more and more photos are digital?
>
> Nunnally & Farkas, 2016, p. 27
>
> Revised: Why do you think that this is a good way to pick up your child when there are other ways that are much faster, such as driving yourself?
>
> Author

Every individual has a distinct perspective on the world. Research enables you to collect these perspectives and incorporate them into your own.

> Example: What makes a photo worthy of going into a photo album?
>
> Nunnally & Farkas, 2016, p. 27
>
> Revised: What makes biking worthy to use to get to work?
>
> Author

A participant may use your design for a variety of reasons at any given time. During an interview, you can ask for an explanation of why the candidate chose your alternative over another one. You can also see how long people spend doing certain tasks and how much tolerance they have when things go poorly.

> Example: When do you think photo albums are most appreciated?
>
> Nunnally & Farkas, 2016, p. 28
>
> Revised: When do you think biking could be a transport option for you?
>
> Author

Creating questionnaire

It's common to ask participants about their backgrounds, their opinions on specific tasks, and how they feel about the product's overall ease of use at various points during a test. It is imperative that you write down all of the questions you expect to be asked in advance.

Writing a questionnaire serves two purposes:

1. To ensure that you ask the same question to each participant.
2. In order to ensure that you don't forget to ask the question.

In order to get an answer, you need to do more than just write it down. In addition, the question must be phrased in the most precise and appropriate manner possible. You'll get less useful information if you ask open-ended questions (Dumas et al., 1999).

A test has three points in which participants may be asked to answer questions: before the tasks begin, after each task, and once they have completed all of them. More specifically, there may be a:

• **Pretest questionnaire** to gather information about the background of the participant.

• **Posttask questionnaire** to gather judgments and ratings after each task.

• **Posttest questionnaire** to gather judgments and ratings after participants have completed all of the tasks.

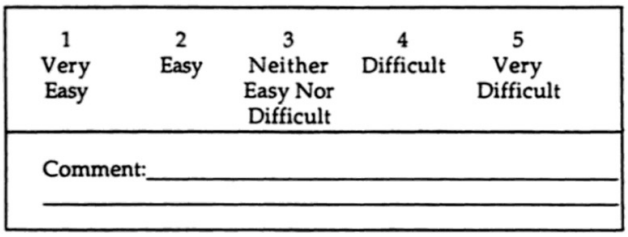

Figure 4-3-2 Written questionnaire sample with open-ended comment (Dumas et al., 1999, p. 208)

Pretest questionnaires are typically used to gather information about the test participant's background and verify their credentials in cases where you haven't already done so. There may be additional information that you need to know even if you have qualified the participants by having them fill out a questionnaire during recruitment (Dumas et al., 1999). For example: You may know how much user know about the area you are designing.

Make **posttask questionnaires** as brief as possible, with no more than six questions and room for the participant to add their own thoughts.

It's time to get the final data from the participants. Participants have gained some perspective on the product's usability after spending a significant amount of time with it. You can use the **post-test questionnaire** to gather those impressions (Dumas et al., 1999).

4.4. Easy to Learn Evaluation

An easy-to-learn solution allows users to build on their past knowledge without having to put in any more work on their part. It's not just the use of specific strategies that makes learning easier; it's also the way you connect with others. If the user is given enough knowledge of a design that allows them to extend their previous experiences into a new context, they will be able to do so (Albers & Mazur, 2003). In the user experience, the learnability of an interface is measured by how quickly and easily a user can complete a task the first time they see it and by how many repetitions it takes for them to become proficient at completing the task. New designs, in particular, necessitate some learning. It's common for learning to take place over time rather than in a single burst of inspiration.

There are different ways to measure the learnability of a design.

Measuring

Learnability data is collected and measured in the same way as other performance metrics, but it's collected at multiple points in time. It's a trial and error process to collect data. It could be every five minutes or once a week. The amount of time between trials, or the amount of data you collect, is based on how frequently you expect to use the product. The first step is to decide on the metrics to be used. Any performance metric can be used to measure learnability, but most commonly it is focused on efficiency, such as the number of steps taken or how long it takes to complete a task successfully. You can expect to see an increase in efficiency as a result of learning (Albert & Tullis, 2013).

Once you've selected your metrics, the next step is to determine how much time should elapse between trials. In the case of long-term learning, what do you do? For example, how often would users interact with a product? It would be ideal if the same participants could return to the lab on a weekly, monthly, or even annual basis. This may not be feasible in many cases. Having to wait three years for the study to be completed might not sit well with the developers and the business sponsors. Using the same participants over a shorter period of time is a more realistic approach that acknowledges the limitations of the data. Data on learnability is commonly analyzed and presented

by looking at a specific performance indicator (such as time spent on task, number of steps or errors made) for each task individually or collectively. As you gain more experience, you'll see how that performance metric shifts. (Albert & Tullis, 2013).

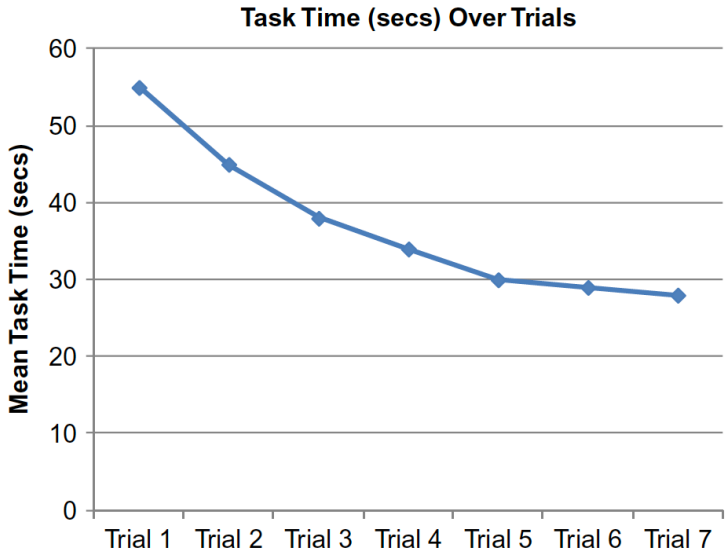

Figure 4-4-1 An example of how to present learnability data (Albert & Tullis, 2013, p. 94)

Each task can be seen as a separate line of data or as an aggregated line of data that represents all of the tasks individually. This can be useful in comparing the learnability of various tasks, but it can also make the chart more difficult to understand. The slope of the line is the first thing you should notice in the graph. The slope (sometimes referred to as the learning curve) should be low and flat on the y axis in the ideal situation. It's necessary to conduct an analysis of variance to evaluate whether or not there is a statistically significant difference between the learning curves (or slopes).

You should also observe the asymptote, or the point where the line begins to flatten. This is the moment at which consumers have acquired the maximum amount of knowledge and there is minimal possibility for advancement. Members of the project team are often curious as to how long it will take someone to reach peak performance. Finally, you must examine the difference between the highest and lowest y-axis numbers. This will indicate how much learning is required to achieve peak performance. Users will be able to learn the product fast if the gap is narrow. If the gap is substantial, it may take

customers a considerable amount of time to master the product. Examining the ratio between the highest and lowest scores is a simple technique to examine the difference between them (Albert & Tullis, 2013).

In certain circumstances, you could find it useful to analyze learnability under various scenarios, as demonstrated in Figure 4-4-1. It illustrates how the interaction speed changes over the course of time with a design. It is clear from the statistics that there is an increase in performance from the initial trial to the second trial, but after that point, the times tend to level off rather rapidly.

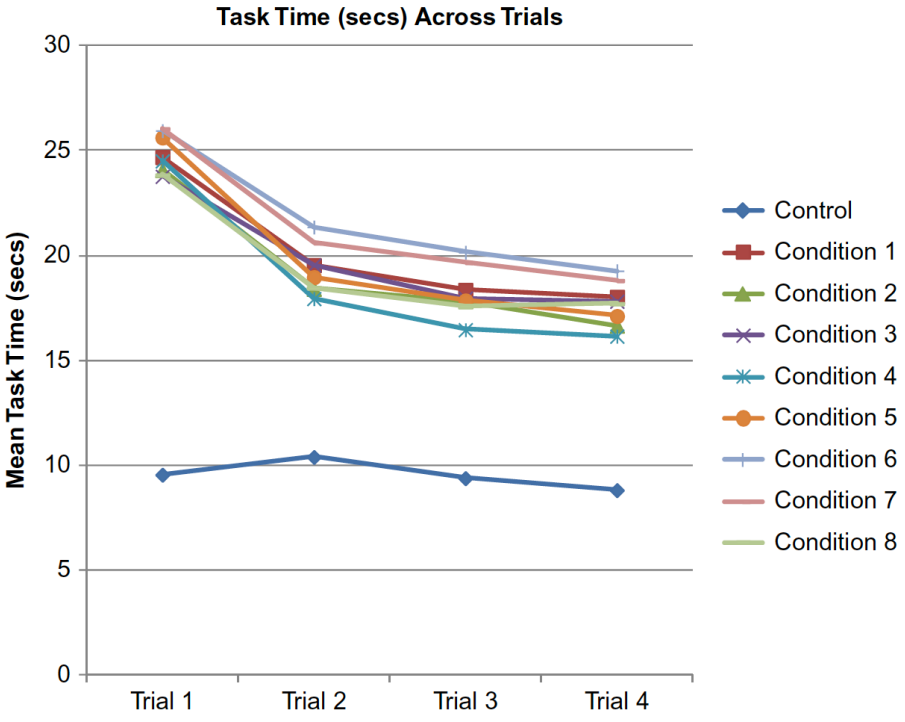

Figure 4-4-2 Looking at the learnability of different types of on-screen (Albert & Tullis, 2013, p. 95)

4.5. Case Study: Visual Simulation Application Mockup

Virtual and digital models, as previously said, have distinct and unique characteristics. When the two modalities are combined, the potentialities of each can be melted together in a blended solution (Ben-Joseph et al., 2002). In architecture and urban design, mixed reality may be used for two major purposes: I on-site augmentation and (ii) in-vitro augmentation. It is feasible, for example, to simulate and test design projects in 1:1 size on-site, resulting in a subjective perspective, or to enhance real models with digital layers. In both circumstances, two types of digital information layers (data) can be added: I personal experience; (ii) data set In the first case, data that helps to render the situation as it would be perceived in reality, such as shadows, people, textures, and so on, can be added to the model; in the second case, the augmentation can display information about the urban context, such as temperature or other weather variables, information about the number of people living in the area, and so on. While we are in the realm of experience simulation in the first scenario, we are now in the realm of conceptual simulation in the second (McKechnie, 1977).

The primary distinguishing aspect of digital models is that they are not physical. This is an obvious consideration that has numerous implications and renders physical and digital models incompatible. Renders are increasingly used to communicate design projects to the general public, but their trustworthiness is perceived to be lower than that of physical models; in fact, it is more difficult to visually weight the tridimensionality of the area, as we do with scaled models, and to identify inaccuracies. Unlike physical mockups, digital mockups do not allow for direct interaction; instead, it is mediated by an interface. Of course, immersive and lifelike interaction9 interfaces are easier to use, especially for laypeople. In fact, the use of 'go between' devices such as a mouse and keyboard can be irritating for persons who are not used to dealing with these types of equipment on a daily basis. In any event, tablets and smartphones are becoming increasingly integrated into people's activities at all ages, gradually decreasing the digital divide, which is bound to collapse in any case. Digital models

have the ability to zoom in and out, allowing the observer to quickly transition from one scale to another. Even though it is easy to lose sight of the area's scale when doing so, it allows for greater freedom in linking details and broader perspectives, which is difficult with physical mockups. As a result, the level of information that may be encoded in a digital model is potentially limitless, as is the percentage of area that can be represented. In this scenario, the limits are determined by the weight of the finished product, the performance of the machine, and, of course, the time and ability required to complete the operation. Because digital models are intangible, they may be easily exchanged and transported (Piga & Petri, 2017).

Of course, the mix of actual and virtual elements can operate with both indoor and outdoor Augmented Reality.

City Sense (AR4CUP) Application

It is based on the use of experiential simulation using Augmented Reality (AR) for predicting and pre-evaluating urban planning initiatives from the standpoint of people. The project will bring to market a novel Augmented Reality (AR) service that will allow stakeholders and residents to envisage potential urban transformations on-site and participate in an interactive co-creation process by providing comments or reviewing findings throughout the design phase.

The mobile AR solution will allow for the simple publication of 3D building models via cloud service, which can then be viewed and commented on in real time by each user from their own perspective.

More specifically, the AR4CUP project seeks to bring to market a novel SAAS (Software As A Service) product that will allow residents and decision-makers to work with architects and developers in a virtuous co-creation process by showing urban projects in Augmented Reality (AR) on-site. The app's data collecting and analysis of environmental preferences will inform the transformation throughout the design phase. The process promotes inclusion and evidence-based decision-making. According to the information provided on the labsimurb website, the importance of the project can also be understood from their funding program EU Horizon 2020 EIT Digital with a budget of €563.406 (Labsimurb budget €214.991). "Experiencing Città Studi," one of the first pilot case study applications of the AR4CUP app developed during the 2020 Eu-

ropean Project, assessed citizens' perceptions of the Città Studi neighborhood's current condition by collecting feedback from final users of Politecnico di Milano university.
Eventually, the service will enable
+ Real estate (RE) developers, architectural offices, and public administrations to communicate urban projects throughout the design phase by using 1 to 1 scale virtual models in Augmented Reality.
+ To benefit from a virtuous co-creation service that includes citizens and stakeholders (for example, by collecting user feedback, comments, activity, and so on).
+ Citizens must be informed and involved in the process, and they must respond to urban project proposals before they are built.
The AR4CUP app will prioritize the quality of representation of urban projects in their context, the establishment of fluid navigation in motion, and the establishment of optimized management of occultations in dynamic contexts (Diminished Reality). Data analysis tools for gathering user feedback and reactions to urban transformations will be integrated into the service to assist designers in improving their urban projects based on relevant metrics. The entire procedure is designed to facilitate collaboration among final users, stakeholders, and public administrators in order to create a virtuous cycle that contributes to lowering the risk of failure in the co-creation of cities' future.
Commercially The project created City Sense, a Software as a Service (SaaS) for assisting the planning and evaluation phases of urban transformations using a participatory human-centered approach. This revolutionary approach assesses the experience of existing or created places on-site via Augmented Reality and off-site via Virtual Reality by combining architecture and representation, environmental and social psychology, data mining, and artificial intelligence. Laval Virtual encourages Extended Reality (XR) solution creators all over the world by recognizing excellent Virtual Reality or Augmented Reality projects and their creators. City Sense assists organizations seeking to improve their communication and interaction with citizens. Specifically, thanks to augmented reality and a mobile app. With this application, you may reach a larger audience and provide a public consultation application focused on mobile accessibility and user experience.

Questionnaires for citizens

Questionnaires are the most important part of the app and the primary source of data for analysis. The app covered a variety of question and answer types:

+ Multiple choice questions
+ Likert scale questions
+ Checkpoints with status
+ Comments and media

which is useful for reducing incorrect data.

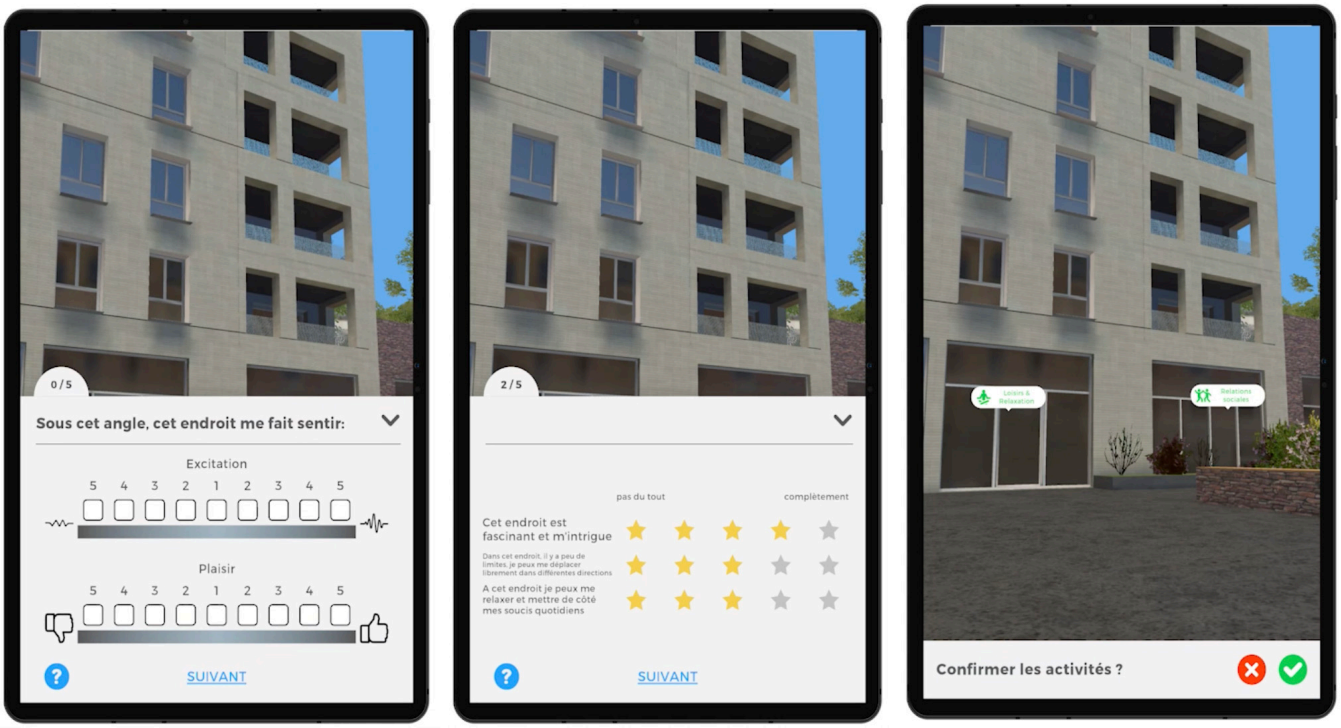

Figure 4-5-1 City Sense citizen's application

Suggestions for improvement

Users can propose and make suggestions on the types of activities that should be available in a place. In the citizen's opinion, this is a good way to find a lack of activities in a specific area.

As a citizen requested the activity, it could also be an option for business investment in a neighborhood. It means that people in the area are feeling a lack of that activity.

Figure 4-5-2 City Sense statistics

Statistics for Designers

A management dashboard with all analyzed data is available for project developers and designers. One of the most useful features for designers is the ability to view and analyze the statistics of those who participated in the consultation. This is one of the most useful features for designers who want to base their design thinking on user experience methods. There are various statistics based on human behavior and phycology research. In this way, user data could be much more useful and bring urban design closer to people and citizens.

Activity zones

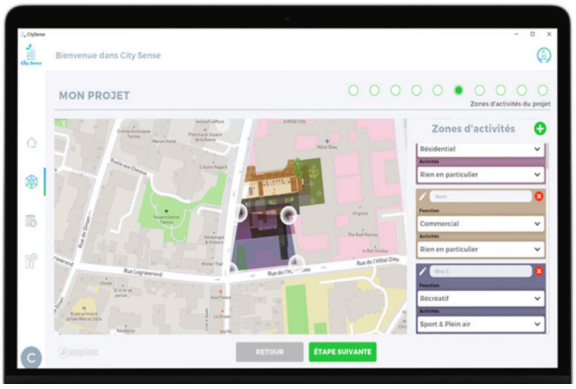

Figure 4-5-3 City Sense activity map

The two most useful data are activity zones and points of interest. These are derived from user behaviors in the citizens app, and the analyzed data may be made available to designers in the dsh-board. This allows designers to determine whether or not their project contains activity zones. Choose from a variety of activities (Shopping, Sport & Outdoor, Culture, Catering, ...). Designers can draw the location on the project and position future activities using dashbard.

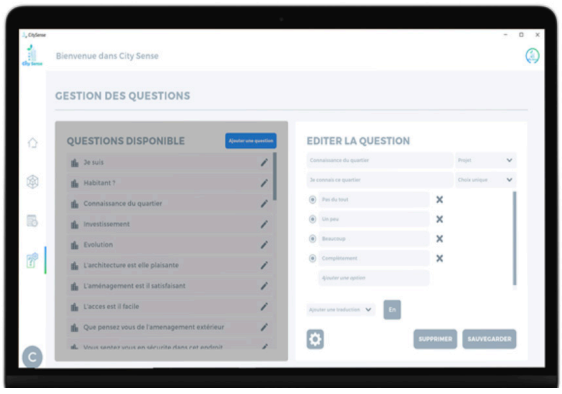

Figure 4-5-4 City Sense questionnaires

Questionnaires

By default, a list of questions is provided, but do you require more? Create your own questions from a designated area and ensure you collect the necessary information. Although this section could be improved, designers can create their own questionnaire and view the results.

City Sense Redesign

To sum up all previous accomplishments. I redesigned City Sense application which allows citizens and stakeholders to walk through the project in an AR or VR environment. As mentioned above, the app can capture user data as they participate in the project development utilizing the user experience methods and analysis literature stated thus far. In the designed project, all questions and data can be used to analyze citizen behavior. Designers can use this prototype to test their idea and enhance their work through iteration thanks to the design thinking process given. There are two groups of users: Citizens and, in general, all regular people. Promoters, or better to say, those helping citizens and designers or stakeholders to collect data and Facilitate user testing.

City Sense is a powerful tool, but it could use some improvements. First and foremost, it needs a general redesigning. To begin redesigning, I attempted to follow the design thinking flow. Begin with some research. To keep the design alive and the target groups in mind, I begin developing a business model.

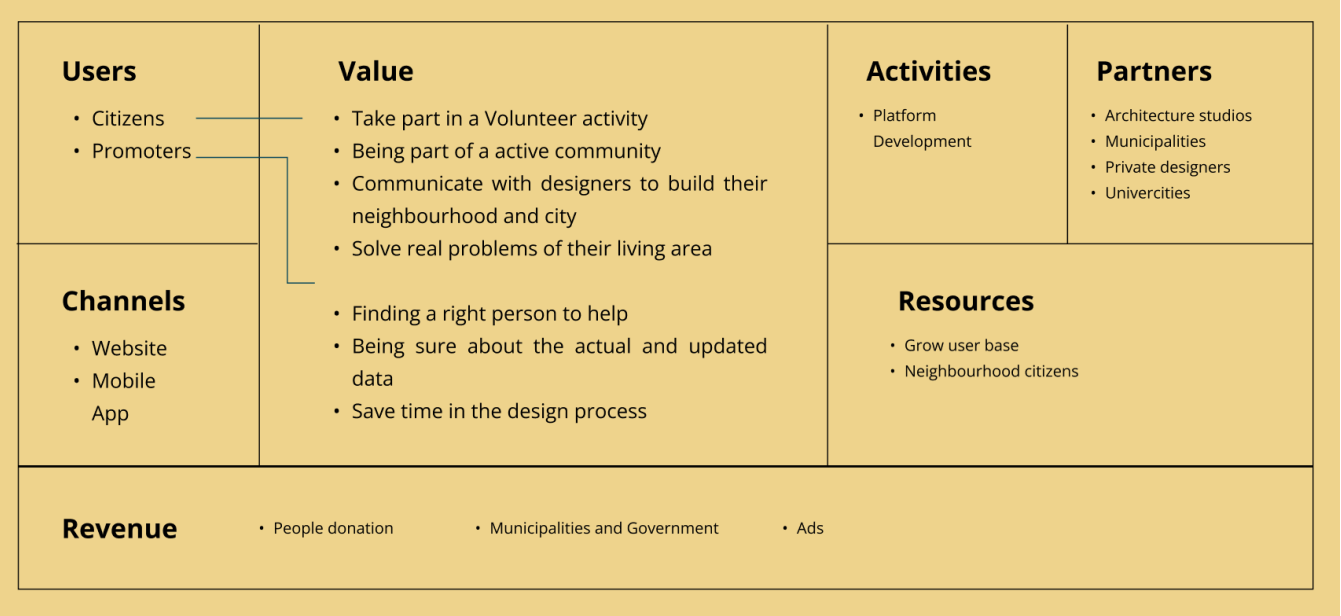

Figure 4-5-5 City Sense redesigned business model proposed by author

ALYSSA

Citizens

34 | Milan | Saleswoman

3 days free

"

I live in Milan and I live near city center. I always use public transportation to move. during the day at work I go back home several times as I work in the same area. I know the city well specially my neighbourhood. What I always thinking about is that how can I help ddesigners and planners to guide them find the right problem. I saw several buildings near me which was good but still they couldn't solve the problems.

Motivations

- Have collaboration to build her city and neighbourhood
- Share her experience with who can use them
- Feel having influence in a big project

Frustration

- Too shy to ask someone or start sharing her experience
- Don't know with who and where she can talk about it

SIA

Promoters

34 | Madrid | Designer

on weekends free

"

I am a designer. now I'm working for a project in Milan to improve public area in some neighbourhoods. It is very hard to find people who can help us about the real problems. I moved to Milan for 2 months but It's a short time to find out all neighbourhood problems. I'm looking to solve real problems and bring some solutions to give a better feeling to citizens or their living area.

Motivations

- Design public urban space project in neighbourhoods to solve problems.
- Believe in giving a better feeling and life to citizens.
- Believe in people live there are the only one who can understand real problems and help to find soloutions.

Frustration

- It is hard to collect updated local data.
- It is hard to find people who can help and wants to help.
- No idea how can involve people in the design process.

Figure 4-5-6 User personas based on two focus group by author

To place more emphasis on user values. It was suggested that a board be created for each group to identify their aims and pain points.

To citizens, volunteering, assisting in the development and resolution of problems in their area, feeling successful in society, and becoming a part of the design are all advantages that every citizen benefits. Their pain points would include not having enough time for volunteer work, being concerned about how much they could engage, and finding the proper

person to contact.

To promoters, make use of the benefits of obtaining quick and trustworthy data, minimizing the need to travel or reside in the design area for an extended period, and engaging local people to have them embrace the project more immediately.

Figure 4-5-7 User Value board by author

All user research and analysis contributed to a deeper understanding of design focus points. The concept is simple: citizens can join the platform to observe ongoing city initiatives, experience and walk through the new design using AR on their mobile phones or tablets, and participate in the concept's improvement. They also may answer a few questions and allow the app to collect specific behavioural data while they walk. The app also can ask them to do some particular tasks in the design based on different project scenarios. Designers could use these data to analyse user behaviour and improve it.

Smartphone App

The service has two interfaces based on the two groups of users. One is the application on mobile phones and tablets in the hands of citizens and all participants. They can go through the app, use a map to find the latest project, and participate in their journey and tests. As part of that process, the app collects user data through their permissions and asks a few questions to analyze the results.

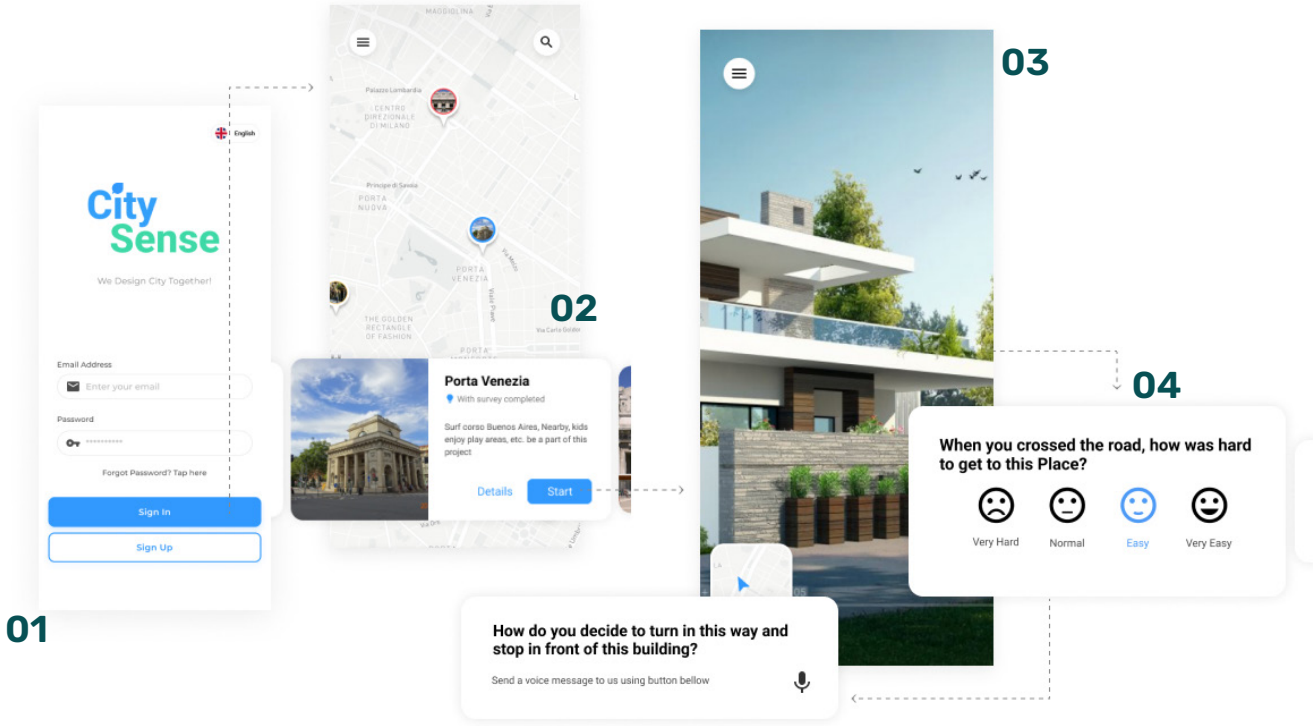

Figure 4-5-8 Redesigned City Sense application

(01) The app allows citizens to create an account. Thus, the data can be saved more efficiently. Citizens can also always stay informed about new updates to the app, as well as keep track of their visits. (02) Users can find projects around the world on the map page of the app, which serves as the app's homepage. With AR projects, however, it is imperative that you are at the same location, and with VR projects, you can be wherever you like. (03) The user begins the project and follows the instructions. By moving their phone camera, they can position themselves anywhere. (04) The app automatically asks them questions regarding the project during each specific place or view. The questions follow the current structure of user experience research questions, plus they can be answered by a voice message to open-ended questions. By doing this, citizens will be able to follow the path more easily and avoid distractions during their journey

Dashboard

The dashboard is used to show the results of tests, analyse them, create new project journeys, etc.; in a word, all management can handle in the dashboard. Designers and researchers can export data to do more analyse on them or use the default analyse results.

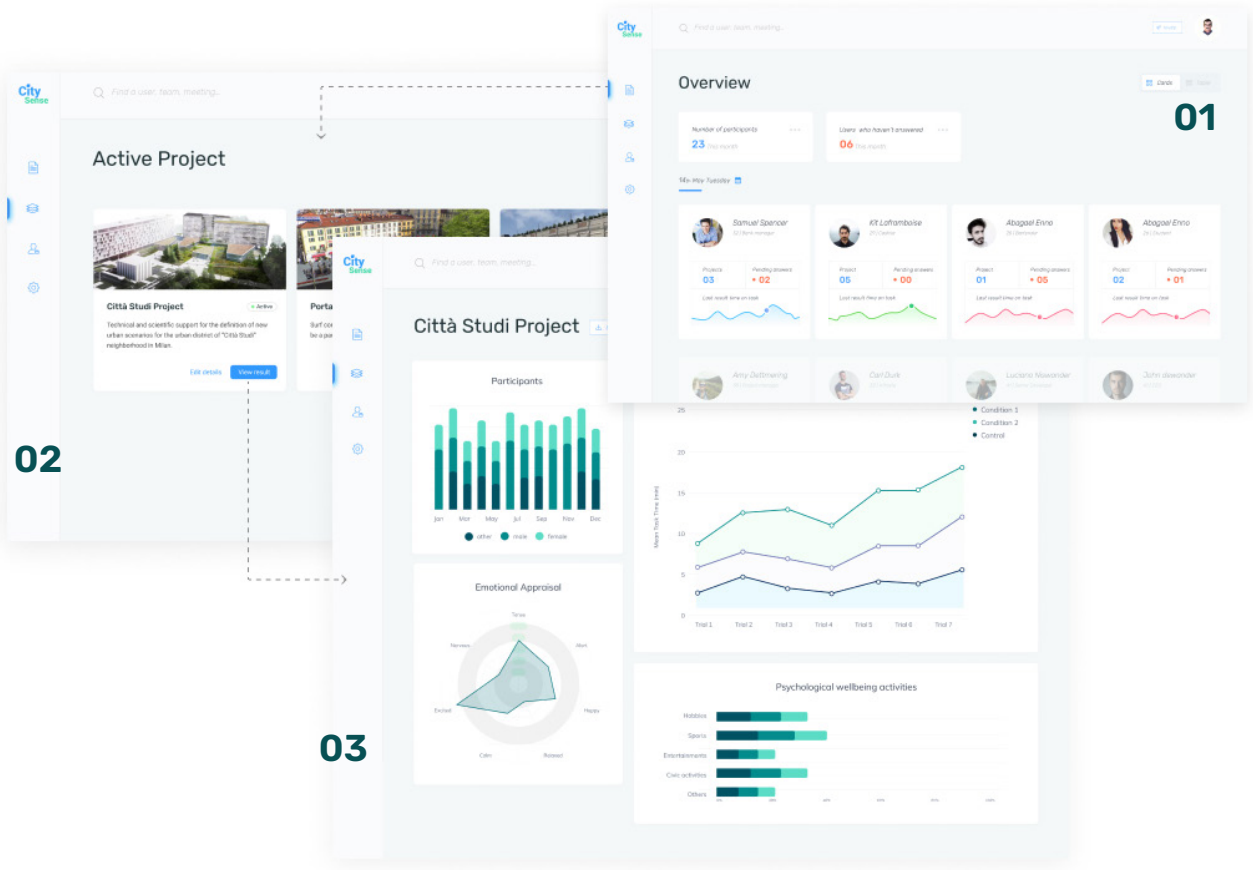

Figure 4-5-9 City Sense management dashboard redesigned

(01) Users of the Dashboard can always stay updated with the last results they've gotten on the main screen. The most important charts and users' activity as they care and want to see on their homepage.

(02) Dashboard users can always manage their active projects, add new projects, or deactivate a project when they feel they have reached their goal. (03) The main charts can be viewed in the analyse menu, where they can filter, export or compare the analyses of the user data.

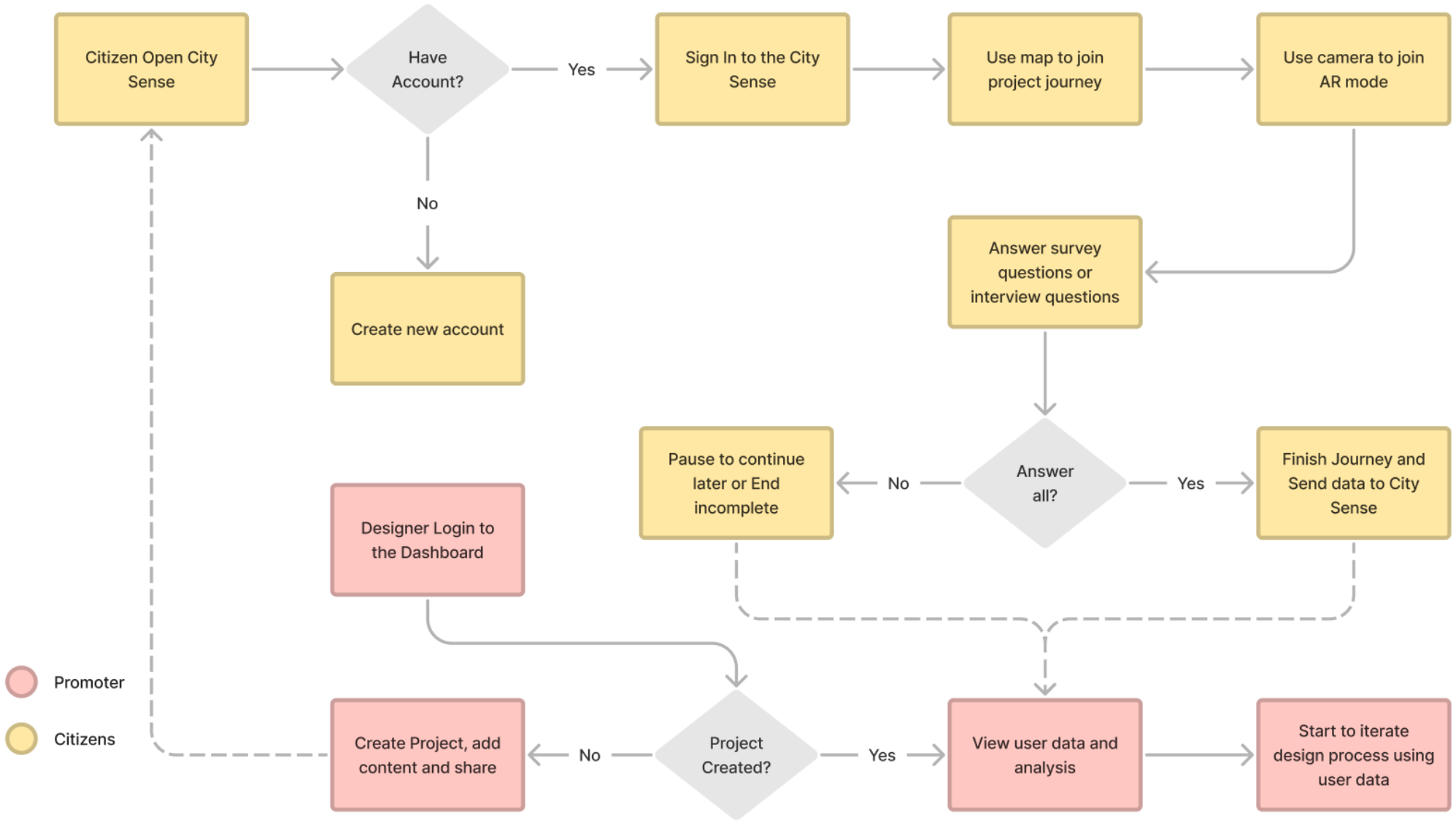

Figure 4-5-10 City Sense process flowchart

Process Flowchart

The whole user research process using the digital service proposed is straightforward (Figure 4-5-5). It starts with promoters, usually designers, creating a project on the platform and sharing it on the app. Then citizens come forward and participate in different project journeys and user tests. After that, all raw and analysed data is accessible on the dashboard for promoters and designers. Finally, designers can Start to iterate the design process using user data.

4.6. Conclusion and Future works

User Experience is a new door into the design based on human behaviour. The concept could be extended to all kinds of design no matter HCI, Architecture, etc. The only thing which matter is Involving users in the design process helps designers achieve essential characteristics of good design. Using design thinking frameworks is the key to organising the design process and care users. It was necessary to pay attention to both design frameworks to improve user experience and bring it into the urban design process. The results showed that something else was missed or paid less attention to during the urban design process. It could be found in the UX methods designers use to make decisions. Furthermore, prototyping, testing, and iterating seemed to get less attention during the urban design process.

It was also apparent that there is less attention by urban designers and architects to their design methods, which made designing learn by heart. In contrast, studios and institutes such as IDEO or Nielson-Norman Group work on UX methods and frameworks to keep them updated and team functional.

The most apparent difference between UD and UX design thinking is less attention to the Prototype phase. It is crucial in user experience since it's a gate to do user testing and find out how much you did a good job and how your design is useful to us-

ers. User experience designers use different research methods to know their users better, which seems similar to urban designers and architectures such as having an interview. But some details need attention and updating; for instance, UX designers have different methods for interviewing or writing down questions. It is crucial also for newbies to a design team who can join fast and continue based on the same interview or data collecting technique. Not everyone learns by heart.

The big entrenched of prototyping in urban design and architecture is scale. However has a rich history in it, and it is still not serious to designers. They are only satisfied with 3D models, which also back to stakeholder requests. The main answer might be real-scale modelling which is not possible in a short time and at less cost. Visual simulation using Virtual Reality or Augmented Reality is an excellent way to follow. Today reasonable price devices are also available and accessible to all. Also, there is no extra cost for modelling needed. Only a few tools could help designers convert their 3d models to VR or AR. more tools are coming. However, during modelling, user needs and tests must be before others.

Usability, also known as the most important UX element, has five inner dimensions. Knowing these dimensions and elements helps designers bring more techniques to their workflow. Usability elements could be merged easily into urban design methods. Keeping the balance between elements is the key to having a successful design. During the current study, it was tried to integrate two dimensions of usability with some selected techniques. Theoretically speaking, it also adjusted techniques and tests proposed could be run through virtual simulation.

Some questions and doubts are left, which are suitable to follow in the future. How we could bring more techniques and adjust to the urban design process. How psychologically we could assess the quality of each test. What are the new ways to involve users in our design process. Users must be the most crucial concern in our design process. It is also recommended to practically use these methods and make a directory of them as fixed urban design and architecture methods, which could be updated.

5. Bibliography

• Alben, L. (1996). Quality of experience: Defining the criteria for effective interaction design. Interactions, 3(3), 11–15. https://doi.org/10.1145/235008.235010

• Albers, M. J., & Mazur, B. (2003). Content & complexity: Information design in technical communication. Lawrence Erlbaum.

• Albert, B., & Tullis, T. (2013). Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics. Newnes.

• Bandyopadhyay, G., Maisch, B., Ge, X., & Hsu, A. (2013). User-driven Innovation for Industrial Environment in China: Opportunities and Challenges.

• Battarbee, K., & Koskinen, I. (2005). Co-experience: User experience as interaction. CoDesign, 1(1), 5–18. https://doi.org/10.1080/15710880412331289917

• Ben-Joseph, E., Ishii, H., Underkoffler, J., Piper, B., & Yeung, L. (2002). Urban Simulation and the Luminous Planning Table Bridging the Gap between the Digital and the Tangible. Journal of Planning Education and Research, 21. https://doi.org/10.1177/0739456X0102100207
• Bosselmann, P. (1984). The Berkeley Environmental Simulation Laboratory: A 12 Year Anniversary. Berkeley Planning Journal, 1(1). https://doi.org/10.5070/BP31113219
• Bosselmann, P. (1998). Representation of Places: Reality and Realism in City Design. University of California Press.
• Braha, D., & Reich, Y. (2003). Topological structures for modeling engineering design processes. Research in Engineering Design, 14, 185–199. https://doi.org/10.1007/s00163-003-0035-3
• Campbell, S., & Fainstein, S. (2003). Introduction: The structure and debates of planning theory. Readings in Planning Theory, 1–16.
• Clare, M., & McConnell, P. (2016). Designing for Cities. https://www.oreilly.com/library/view/designing-for-cities/9781492042235/
• Dumas, J. S., Dumas, J. S., & Redish, J. (1999). A Practical Guide to Usability Testing. Intellect Books.
• Faludi, A. (1986). Critical rationalism and planning methodology / A. Faludi. Pion.
• Fredericks, J., Caldwell, G. A., & Tomitsch, M. (2016). Middle-Out Design: Collaborative Community Engagement in Urban HCI. 5.
• Garrett, J. J. (2010). The Elements of User Experience: User-Centered Design for the Web and Beyond. Pearson Education.
• Hassenzahl, M., & Tractinsky, N. (2006). User experience—A research agenda. Behaviour & Information Technology, 25(2), 91–97. https://doi.org/10.1080/01449290500330331
• Hobbs, F. D., & Doling, J. F. (1981). Planning for Engineers and Surveyors. Pergamon Press.
• IDEO (Ed.). (2015). The field guide to human-centered design: Design kit (1st. ed). Design Kit.
• Ioppolo, G., Cucurachi, S., Salomone, R., Shi, L., & Yigitcanlar, T. (2019). Integrating strategic environmental assessment and material flow accounting: A novel approach for moving towards sustainable urban futures. The International Journal of Life Cycle Assessment, 24(7), 1269–1284. https://doi.

org/10.1007/s11367-018-1494-0
• Johansson-Sköldberg, U., Woodilla, J., & Çetinkaya, M. (2013). Design Thinking: Past, Present and Possible Futures. Creativity and Innovation Management, 22(2), 121–146. https://doi.org/10.1111/caim.12023
• Kavakli, M., & Gero, J. (2001). Sketching as mental imagery processing. Design Studies, 22, 347–364. https://doi.org/10.1016/S0142-694X(01)00002-3
• Ledgerwood, G. (1985). Urban innovation: The transformation of London's docklands : 1968-1984. Gower.
• Longato, D., Lucertini, G., Dalla Fontana, M., & Musco, F. (2019). Including Urban Metabolism Principles in Decision-Making: A Methodology for Planning Waste and Resource Management. Sustainability, 11(7), 2101. https://doi.org/10.3390/su11072101
• McKechnie, G. E. (1977). Simulation Techniques in Environmental Psychology. https://link.springer.com/chapter/10.1007/978-1-4684-2277-1_7
• Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1995). Augmented reality: A class of displays on the reality-virtuality continuum (H. Das, Ed.; pp. 282–292). https://doi.org/10.1117/12.197321
• Myerson, J. (2017). Scaling Down: Why Designers Need to Reverse Their Thinking. She Ji: The Journal of Design, Economics, and Innovation, 2, 288–299. https://doi.org/10.1016/j.sheji.2017.06.001
• Nguyen, T. H. (2020). Community-Centered Design in A Hybrid Culture: Designing for Human Connection and Community Building by Utilizing Local Assets, Shared Resources and Co-Benefits. https://digital.library.txstate.edu/handle/10877/13021
• Norman, D. (1988). The Design of Everyday Things. https://3lib.net/book/2374822/5226fa
• Nunnally, B., & Farkas, D. (2016). UX Research: Practical Techniques for Designing Better Products. O'Reilly Media, Inc.
• Okeil, A. (2010). Hybrid design environments: Immersive and non-immersive architectural design. Journal of Information Technology in Construction (ITcon), 15(16), 202–216. https://doi.org/10/16
• Owen, C. (2017). Design Thinking: Notes on its Nature and Use (Vol. 2).
• Piga, B. (2017). Experiential Simulation for Urban Design: From Design Thinking to Final Presentation. In Urban Design and Representation: A Multidisciplinary and Multisensory Approach (pp. 23–36). https://doi.org/10.1007/978-

3-319-51804-6_3

• Piga, B., & Morello, E. (2015). Environmental design studies on perception and simulation: An urban design approach. Ambiances. Environnement Sensible, Architecture et Espace Urbain, 1, Article 1. https://doi.org/10.4000/ambiances.647

• Piga, B., & Petri, V. (2017). Augmented Maquette for Urban Design.

• Pombo, F., & Tschimmel, K. (2005). Sapiens and demens in design thinking–perception as core.

• Portman, M. E., Natapov, A., & Fisher-Gewirtzman, D. (2015). To go where no man has gone before: Virtual reality in architecture, landscape architecture and environmental planning. Computers, Environment and Urban Systems, 54, 376–384. https://doi.org/10.1016/j.compenvurbsys.2015.05.001

• Razzouk, R., & Shute, V. (2012). What Is Design Thinking and Why Is It Important? Review of Educational Research, 82(3), 330–348. https://doi.org/10.3102/0034654312457429

• Rowe, P. G. (1991). Design Thinking. MIT Press.

• Stempfle, J., & Badke-Schaub, P. (2002). Thinking in design teams—An analysis of team communication. Design Studies, 23(5), 473–496. https://doi.org/10.1016/S0142-694X(02)00004-2

• Taylor, N. (1998). Urban Planning Theory Since 1945. https://doi.org/10.4135/9781446218648

• Thoring, K., & Müller, R. M. (2011). Understanding the creative mechanisms of design thinking: An evolutionary approach. Procedings of the Second Conference on Creativity and Innovation in Design, 137–147. https://doi.org/10.1145/2079216.2079236

• Tschimmel, K. (2012). Design Thinking as an effective Toolkit for Innovation. https://doi.org/10.13140/2.1.2570.3361

• UN-Habitat. (2007). A guide for Municipalities: Inclusive and Sustainable Urban Development Planning.

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