School of Industrial and Information Engineering

Master of Science in Management Engineering

Digital business and market innovations

Escaping reality or virtual reality?

An empirical experiment on engagement in real and virtual escape rooms

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ABSTACT

In an increasingly digitalized world, where the possibility of interfacing with virtual contexts is progressively more common, it becomes meaningful to understand the effect of the virtual on people, who until recently were mainly used to physical experiences. Therefore, the present work aims to study in-depth one of the top high technologies of the moment, whose impact on users is still uncertain, but it will surely be far from negligible: Virtual Reality (VR)

For this purpose, an analysis of the existing literature review on virtual reality has been proposed, focused on understanding its impact on users. From this analysis emerged a possible relationship between the use of virtual reality and behavioural manifestations linked to the three engagement dimensions: cognitive, emotional and physical engagement. Anyway, in the literature, we experience the lack of an extensive study on this relationship, that considers the engagements' components and how VR affects each of them. To fulfil this gap, it has been studying empirically such relationship comparing the engagement of two groups who paly escape rooms, one in reality and the other in virtual reality.

Results show that VR is able to provide the same engagement of the corresponding virtual experience, becoming an optimum substitution of reality, when it is impossible. Anyway, to require virtual reality an extra impact on users it needs to give them a new meaning. Furthermore, it has been found that the use of technology can cause high-tech anxiety, therefore individuals perceived self-efficacy plays a crucial role, becoming an enabler of the engagement. The empirical research aims at being the first milestone to investigated virtual reality, not only as technological innovation, rather as a support and as an extension of people's potential, with a human-centric vision, and looking for significant meaning.

EXECUTIVE SUMMARY

Technology has never been more influential than it is in the last years. In 2012, the top five publicly traded companies by market capitalization were three natural resource companies, one financial corporation, and just one tech company (Financial Times, 2012). Today, the top five public companies by market capitalization are Apple, Alphabet, Microsoft, Amazon, and Berkshire Hathaway, four of which are tech companies (PricewaterhouseCoopers, Global Top 100 companies by market capitalisation, 2019). In this increasingly digitalized world, where the possibility of interfacing with virtual contexts is progressively more common, it becomes worthwhile to understand the effect of the virtual on people, who until recently were mainly used to physical experiences. Therefore, the present work aims to study in-depth one of the top high technologies of the moment, whose impact on users is still uncertain, but it will surely be far from negligible: Virtual Reality (VR).

The common perception is that VR remains largely limited to the world of games and entertainment, but things are changing fast. According to IDC[1], during 2019, industrial spending on these tools is overtaking consumer spending and according to Accenture[2], by 2023, industrial usage will be triple consumer usage. Therefore, studying VR becomes meaningful also for firms. Some scholars think that virtual reality has the potential to revolutionize many sectors (Blascovich & Bailenson, 2011; Standen & Brown, 2006). In the learning field, several kinds of research have aimed at empathizing VR's opportunities, as enriching students' learning experience, making it more enjoyable, exciting and interesting (Pantelidis, 2009; Lee et al., 2017), or enhancing employees' learning outcomes making employees more active (Lau et al., 2018). In the tourism field, VR is studied as a tool to attract visitors in a potential destination, influencing their emotional state (Cho et al., 2002; Neuhofer et al., 2012; Marasco et al, 2018). Finally, remaining on the costumers' experience, Nielsen and YuMe (2016) examined the power of the immersive content experiences to engage viewers, finding that contents in VR are more emotionally engaging than traditional ones, with higher and longer peaks in costumers' attention. Despite the difference among the fields, all these studies mention as VR's potentialities behavioural manifestations (excitement, attention, activation, etc) linked to the engagement, and, more in detail, to the three engagement dimensions

[1] IDC Worldwide Semiannual Augmented and Virtual Reality Spending Guide, May 2019
[2] Accenture, A responsible future for immersive technologies, May 2019

theorized by Khan (1990). This lead to hypothesize that it exists a correlation between the use of virtual reality and engagement, nevertheless, there are no studies that deepen such relation. Therefore, the present dissertation aims to empirically study the relationship between virtual reality and the three Khan's (1990) engagement dimensions: cognitive, emotional and physical engagement. This research can give to scholars a clearer vision of how VR impact on engagement and could help in understanding how to maximize the VR's opportunities.

Literature Review

The first idea of virtual reality (VR) appeared in 1965, when Ivan Sutherland, a computer scientist, talking about the display of his time, presented his vision of the "Ultimate Display". The concept was a virtual world, viewed through a head-mounted device (HMD), which replicated reality so well that the user would not be able to differentiate from actual reality. From that moment, different points of view have been given in order to provide a specific VR description, each one emphasizing some features, rather than others, necessary to constitute an experience as VR. Table 1 summarized the key features highlighted by the authors and their definitions.

Table 1 - Virtual Reality features

Features		***Author(s)***
Immersion	The extent to which a user is isolated from the real world thanks to the computer's displays ability to deliver an inclusive, extensive, surrounding and vivid illusion of reality.	Fuchs et al., 1992; Gigante, 1993; Von Schweber and Von Schweber, 1995; Gutierrez et al., 2008
Interaction	Ability to recreate in the virtual environment a mutual influence or action among people, facts, phenomenon and substances.	Gigante, 1993; Von Schweber and Von Schweber, 1995; Burdea and Coiffet, 2003; Guttentag, 2010; Estupiñán et al., 2014
Multi-sensory	The activation and the usage of more senses in the virtual experience	Fuchs et al., 1993; Gigante, 1995; Von Schweber and Von Schweber, 1995; Guttentag, 2010; Estupiñán et al., 2014

Based on these features virtual reality could be defined ad a computer-generated 3D environment, called also virtual environment, that provides to the user a fully immersive, multisensory, interactive experience. However, this definition considers VR essentially as technology, while other approaches forward a more complex vision, considering VR as a human experience and underlining how "the essence of VR is the inclusive relationship between the participant and the virtual environment" (Mantovani, 2001). In this context, the concept of presence, which is a psychological condition of the users, has been considered a crucial one. Participants who are highly present experience the virtual environment as a more engaging reality than the surrounding physical world (Slater and Wilbur, 1997). It is possible to differentiate three types of presence (Lee, 2004):

- *Physical presence*: when individuals fail to notice the artificial nature of simulated objects or environments;
- *Social presence:* when virtual social actors are perceived as actual social actors;
- *Self-presence:* when a person experiences the virtual self as the actual self.

This tripartition is very recurrent in the literature (Bailey et al., 2012) and some authors demonstrated empirically the VR ability to induce these types of presence (Meehan et al., 2002; Nowak and Biocca, 2003; Lenggenhager et al., 2007). The degree of presence evoked by a virtual environment generates physiological responses similar to those induced by the corresponding real environment, and greater presence implies greater users' responses (Meehan et al, 2002). The VR's peculiar capability to activate and engage users, impacting on their emotions through the sense of presence, has been deepened in several fields. Starting from tourism, VR has been investigated as a powerful tool to attract visitors in a potential destination, through virtual tours (Cho et al., 2002; Neuhofer et al., 2012; Marasco et al., 2018). In detail, it has been demonstrated that virtual images emotionally engage the users and can attract enough to motivate them to visit, recommend, and find out more information about the actual site (Pantano and Corvello, 2014; Marasco et al., 2018). Furthermore, Pantano and Corvello (2014), studying cultural heritage sites, noticed that virtual tours improved the combination of entertainment and education. Virtual reality, indeed, beyond offering interactive and enjoyable environments that supported tourists in choosing destinations, easing learning and dissemination of arts and culture. This insight makes an in-depth analysis of the VR effects in the educational field interesting. Studies on the applications and effectiveness of virtual reality in education and training have begun since the 1990s when the technology wasn't ready yet, but it could already guess its potential. In those years, it was found higher students' enjoinment and motivation in VR conditions (Youngblut, 1998). The strengths in the process was that learner could participate in the learning environment with a sense of presence that increased their engagement in what they see, listen and do. This led learners to new discoveries, motivating, encouraging and exciting them (Pantelidis, 2009). Going on through the years, with the improvement of the technology, some experiments investigated deeply the VR impact on learners. The results demonstrated that participants in the VR conditions rated their enjoyment and interest to be higher (Lee et al., 2017). Furthermore, besides a higher activation level and a stronger affective involvement, there was a simultaneous rise of the emotional and cognitive engagement during the VR experiences (Vesisenaho et al.,2019). This impact on learning has caught also the firms' attention, and scholars studied VR effects on employees' training. One example is the VR application in Walmart as a sales training tool. This implementation showed that with VR training, trainees performed better at their actual jobs. The use of VR has transformed and made the training more dynamic, immersive and engaging (Upadhyay and Khandelwal, 2018). Always considering the organizational interest, it was found that VR contents are more emotionally engaging than the TV experience. Besides, VR sustained cognitive engagement longer and with higher peaks thanks to contents that encouraged exploration (Nielsen and YuMe, 2016). The latter finding resumes something that Youngblut (1998) had already argued at his time: the VR unique capability is to let enjoy a first-person experience that activates users, making them active participants. And, in the case of training, allowing the so-called experiential learning. These insights led researchers to investigate also the effects on the effectiveness of learning, up to the point of studying the impacts of VR on problem-solving. Lau and colleagues (2018), with an experiment on professional training, demonstrated that VR training not only improves the technical knowledge but also enhance problem-solving, independent learning and critical reflection. This study reinforces the opinion that virtual reality allows being actively engaged in a task through immersive, first-person experience, that enhances situated learning approaches, where users can explore new behaviour and be proactive (Lau et al., 2018; Wu et al., 2019).

In conclusion, the whole VR literature review pointed out a significant influence of the virtual reality on behavioral manifestations linked to the engagement (Youngblut, 1998; Nielsen and YuMe, 2016; Lau et al., 2018; Vesisenaho et al., 2019). Furthermore, the insight of VR ability to stimulate independent learning and problem-solving makes studying the virtual reality as problem-solving stimulator really interesting. For this reason, it will be proposed a brief literature review on the engagement, focused on Kahn's theory, as the father of the engagement's tripartition in emotional, cognitive and physical. Finally, a brief analysis of problem-solving has been proposed too.

Kahn theory of engagement

The engagement has been widely investigated in the literature since is a key variable in many fields. When engaged, individuals should be attentive, emotionally connected and fully concentrated on their performance, thereby they can get better outcomes in what they do (Kahn, 1990). The first conceptualization of the engagement was the work of Kahn (1990), who described it as a unique and important motivational concept in an organization. The core of Kahn's engagement model is the employed (or not) of the individual's preferred self in his performances. The preferred self alludes to the fact that people have dimensions of themselves that, given appropriate certain conditions, they prefer to use and express. These dimensions are three: cognitive, emotional and physical engagement.

- Cognitive engagement indicates individuals' mental dedication to what he experienced and can be recognized through attention and absorption (Harrigan et al., 2017).
- Emotional engagement is the individual's summative and enduring level of emotions (Harrigan et al., 2017). It is evidenced through enjoyment, enthusiasm and dedication.
- Physical engagement refers to an individual's energy. It can be recognized through activation and the vigour (Harrigan et al., 2017).

Table 2 summarizes for each engagement dimension its behavioural manifestations.

Table 2 - Engagement dimensions

Engagement dimensions	***Behavioural manifestations***
Cognitive engagement	Attention, absorption, concentration, immersion, focus
Emotional engagement	Enjoyment, enthusiasm, dedication
Physical engagement	Vigour, activation, effort

Problem solving

Problem-solving is defined as "a series of mental operations that are directed toward some goal" (Mayer, 1985). The first studies about the problem-solving approached it as a methodology with a step process (Polya, 1945). Nevertheless, this strategy was primarily suitable for solving simple word problems, those found in school textbooks, while problem solving concerned struggling with complex non-routine problems (English and Sriraman, 2010). Focusing on applying a problem-solving method, without understanding how and why individuals make decisions, was non-productive (Schoenfeld, 1992; English et al., 2008). Therefore, many authors have begun to study psychological factors that could influence problem-solving results. Results indicated that engagement is a strong predictor of the problem representation, and the higher is the engagement, the higher is the outcome in solving complex problems (Eseryel et al., 2014). Going more in-depth, it was found a significant positive influence of another variable on the engagement: the self-efficacy (Eseryel et al., 2014). Perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance (Bandura, 1997). The stronger the perceived self-efficacy, the higher the goal challenges people set for themselves and the firmer is their effort to them (Bandura, 1997). Indeed, it has been found that perceived ability provided the best prediction of achievement and engagement (Miller et al., 1996). An increase of self-efficacy leads to the raised of engagement and thereby to a higher effort in solving the problem, a more persistent in pursuing tasks and, finally, to better outcomes (Pajares and Graham, 1999; Nicolaidou and Philippou, 2003; Eseryel et al., 2014).

RESEARCH FRAMEWORK

The analysis of the literature gave newsworthy insights to study deeper the potential of virtual reality in influencing the engagement. It has been found that VR may induce in the users the sense of being in the virtual environment, called "sense of presence". The sense of presence allows feeling in the synthetic experience the same reactions that the individual would have in a real situation. Consequentially to be immersed in the environment leads the users to be engaged in what they do virtually (Meehan et al., 2002). These studies were deepened confirming VR ability to affect individuals' engagement (Nielsen and YuMe, 2016; Vesisenaho et al., 2019). Going more in-depth, it has been found that HMDs are able to immerse users in virtual environments, capturing users' attention in a way that causes them to dive inside the simulated world, causing deeper cognitive processing (Hanson & Shelton, 2008; Narraro-Haro et al., 2016; Lee et al., 2017). The other great potential of the sense of presence is that the virtual representations may impact users' emotions (Meehan et al, 2002). Virtual images can raise enjoyment, excitement, pleasure and interest, attributes linked to the Khan's conceptualization of emotional engagement. Finally, the capability of allowing a first-person experience enhances situated learning approaches, where users can explore new behavior and be proactive. This approach leads to an increment of the users' activation and commitment (Youngblut, 1998; Lau et al., 2018). All these considerations lead to building three research hypotheses:

H1. *Virtual reality is able to enhance cognitive engagement*
H2. *Virtual reality is able to enhance emotional engagement*
H3. *Virtual reality is able to enhance physical engagement*

Researches on complex problem solving revealed that engagement is the strongest predictor of problem-solving. Individual more involved, indeed, raise significantly their effort, up to achieve better outcomes (Eseryel et al., 2014; Lein et al., 2016). Likewise, subjects immerse in a first-person virtual experience has been demonstrated that enhances their problem-solving abilities (Lau et al., 2018). The use of virtual reality, indeed, provides new possibilities for the development of problem-solving abilities, making the contents more interesting and interactive, improving motivation and attention, and encouraging to discover and explore their knowledge (Wu et al., 2019). Therefore, it is reasonable to assume that also in VR exist a positive relationship between problem-solving and VR. Overall:

H4. *In virtual environments, cognitive engagement is positively associated with problem solving*
H5. *In virtual environments, emotional engagement is positively associated with problem solving*
H6. *In virtual environments, physical engagement is positively associated with problem solving*

Finally, in studying complex problem-solving contexts, it can't be left out the perceived self-efficacy, considered a substantial influencer of effort in solving problems (Miller et al., 1996; Eseryel et al., 2014). The stronger is the perceived self-efficacy, the higher are the goal challenges that people set for themselves and the firmer is their commitment to them (Bandura, 1997). An increase of self-efficacy leads to higher engagement and effort in solving the problem, that often results in better outcomes (Pajares and Graham, 1999; Nicolaidou and Philippou, 2003; Eseryel et al., 2014). Thereby it comes interesting to understand whether this relation exists also in VR. Overall:

H7. *In virtual environments, self-efficacy is positively associated with cognitive engagement*

H8. *In virtual environments, self-efficacy is positively associated with emotional engagement*

H9. *In virtual environments, self-efficacy is positively associated with physical engagement*

The hypotheses formulated can be summarized in the research models exhibit in Figure 1 and Figure 2.

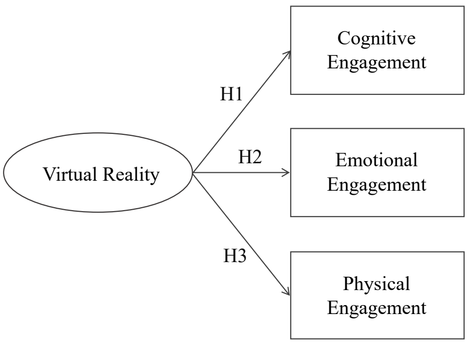

Figure 1 - Research Model 1

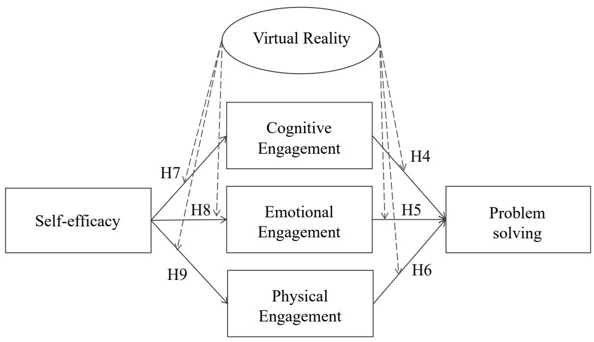

Figure 2 - Research Model 2

Research design

The first step to solve, in order to test empirically the hypotheses, was to find an appropriate experience. The best filed found has been one of the escape rooms. For their game mechanisms, indeed, escape rooms were defined as situated problem-solving environments, in which players are immersed in a culture and way of thinking and have to challenge their problem-solving abilities (Dede, 2009; Gee, 2007). Furthermore, the last years were developed virtual escape rooms, that have the same logic of the real ones but are played in a virtual world. Finally, they are spread enough to have locations in which players can go and play, allowing the collection of a good sample of data.

The escape room players, both of the virtual and of real one, have been invited to complete an online questionnaire after the game experience. Participants were not randomly assigned to the treatment conditions, but unconsciously self-selected on the basis of the escape room they went to play, classifying this research as a quasi-experiment (Podsakoff and Podsakoff, 2019). The survey was accessible through a QR and administered through www.Qualtrics.com platform. The QR code was provided by the gamemasters in the real escape rooms; while in the virtual one, due to the small numbers of people attending this kind of escape, it was provided by me, to increase as much as possible the response rate. The survey administration lasts just over 2 months in order to reach an acceptable number of answers. The questionnaire was divided into five main sections of questions:

- control variables: general information to have some insights on the population;
- escape room data: information about the resolution of the game (resolution time, clues required, numbers of players) to operationalize problem solving;
- self-efficacy questionnaire: a self-reported questionnaire based on a five-point Likert scale;
- engagement questionnaire: a self-reported questionnaire based on a five-point Likert scale.

To measure the self-efficacy, it was studied the guidelines given by Bandura (2006) in *"Guide for constructing self-efficacy scales"* and it was chosen a scale that better followed that indications. The scale was developed by Miller and colleagues (1993) to evaluate students' perceived ability in mathematics and subsequently used in many other studies. Of course, the scale has been slightly modified to best fit with the context. Likewise, for the engagement, it has been chosen the scale that best fitted with Khan's (1990) conceptualization of the engagement, Rich and colleagues' (2010) scales. The items of this scale, indeed, were built by studying the engagement measures present in the literature at their time and reviewing them to fit better Khan's conceptualization. However, in order to be applied to the present study, the scale has been slightly modified to best fit with the context. The scale is composed of eighteen items, six for each engagement dimension.

Data analysis

Data has been entirely analyzed with SPSS Statistics. The first step was to lead the factor analysis to reduce the items measured for self-efficacy and engagement into fewer latent variables (Yong and Pearce, 2013). In order to ensure that variables in each proposed construct were internally consistent, reliability assessment was carried out using Composite Reliability, Chronbach's Alpha and Average Variance Explained.

To the first three hypotheses a t-test has been performed, in order to verify whether existed a significant difference in mean per each of the three dimensions between the two groups of players. This test required continuous, normally distributed variable. Anyway, it is relatively robust to moderate violations of the normality assumption even with samples of 40 observations (Barrett & Goldsmith, 1976; Sullivan & d'Agostino,1992; Sawilowsky & Hillman, 1993; Lumleye et al., 2002).

To test whether players experienced different levels of engagement on the basis of their problem solving it was used a one-way Analysis of Variance (ANOVA). In detail, it was defined three categories of resolution time (less than 50' = high problem solving; 51'-60'= medium problem solving; room not completed = low problem solving) and three categories of hints required (0-1 high problem solving; 2-3 medium problem solving; 4 or more low problem solving). The ANOVA has been used for examining the differences in the mean values of the engagement among these groups. As for the t-test, the ANOVA has been chosen for its robustness in the presence of deviations from normality (Blanca et al., 2017).

Finally, the correlation between self-efficacy and each engagement dimension was analysed using the Pearson correlation test. As the other methods, also the Pearson correlation was chosen for its robustness even when the sample size is very small, till a minimum of 5 observations (David, 1938; Bishara and Hittner, 2012).

Empirical results

Overall, 163 observations have been obtained, 75 in the virtual escape room and 85 in the traditional one.

The results of the factor analysis loadings, Cronbach's alphas, Composite Reliability and Average Variance Extracted demonstrated all high construct reliability, as it could be expected given the high validity of the scales chosen.

Afterwards, the t-test was performed, and all the engagement dimensions presented a p-value higher than 0.05, therefore it was not possible to reject the null hypothesis of the equal mean. This result implies that the two groups of players experienced the same level engagement, in all its different aspects. Therefore, the three hypotheses of Model 1 (H1, H2, H3) has been rejected.

Continuing with the analysis, it was performed an ANOVA on the whole population, regardless of the game experience, to study the relationship between engagement and problem-solving. The main findings regard physical engagement, which resulted in a positive correlation with the resolution time in the whole population. Repeating the same analysis in the two populations (virtual and real players) no significant correlations were found. Anyway, the engagement trend was exactly the same for both players, meaning that the two sample sizes were likely not large enough to demonstrate a correlation, but having the same pattern the sum of data gives a positive correlation. Anyway, there was not enough evidence to accept H4, H5, H6.

Finally, Pearson' results demonstrated a significant positive correlation between self-efficacy and cognitive engagement ($r=0.260$, H7) and between self-efficacy and emotional engagement ($r=0.475$, H8) only in the players of the virtual escape room, while in the traditional game no significant correlations were found. Therefore, H7 and H8 was accepted, while H9 has been rejected.

Discussion

On the contrary of what could expect from VR literature, all the three hypotheses regarding the enhancement of engagement in virtual conditions have been rejected. Nevertheless, in the experiment, the difference between the two groups was just the introduction of the technology, while the experience lived, and logics of the escape rooms were exactly the same. In other words, the "meaning" of the experience did not change between the two groups, but it changed just the technology. Virtual reality, used in this way, becomes what is commonly known as "Technology-push innovation" (Verganti, 2011). Otherwise, the experiments that demonstrated a rise of some behavioral manifestations of the engagement, compared VR with flat-screen formats. Thereby, VR changed not only how the content was delivered, but also its meaning, passing from something to see to something to live (Lee et al., 2017; Lau et al., 2019). In those cases, VR was used as a "technology epiphany", that is the overlapping between technology push and design-driven innovation, that is an innovation of meaning (Verganti, 2011). Nevertheless, this experiment brings to another noteworthy conclusion: the simulation of real experience in virtual reality engages the users as much as live the corresponding real experience. Therefore, for the same meaning, virtual reality is not enough to increase the participants' engagement, but still manages to engage users in the same way, acting as a valid reality simulator.

Another important result of the experiment regards the role of physical engagement in the relationship with problem-solving (H6). Physical engagement, indeed, is the only engagement dimension that not change its trend between the virtual and the real experience and is positively correlated with the resolution time. This demonstrated that among the three dimensions of engagement, physical engagemnt is the best predictor of performance also in virtual reality (Lauring and Selmer, 2018). Physically engaged individuals have been argued to be energetic and able to persist when difficulties arise, these characteristics made them able to perform well despite the novelty of context (Schaufeli et al., 2002; Bakker et al., 2004; Bakker and Demerouti, 2008; Christian et al., 2011; Britt et al., 2012; Lauring and Selmer, 2018). Likewise, in the experiment, physically engaged individuals solve the room faster than others, both in real and in the virtual environment, without differences due to the format utilized.

Finally, the last important conclusions concern the role of self-efficacy, which only in VR is positively correlated with cognitive engagement (H7) and emotional engagement (H8). This result can be linked to a similar discovery on users' response to computers, and more recently to virtual online training, where searchers noted that some workers experienced a sort of "high tech anxiety", that is the difficulty of dealing with the constant effect and change of technological advances (Frank & Rickard, 1988; Hemby, 1998; Goldberg, 1998). This "high tech anxiety" was found out being negatively correlated to the computer self-efficacy and the level of engagement (Bandura, 1995; Muira, 1987; Durndell, & Haag, 2002). Therefore, it is plausible to assume that exists "high tech anxiety" also in virtual environments. Such anxiety becomes an obstacle to the engagement, therefore only who has a high self-efficacy can also experience high cognitive and emotional engagement. Physical engagement falls outside this reasoning, since, as previously affirmed, are the ones who better respond to new situations or difficulties.

Conclusions

Confirming virtual reality as an optimum reality simulator, beyond contributing to the VR's knowledge, affirming that virtual environment generates physiological responses and engagement similar to those induced by the corresponding real environment (Meehan et al, 2002), may give noteworthy insights also to firms. In detail, the advice that can be given to managers is twofold: use VR as reality substitution only if the real corresponding experience is impossible; otherwise, it is not possible to require virtual reality an extra impact on users, it needs to give them a new meaning to engaging them deeper in the virtual experience. In addition, the discovery of the "high tech anxiety", beside validated this theory on virtual reality, and likely, on technological innovations in general, may suggest to managers how introducing VR with employees. An important first is making people confident with this technology, trying to increase their perceived self-efficacy. In this process, a good choice could be starting from pilot projects with individuals who usually are physically engaged in their work, because, are the ones who spend more effort despite the novelty of the contexts and who can achieve betterer results.

Of course, this research is not beyond limitations. First of all, the small sample size and the choice of a quasi-experiment, which led to pre-existing differences between the groups. For this reason, future research may enhance the generalizability of results by investigating a wider population, both in terms of size and heterogeneity. Furthermore, it might be interesting to compare engagement results in a virtual experience of two groups: one group with training back to make the people self-confident with VR, the other without the training, to investigate deeply the roles of high-tech anxiety and self-efficacy.

Finally, the best wish that this research would like to do is that virtual reality will be studied in the future, not only as technological innovation, rather as a support and as an extension of people's potential, with a human-centric vision, and looking for significant meanings.

1 | INTRODUCTION

Technology has never been more influential than it is in the last years. In 2012, the top five publicly traded companies by market capitalization were three natural resource companies (ExxonMobil, PetroChina, and Shell), one financial corporation (Industrial and Commercial Bank of China), and just one tech company (Apple) (Financial Times, 2012). Today, the top five public companies by market capitalization are Apple, Alphabet, Microsoft, Amazon, and Berkshire Hathaway, four of which are tech companies and just one multi-industry company (Berkshire Hathaway) (Pricewaterhouse-Coopers, Global Top 100 companies by market capitalisation, 2019). In this increasingly digitalized world, where the possibility of interfacing with virtual contexts is progressively more common, it becomes worthwhile to understand the effect of the virtual on people, who until recently were mainly used to physical experiences. Therefore, the present work aims to study in-depth one of the top high technologies of the moment, whose impact on users is still uncertain, but it will surely be far from negligible: Virtual Reality (VR).

The choice of virtual reality arises from the fact that today VR is among those high technologies that are still looked at with suspicion, between those who think that it could transform our future and those who believe will be just a flop. The common perception is that VR and AR remain largely limited to the world of games and entertainment, but things are changing fast. According to IDC[3], during 2019, industrial spending on these tools is overtaking consumer spending. The acceleration is such that according to Accenture[4], by 2023, industrial usage will be triple consumer usage. Anyway, before going into detail, it needs to take a step back and ask: what is what virtual reality? It is important to introduce briefly VR since more and more often we heard about VR, AR, MR, or going at some events we are immersed in a virtual video trough a head-mounted device (HDM) and it is common to categorize wrongly all of this as virtual reality. Virtual is a simulated experience accessible through headsets and this is the first difference from AR and XR. Augmented Reality (AR), indeed, is an experience in a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information. A common example of AR is Pokémon Go. Mixed reality (MR) is the merging of real and virtual worlds to produce new environments and

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[3] IDC Worldwide Semiannual Augmented and Virtual Reality Spending Guide, May 2019
[4] Accenture, A responsible future for immersive technologies, May 2019

visualizations, where physical and digital objects co-exist and interact in real-time. Mixed reality does not exclusively take place in either the physical or virtual world but is a hybrid of reality and it is accessible through particular HDMs. MR give, for instance, the possibility to manage a virtual prototype, with colleagues, in the real world. Figure 3, 4 and 5 show the three different technologies.

Figure 3 - Virtual Reality

Figure 4 - Augmented Reality

Figure 5 - Mixed Reality

Finally, the last and maybe most misleading difference is the between VR and 360-degree video, also known as immersive video. Both are simulated experience, but the first is an interactive experience, while the latter is a passive view of virtual places, in every direction (360-degree).

Once briefly clarified what virtual reality is, it is possible going on and investigate why VR should be interesting for organizations, therefore why industrial spending is quickly increasing. Some scholars think that virtual reality has the potential to revolutionize not only the fields of entertainment and gaming but many other sectors, such as the education (Standen and Brown, 2006; Blascovich and Bailenson, 2011). In the education, and more in general in the learning field, several kinds of research have aimed at empathizing VR's opportunities, as enriching students' learning experience, making it more enjoyable, exciting and interesting (Pantelidis, 2009; Lee et al., 2017), or enhancing employees' learning outcomes, thanks to situated learning approaches, that evoke employees to explore new learning behaviours, being more active (Lau et al., 2018). Another filed interested in VR is the tourism, where VR is studied as a powerful tool to attract visitors in a potential destination through virtual tours, influencing their emotional state (Cho et al., 2002; Neuhofer et al., 2012; Marasco et al, 2018). Remaining on the costumers' experience, Nielsen and YuMe (2016) examined the power of the immersive contents experiences to engage viewers and found that contents in VR are more emotionally engaging than traditional ones, with higher and longer peaks in costumers' attention. Last but not least, researches could be found also in the medical field, where VR is studying as a tool for allowing participants to practise behaviours in role-play situations, treating anxiety, stress or social disorders (Parsons and Mitchell, 2002). Despite the difference among the fields, all these studies mention, as VR’s potentialities, behavioural manifestations (excitement, attention, activation, etc) linked to the engagement, and, more in detail, to the three engagement dimensions theorized by Khan (1990). This lead to hypothesize that it exists a correlation between the use of virtual reality and engagement. Nevertheless, even if many studies emphasize the relation between VR and engagement's behavioural manifestations, there are not studies that deepen such relation. For this reason, the present dissertation aims to empirically study the relationship between virtual reality and the three Khan’s (1990) engagement dimensions: cognitive, emotional and physical engagement. This research can give to scholars a clearer vision of how VR impact on engagement, and in detail, whether some engagement aspect is more influenced by VR. This vision could help in understanding the VR effect on users and how to maximize the VR’s opportunities: when and why using it. Therefore, it becomes interesting also for managers that could take this study as insight to understand how maximized VR business opportunities. In particular, the relationship between engagement and virtual reality could be interesting for managers for a double perspective: for the external and internal customers. Indeed, if VR would enhance engagement it could study several applications in the firms, both for increasing the employees’ engagement in some organizational processes and to engage customers in the brand.

To sum up, the virtual reality application is starting to grow fast, its future is still uncertain, but far from negligible. Several studies, in different fields, have trying to assess which are the opportunities behind this technology and taking all these studies together it emerges a possible relationship between virtual reality and engagement. Therefore, the present dissertation aims to conduct an in-depth analysis of the already existing literature, investigate empirically the gap found, that is the relationship between virtual reality and engagement and, finally, conclude with theoretical and managerial contributions, in the hope to bring interesting insights to future researches or business developments.

2 | LITERATURE REVIEW

The following literature review focuses on defining what is virtual reality and which are its effects on users. To accomplish the goal, the literature has been studied in order, eventually, find a gap worthy of investigating. Therefore, papers from different authors and years have been studied, alongside books, thesis and online newspapers. Different fields have been considered, too, nevertheless, education has been the most investigated since there is more significant evidence regarding the VR impact on individuals.

The papers were first searched through Scopus, leveraging the keyword "virtual reality" in the title and/or in the abstract. Then, an in-depth analysis of the abstract was led in order to select papers that highlighted some VR impact on users.

The most significant evidence was the VR impact on engagement since many studies empathized a VR enhancement of behavioural manifestations linked to Khan's (1990) theory of engagement. Hence it has been searched through Scopus, Google Scholar and the references of the literature already studied, further papers to have further insights on this peculiar empirical field.

During the review, it has been found also papers that highlighted the VR capability of activating users, enhancing the situated learning approach and increasing their problem-solving skills. Therefore, the possible relationship between VR and problem solving was deepened too. Subsequently, to have a deeper view of the topic and a deeper understanding of such relationships, the literature focuses on defining engagement and problem-solving has been investigated.

The chapter is divided into two main sections: one dedicated to virtual reality and the other to the engagement and problem solving.

The first section starts with an introduction to the concept of virtual reality, exploring the main definitions and the features that characterize an experience as VR, identified by authors throughout the years. The sense of presence in virtual environments is then deepened as the key psychological feature of virtual reality. In detail, its ability to affect users' emotions has been explored, a peculiarity for which it is considered a KPI of virtual experiences. Going more in-depth into the analysis, the VR literature review is proposed in order to analyse its impact on users and investigate the possible relationship between virtual experience and engagement.

According to the researchers, virtual reality resulted significantly in influencing the involvement, in particular through attributes due to Kahn tripartition of engagement,

thereby the second section proposes a brief literature review on the Kahn theory of engagement.
Furthermore, it also emerges that a virtual experience can enhance problem-solving skills, thereby it has been proposed a brief problem-solving analysis too. Going more in-depth, the problem solving's analysis was addressed to investigate the main variables impacting on it, with the final aim to understand which could be the correlation that enhances problem-solving in a virtual experience.

2.1 | Virtual reality

2.1.1 Definitions

The first idea of virtual reality (VR) appeared in 1965, when Ivan Sutherland, a computer scientist, talking about the display of his time, presented his vision of the "Ultimate Display".
The concept was a virtual world, viewed through a head-mounted device (HMD), which replicated reality so well that the user would not be able to differentiate from actual reality.

> *"The ultimate display would be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked." (Sutherland, 1965)*

His vision was followed three years later by the creation of the first virtual reality HMD (Figure 6), always work of Sutherland, together with his student Bob Sproull. The device, named The Sword of Damocles, was quite primitive as it could only show simple virtual wire-frame shapes.
Sutherland's definition and invention are considered the starting point of the studies on virtual reality.

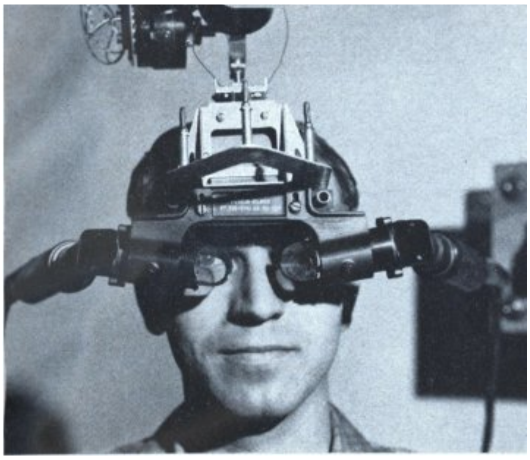

Figure 6 - The Sword of Damocles by Ivan Sutherland

In the literature, there is not a unique definition of Virtual Reality (Mazuryk and Gervautz, 1999). During the years, different points of view have been given in order to provide a specific description, each one emphasizing some features, rather than others, necessary to constitute an experience as VR. Many terminologies have been used too. The most popular are Virtual Reality (VR) and Virtual Environment (VE), the less common, Synthetic Experience, Virtual Worlds, Artificial Worlds or Artificial Reality (Mazuryk and Gervautz, 1999).
To better understand the different terms and characteristics highlighted in the years, a brief analysis of the main authors' proposed definitions in the virtual reality literature is following.
Fuchs and colleagues (1992) defined virtual environment as:

"Real-time interactive graphics with three-dimensional models, when combined with a display technology that gives the user immersion in the model world and direct manipulation".

In this paper, care was taken in the choice of the term VE, considered the most accurate, since includes the words *virtual*, meaning "*being in effect but not in actual fact*", and *environment*, indicating *"the conditions, the circumstances and the influences surrounding and affecting an organism"*.
The basis for the Virtual Reality idea is that a computer may synthesize a three-dimensional (3D) graphical environment from numerical data. Using visual and auditory output devices, the user can experience the environment as if it were part of the world.

The computer-generated world may be either a model of a real-world object, an abstract world that doesn't exist in a real sense but is understood by humans, such as a chemical molecule, or it might be in a completely imaginary science-fiction world. This is the technological base definition, shared by all the authors, whereupon everyone highlighted some features that, in their opinion, are crucial for a virtual experience.
According to Fuchs and colleagues (1992), the key features that differentiate the VR from the other experiences are two: the immersion and the manipulation.
Immersion refers to the extent to which a user is isolated from the real world. It is a description of the technology and describes the level to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a user, where:

- Inclusive indicates the extent to which physical reality is shut out.
- Extensive refers to the range of sensory modalities accommodated.
- Surrounding implies the extent to which this virtual reality is panoramic rather than limited to a narrow field.
- Vivid indicates the resolution, fidelity, and variety of energy simulated within a particular modality, as the visual and colour resolution
(Slater and Wilbur, 1997).

Manipulation denotes the possibility to touch and change the conditions of the virtual environment elements. This concept has been deepened in the definition provided by **Gigante (1993)**:

> *"VR is an interactive, participatory environment that could sustain many remote users sharing a virtual place. VR is characterized by the illusion of participation in a synthetic environment than external observation of such an environment. (...) VR is an immersive, multisensory experience. It is also referred to as virtual environments, virtual worlds, or microworlds."*

Here the focus has been widened, considering both the concepts seen in the previous definition, although described differently and including some other features.

The illusion of being in a synthetic environment could be considered comparable to the previous notion of immersion, even if with a slightly different meaning. Immersion, in fact, refers to a deeper involvement compared to an illusion, that that is more a characteristic of the immersion given by a good immersion.
The interactive environment, instead, takes up and enlarge the concept of manipulation, since involves a mutual influence or action among people, facts, phenomenon and substances. Nevertheless, this concept for Fuchs and colleagues (1992) was in some way implicit in the choice of the term environment.
The elements that have been completely introduced in this definition are the participation and the multisensory experience.
The first regards chance of share the virtual space with other people and be able to interact with them in this environment, as in the real one.
The second refers to the activation and the usage of more senses in the virtual experience, expanding even then the idea of manipulation, that includes just the sense of touch.
The tactile interface, linked to the interactivity and the multisensory experience, has been taken and extended by **Von Schweber and Von Schweber (1995)**:

"Virtual reality lets you navigate and view a world of three dimensions in real time, with six degrees of freedom (6DOF): the freedom to move and look forward and backward, left and right, or up and down. In real life, exist in three dimensions, you experience real time, and you have the ability to interact with the world around you. (...). The key here is interactivity, not gadgetry. Virtual reality is defined by this minimum level of interactivity, and it isn't surprising that interactivity is the key. A physicist will tell you that interaction is the fundamental unit of physical reality."

Particular emphasis has been placed on two elements.
The presence of all the three dimensions of real-life even in the virtual world is the first.
The peculiarity of this feature is that experiencing all the dimensions in real-time with the normal freedom of movement of everyday life, makes the virtual world fully comparable to the real one, not only for the setting but also for the feelings.

This concept, together with the presence of the verb *navigate*, that recalls the idea of immersion, and the introduction of the six degrees of freedom, that remind the surrounding illusion of reality, one of the features of the immersion, classifies the virtual reality as an experience that allows being immersed in a virtual world, comparable for all the dimensions experienced to the real one.
The second element that has been stressed is the interactivity, seen as the key to define the experience of VR. This notion has inside also the previous definition of the multisensory experienced. For the authors, indeed, being able to touch, feel, and manipulate objects in the surroundings, in addition to seeing (and/or hearing) them, gives a sense of compelling immersion in the environment that is otherwise not possible. The real VR difference from the other technologies is the tactile interactivity, that is something peculiar just of virtual and actual reality. It has been argued that is quite likely that much greater immersion can be achieved by the synchronous operation of even a simple haptic interface with a visual display, than by large improvements in the fidelity of the visual display alone (Von Schweber and Von Schweber 1995).

The interactivity is the key even for **Burdea and Coiffet (2003)**, nevertheless, the interaction alone is not enough to classify an experience as VR and a further definition has been exposed:

> *"What is virtual reality? It is a simulation in which computer graphics is used to create a realistic looking world. Moreover, the synthetic world is not static, but respond to user's inputs. This defines a key feature of virtual reality, which is real time interactivity."*

Even in this paper, care has been posed on the ability of VR to recreate a realistic world, anyway the features, that make the virtual environment comparable to the real one, have not been specified.
The uniqueness underlined by Burdea and Coiffet (2003), is that virtual reality is not simply interactive, but it is real-time interactive, where real-time means that the computer is able to detect a user's input and modify the virtual world instantaneously.
Another important variable had been presented by **Gutierrez and colleagues (2008)**:

"VR creates in the user the illusion of being in an environment that can be perceived as believable place with enough interactivity to perform specific tasks in an efficient and comfortable way. There are two main factors that describe the VR experience from the physical and psychological points of view: immersion and presence."

The focal points in the definition are two: the immersion and the presence.
The immersion, although has been widely discussed in the previous definitions, requires a further analysis led by this paper. Gutierrez and colleagues (2008) classified immersion in:

- *Fully immersive system*: where the user is completely encompassed by the VE and has no interaction with the real world. These systems use HMDs;
- *Semi-immersive* or *non-immersive system*: where the user retains some contact with the real world. These systems use large projection screens (semi-immersive) or desktop (non-immersive).

The classification depends on how much the user can perceive (see, hear, touch) the real world during the simulation. In their analysis, the virtual environment provides substitution of the real one by enabling the user to lock out physical world stimuli and fully immerse himself in the virtual world. The same concept was present in the attribute "inclusive" given by Slater and Wilbur (1997).
'Semi-immersive' or 'non-immersive system' are, instead, technologies as videogames or augmented reality, that although engaging are not able to exclude the perception of the real environment.
The sense of presence, instead, refers to the of consciousness, the sense of being in the virtual environment. It is considered a subjective concept, associated with the psychology of the user. Presence is activated when the user is aware of being in a virtual environment and nevertheless his behaviour is similar to the one that he would have had in a real-life situation. Participants who are highly present should experience the VE as more the engaging reality than the surrounding physical world, and consider the environment specified by the displays as places visited rather than images seen (Slater and Wilbur, 1997).
Finally, the last definitions are almost aligned, like the one of **Guttentag (2010)**:

> *"VR is defined as the use of a computer-generated 3D environment – called a 'virtual environment' – that one can navigate and possibly interact with, resulting in real-time simulation of one or more of the user's five senses."*

Or one of **Estupiñán and colleagues (2014)**:

> *"Virtual Reality can be defined as a multi-sensorial experience that enables the user to interact with objects or situations generated using a computer-generated virtual environment, creating a human-computer interface that could be used to design specific and individualized activities"*

Here some of the key features of VR, previously seen, have been summarized: the interactivity, the real-time simulation and the multisensory experienced. In Guttentag's (2010) paper, a great deal of attention has been paid on the term "navigate" used also in Von Schweber's definition, that refers to the ability to move around and explore the VE and that remind semantic area of immersion.

Recap and conclusion

Although there are some differences between definitions proposed, they have many features in common and even if many terminologies have been used, some of them can be grouped in the same concept. To sum up, the main features that classified an experience as VR are:

- *Immersion*: the extent to which a user is isolated from the real world. In detail, the VR is able to provide full immersion. This concept includes words as illusion, simulation and navigation, used in many VR descriptions;
- *Interaction*: the ability to recreate in the VE a mutual influence or action among people, facts, phenomenon and substances. In particular, in the VR as in reality, there is real-time interaction. The notion of manipulation falls in the definition of interaction;
- *Multisensory experience*: the activation and the usage of more senses in the virtual experience. In detail, the peculiarity of VR is the involvement of the sense of touch, that is not present in other technologies. The concept of multisensory experience could be sometimes included in the one of immersion, especially

considering the immersion as extensive, where extensive refers to the range of sensory modalities accommodated.

Table 3 summarized which features, according to the authors mentioned, characterized an experience as virtual.

Table 3 - Virtual Reality's features per authors

VR's Features	***Author(s)***
Immersion	Fuchs et al., 1992; Gigante, 1993; Von Schweber and Von Schweber, 1995; Gutierrez et al., 2008
Interaction	Gigante, 1993; Von Schweber and Von Schweber, 1995; Burdea and Coiffet, 2003 (Real-time); Guttentag, 2010; Estupiñán et al., 2014
Multi-sensory	Fuchs et al., 1993 (manipulation); Gigante, 1995; Von Schweber and Von Schweber, 1995; Guttentag, 2010; Estupiñán et al., 2014

Participation, cited by Gigante (1993), is surely one of the characteristics of virtual reality but is not necessary to define an experience as VR since it is possible to enjoy a virtual experience even alone.
The sense of presence is a significant peculiarity, nevertheless, as it has been argued, it is not a technological feature of the VR, but rather a psychological condition of the users. Presence, in fact, is the sense of being in the virtual environment and refers to the behaviour of the users. For this reason, it is not appropriate to mention the presence in the VR definition as a technological tool, but it is surely interesting to investigate further this topic as a psychological state induced by VR.
Although all the authors mentioned have defined VR essentially as a technology, other approaches forward a more complex vision, considering VR as a human experience and underlining how "the essence of VR is the inclusive relationship between the participant and the virtual environment" (Mantovani, 2001). In this context, the concept of presence has been considered a crucial one. For this reason, it will be deepened in the next section.

In the literature it does not exist a unique definition of virtual reality, anyway, in light of the analysis done and of the features highlighted as necessary for a VR experience, an exhaustive definition could be:

"VR is a computer-generated 3D environment – called also 'virtual environment'- that provides to the user a fully immersive, multisensory, interactive experience."

This definition, to which this research will refer, classified virtual reality as just as technological tool, while the experience that virtual reality creates will be studied in the next sections.

2.1.2 Sense of presence

As discussed in the previous paragraphs, the presence, described as the sense of being in the virtual environment, is one of the main VR characteristics (Mantovani, 2001). The peculiarity of this feature is that it is a psychological condition of the users. Participants who are highly present experience the virtual environment as more an engaging reality than the surrounding physical world, considering the environment specified by the displays as places visited rather than images seen (Slater and Wilbur, 1997).
It has been demonstrated, that the sense of being in a VE has a direct impact on the users' reactions. The degree of presence evoked by a virtual environment, indeed, generates physiological responses similar to those induced by the corresponding real environment, and greater presence implies greater users' responses (Meehan et al, 2002). This strong impact, on users' feelings and reactions, makes interesting a deeper analysis of this variable.
The leading definition of presence has been provided by Lee (2004), who depicted presence as a psychological state in which virtual objects are experienced as actual ones in either sensory or non-sensory ways. By including the sensory distinction, it is included the possibility of experiencing presence even during the use of low-tech non-sensory media, such as books. However, since the focus of this discussion is on VR, the distinction between sensory and non-sensory experiences is not relevant. As seen in the previous section and as Lee himself affirmed, virtual environments are sensory in nature.
It is possible to differentiate three types of presence (Lee, 2004):

- *Physical presence*: when individuals fail to notice the artificial nature of simulated objects or environments;
- *Social presence:* when virtual social actors are perceived as actual social actors;
- *Self-presence:* when a person experiences the virtual self as the actual self.

This tripartition is very recurrent in the literature (Bailey et al., 2012), and in several cases, the VR ability to induce these types of presence has been demonstrated empirically (Meehan et al., 2002; Nowak and Biocca, 2003; Lenggenhager et al., 2007).
Physical presence, for instance, has been proven by Meehan and colleagues (2002).
In order to verify whether the presence had evoked physiological responses similar to those induced by the corresponding real environment, they exposed the users to a simulation of a danger-of-falling, stress-inducing environment, exhibited in Figure 7.

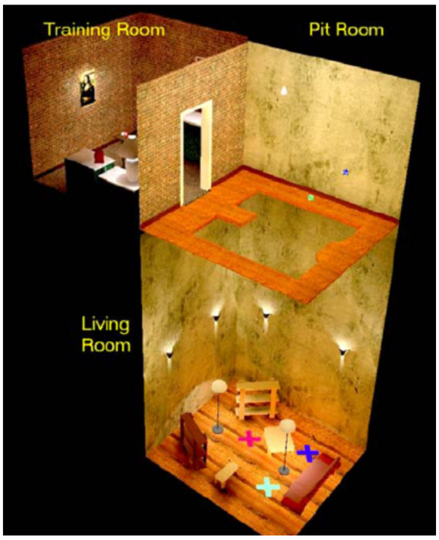

Figure 7 - Experiment on physical presence

The participants started the experience in the Training Room and later entered the Pit Room. The view of the Pit Room caused physiological responses in the subjects similar to the one that they would have in a real situation, as the rise of heart rate, of skin conductance and skin temperature. The results showed that the users perceived the virtual environment as the actual one, failing to keep in mind the artificial nature of simulated objects (Meehan et al, 2002).

Social presence has been studied by Nowak and Biocca (2003). They investigated empirically whether the users perceived virtual social actors as real one by testing their social response to both humans and nonhumans.
In a virtual environment, people can be present in two different ways: agents or avatars.
The term agent is used to describe an entity whose actions are controlled by a computer algorithm (a bot), whereas the term avatar is used to describe an entity whose actions are controlled by a human in real-time.

The experiment results showed that participants feel the same social presence both with avatars and agents. In the encounter with entities, indeed, those that appeared human received special attention, regardless of whether they were real or not.
Agents in virtual environments behave or appear in ways that activate selective neuropsychological responses, which lead to the perception that these entities are real. In other words, computer-generated agents activate people’s tendency to respond socially. This may mean that people are unable or unwilling to distinguish between humans and nonhumans in the face of similar morphology and behaviour (Keil, 1994).
Furthermore, it has been demonstrated that the presence of a virtual body causes people to feel more immersed in the virtual environment, indicating that immersion and presence are in some way linked (Nowak and Biocca, 2003).

The self-presence has been examined with an empirical study by Lenggenhager and colleagues (2007). The experiment aimed to induce out-of-body experience in healthy participants in order to investigate the selfhood. It has been used the virtual reality to create a multi-sensory conflict where participants experienced through an HMD their own virtual body standing two meters in front of them, as shown in Figure 8.

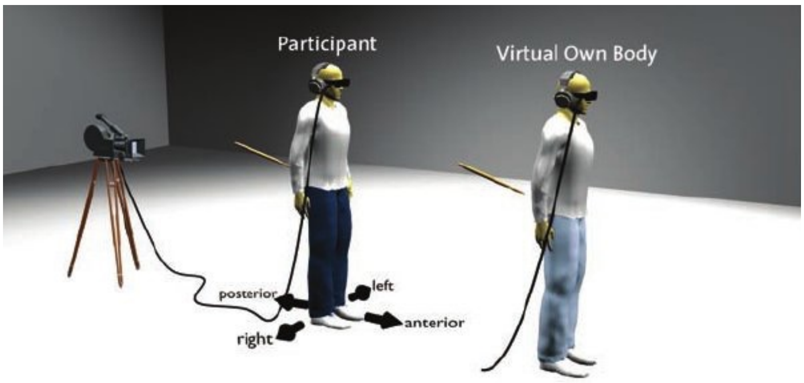

Figure 8 - Experiment on self-presence

The results showed VR can induce self-presence, in fact, participants systematically experienced the virtual body as if it were their own. This finding was validated by the participants’ mislocalization of their own bodies to a position outside them. Furthermore, the results suggest that under conditions of multisensory conflict between visual signals and tactile, proprioceptive, and vestibular signals the sense that predominates is the sight.

Taking into account the significant impact that the sense of presence has on the users, it cannot be considered simply an intrinsic feature of the VR, but it may be regarded as a measure of the success, a key performance indicator of the virtual experience (Meehan et al., 2002; Nowak and Biocca, 2003). In detail, it indicates how much participants feel immersed in the VR environment and how much perceive representations as realistic (Skalski and Tamborini, 2007; Schnack at al., 2019). Therefore, presence is strictly related to the immersion and the better the computer display is capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality, the better the user's sense of presence will be. Conversely, the higher is the sense of presence the higher the user will be isolated from the real world and immersed into the virtual one. Another key variable on the determination of the perceived presence is the interactivity, where the higher is the interaction the higher is the sense of presence perceived by the users (Skalski and Tamborini, 2007).

To sum up, the VR has a potential on the users that no other media have. Immersive virtual environments are able to generate a so great perception of presence, that the users forget the real world and consider the virtual one as their reality of that moment. This leads the subjects to have the same reactions that they would have in the real world. Therefore, immersive virtual environments may have significantly high effects on the users' emotions. This effect leads to several outcomes:

- The physical presence shifts the viewer's whole attention from the physical place to the virtual one, evoking a sensation of being somewhere else and making it easier to immerse and engage him in the experience;
- The opportunity to interact with social actors, independently if they are real or guided by a computer, leads to activation of the viewer and to increase the message processing, which in turn affect both attitude and behavioural intentions (Skalski and Tamborini, 2007; Nowak and Biocca, 2003);
- The opportunity to explore a virtual environment causes the viewer to look around for information. The ability to shape his/her own experience can make the viewer more vested in it. All these mechanisms can lead the viewer to take more ownership of the experience, and thus evoke emotional and cognitive engagement (YuMe & Nielsen, 2016).

These conclusions lead to think that virtual reality has great potential to activate and engage users, impacting on their emotions. For this reason, the next section will be dedicated to deepening the studies of virtual reality concerning the VR effects on individuals, especially on attention and involvement, and more in general on the engagement.

2.1.3 VR IMPACT ON ENGAGEMENT

As already seen, exposing a subject to a virtual threatening situation triggers genuine physiological responses (Meehan et al, 2002). It implies that virtual representations are so realistic to be able to induce emotions in the users. This great VR capability has encouraged many authors to investigate its impacts and potential in several fields. For instance, in tourism, VR has been studied as a tool to attract potential visitors to various destinations or in education as an incentive to engage students in the learning process.

Due to its ability to reproduce realistic environments and immerse the user in a more engaging reality than the actual one (Slater and Wilbur, 1997), it has been hypothesized that VR could be a powerful tool to attract visitors in a potential destination, through virtual tours. In detail, the strength of virtual tour experiences for destination marketing, lies in the ability of potential visitors to assess the value of the actual experience more accurately (Cho et al., 2002), giving them the possibility to virtually experience the pre-visit stage, where awareness, interest and expectation develop in the tourists' mind (Neuhofer et al., 2012).

Investigating this topic, it has been demonstrated by Marasco et al (2018), that virtual reality has a positive influence on cognitive images and on the intention to effectively visit a site. Going more in-depth in the study, the key variable in this process is the perceived visual appeal (PVA), that refers to the exhibition of visual elements and is defined as the interest that a picture generates on individuals. PVA has a direct positive relationship both with the emotional involvement (EI), defined as the degree to which an individual is emotionally engaged in a behaviour, and the behavioural intentions, the willing to visit/revisit the destination and to their willingness to recommend it to others. In other words, VR, through the PVA, has an impact on the formation of affective images and the intention to act of the users. This relationship has been represented in Figure 9, wherein parentheses can be seen the t-values and outside the standardized path coefficients (*p < 0.1, **p < 0,001).

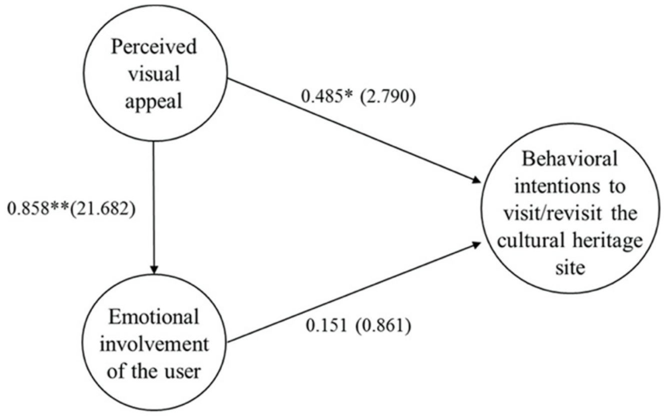

Figure 9 - Tourism's experiment on images and emotional involvement

The basic concept is the same as in the consultation of a travel catalogue, where if a photo generates interest in a potential visitor, he is more motivated to visit that place. The difference is that with virtual reality the user is immersed in the location and consequentially the interest that the image may arise is much stronger and closer to the one that he would have in the real place. Therefore, virtual images emotionally engage users and can attract enough to motivate them to visit, recommend, and find out more information about the actual site (Marasco et al., 2018). This correlation reinforces also the opinion that the presence is strictly related to the immersion and so, to the computer ability to deliver quality images.

Another interesting result, which has been highlighted by the research, concerns the role of EI in influencing the potential visitors' behavioural intentions. The emotional involvement, indeed, did not have a significant positive effect on behavioural intentions. On the contrary, another study in the same field has shown that one of the most impacting variables in choosing to visit a destination, after a virtual tour, is the enjoyment, defining as an emotional state or an intrinsic motivation able to stimulate a user to continue a behaviour (Pantano and Corvello, 2014). Nevertheless, the most important outcome is that both the mentioned studies (Pantano and Corvello, 2014; Marasco et al., 2018) agree on the capability of VR to influence the emotional state of individuals, through the images seen, the same conclusion made by Meehan and colleagues (2002) studying the sense of presence. Furthermore, Pantano and Corvello (2014), shifting the focus of tourism destination marketing on cultural heritage sites, noticed that virtual tours improved the combination of entertainment and education. Virtual reality, indeed, beyond offering interactive and enjoyable environments that supported tourists in choosing destinations, easing learning and dissemination of arts and culture.

This insight on learning makes an in-depth study of the VR effects in the educational field interesting, as it highlights the ability of the virtual images to provide contents, increasing the interest and involvement of users (Pantano and Corvello, 2014). Studies on the applications and effectiveness of virtual reality in education and training have begun since the 1990s when the technology wasn't ready yet, but it could already guess its potential.
Youngblut (1998) conducted an extensive survey of research and educational uses of virtual reality during the 1990s. The survey attempted to answer questions about the use and effectiveness of virtual reality. He found that, notwithstanding the low resolution and the cumbersomeness of the HMDs of that time, students' enjoinment was common, and teachers report striking improvements in students' motivation.
Similar outcomes were pointed out also that Pantelidis (2009), that led a qualitative study on the reasons to use virtual reality in education and training. He argued that at every level of education, virtual reality has the potential to make a difference, to lead learners to new discoveries, to motivate and encourage and excite. The strengths in the process is that learner can participate in the learning environment with a sense of presence that increases their engagement in what they see, listen and do. Going on through the years, with the improvement of the technology the VR impact on individuals' engagement was even greater.
Lee and colleagues (2017), enacted experiments in business classrooms that compared the Google Cardboard VR with the traditional flat-screen format. The results demonstrated that participants in the VR condition rated their enjoyment and interest to be higher. In other words, VR increased pleasure and interest in learning educational contents. If the VR impact on emotions and commitment seems clear, Vesisenaho and colleagues (2019), studying empirically the emotional reactions in the context of engaging experiences, added another result. They compared physiological status, measured through heart rate variability during the experiences, with emotional involvement, assessed with a self-report questionnaire. The results showed that during the virtual experience there was a higher activation level and a stronger affective involvement, moreover physiological (objective) and experiential (subjective) data grew simultaneously, reflecting a parallel rise of the emotional and cognitive engagement during the VR experiences.
As stated by Pantelidis (2009), VR has an impact on motivation at every level of education, therefore it has been explored also in professional training. A noteworthy

example is the VR application in Walmart as a sales training tool. In particular, it has been used to train employees in view of crucial times of the year, such as Black Friday. Through the HDMs, the employees entered in a simulated real-world scenario and were submitted to simple decisions based on what they saw. The training aimed to teach selling techniques and to guide the employee through some operational procedures, such as stacking and arranging. This implementation showed that with VR training, the real jobs' mimics and the immersive experience, trainees then performed better at their actual jobs. The use of VR has transformed and made the training more dynamic, immersive, engaging, affordable, and remotely accessible to everyone. In conclusion, VR increased engagement and improve retention, increasing cognitive memory (Upadhyay and Khandelwal, 2018).

This capacity of VR of engaging individuals was not investigated just in the learners or in the tourists, but also in costumers. Nielsen and YuMe (2016), examined the power of the immersive content experiences to engage viewers. Their goal was to answer three main questions:

1. How do consumers' non-conscious, emotional responses differ between content viewed in VR, 360-degree video, and 2D (flat-screen TV)?
2. How do consumers deploy visual attention and use physical space differently in these next-generation environments relative to TV?
3. What are some early guidelines for crafting great creative in VR and 360-degree video environments?

It was found that content in VR is more emotionally engaging than content in other environments, eliciting a 27% higher emotional engagement than the TV experience. Cognitive engagement with VR content also peaks higher than TV and sustains engagement longer. Content characteristics also influence engagement. Contents that encourage exploration (through a more free-form, less plot-directed style) lead to higher levels of engagement in immersive environments.

The VR impact on enjoyment, interest, motivation and engagement is a very important outcome since could leads to several significant results in various field. For this reason, it has been studied the possible causes of such VR effects.

The potential cause is associated with the sense of presence, as it allows individuals to translate the personal experiences, emotions and memories to the virtual environment. As a result, such experience can become more meaningful for the individual, having a higher emotional impact and rising cognitive memory (Gallo, 2002; Upadhyay and Khandelwal, 2018). Moreover, as previously seen, the engagement increases when the virtual contents encourage explorations (Nielsen and YuMe, 2016). This is particularly stronger in the learning process since people can learn through situational involvement, but it is also true for marketing contents (Nielsen and YuMe, 2016). Therefore, another possible cause is the VR capability to let enjoy a first-person experience that further activates users, making them active participants. This ability will be explored in the following section.

2.1.4 VR IMPACT ON PROBLEM SOLVING

Youngblut (1998), found that the unique capabilities of VR technology include to allowing learners to see in first-person the effect of changing physical laws, or observe events and visit environments that distance, time, or safety factors normally preclude. These capabilities allow living a learning experience, rather than reading or listening to object to being learned, allowing the so-called experiential learning. Furthermore, the possibility to participate actively at the learning process, by virtually observing the object of study and manipulating it, lead to constructivist learning, where the users, building their own learning process, are more involved in it and their commitment and outcomes are higher (Youngblut, 1998). These insights led researchers to investigate the effects that VR could have on the effectiveness of learning, up to the point of studying its impacts on problem solving.

Insights on VR potential to stimulate problem solving dates back to 90s, when Beroggi and colleagues (1995) proposed a qualitative study aim to provide the emergency management community with a pragmatic overview of virtual reality technology and to propose where the technology could support problem solving and decision making in emergency management. Nevertheless, during the following years, been much empirical research in the literature to investigate the effects of virtual reality on problem solving. The few studies present date back to recent times.

Noteworthy research, concerning professional training, has been led by Lau and colleagues (2018), who performed an empirical study on Omni-channel retailing employees. They divided 40 employees into two groups, one experimental group who tested the virtual training and a control group, who experienced a traditional learning method. The aim of the training was enhancing the employees learning achievements on the Omni-channel retailing method and knowledge. After the training, the assessment of the outcome was divided into two parts, a professional test to evaluate the professional knowledge and problem solving, and a 550-word reflective journal on self-evaluation and study insights, in orders to assess critical reflection and independent learning. A summary of the experiment design is exhibited in Figure 10.

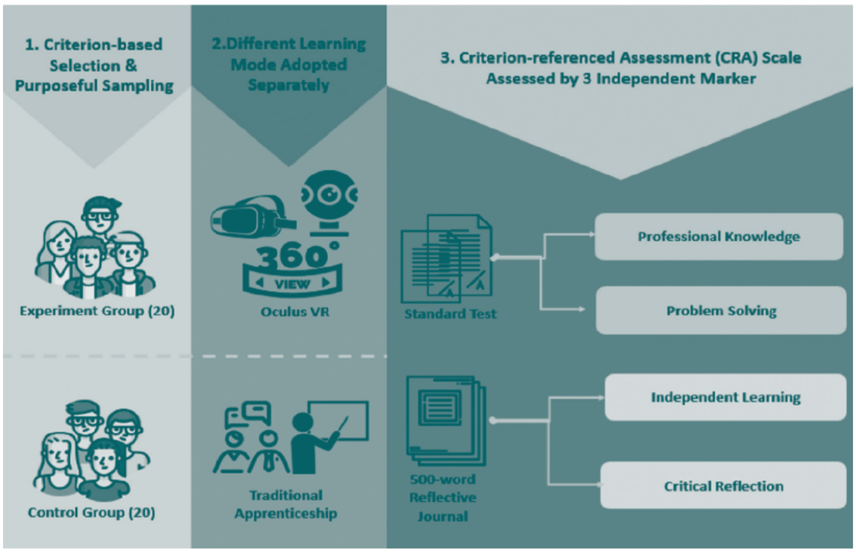

Figure 10 - Experiment design on problem solving

The results showed that there was a significant enhancement of employees learning outcomes when using VR. This outcome is extremely interesting since demonstrated that VR not only improves the technical knowledge but also enhance problem solving, independent learning and critical reflection. This study reinforces the opinion that virtual reality allows to be actively engaged in a task through immersive, first-person experience, that enhances situated learning approaches, where users can explore new behaviour and be proactive. This approach leads to an increment of the users' activation and engagement e improves their outcomes (Lau et al., 2018).

Another noteworthy research has been led by Wu and colleague (2019), who studied the use of exploratory scientific practice activities based on Spherical Video-based Virtual Reality (SVVR) in science classes and verified the impact of such activities on the problem-solving abilities of students. The results showed that integrating SVVR into exploratory scientific practice instructions has a significant effect on students' learning outcomes and problem-solving abilities. In other words, the use of virtual reality in teaching practices provided new possibilities for the development of problem-solving abilities by providing students with a richer situation, making the learning process more interesting and interactive, improving students' motivation and attention, and helping them to discover and explore their own knowledge (Wu et al., 2019).

2.1.5 Recap and conclusion on VR literature

The whole VR literature reviewed, pointed out a significant influence of the virtual reality on behavioural manifestations linked to the engagement. In detail, the most analysed by researchers were aspects related to emotional engagement, like excitement or enjoyment. Some studies showed also evidence on VR impact on cognitive engagement (Nielsen and YuMe, 2016; Vesisenaho et al., 2019). Finally, the VR capability of allowing a first-person experience, that enhances situated learning approaches, where users can explore new behaviour and be proactive, leads to an increment of the users' activation and commitment (Youngblut, 1998; Lau et al., 2018), reminding to the concept of the physical engagement.

For this reason, in the following section will be proposed a brief literature review on the engagement, focused on Kahn's theory, as the father of the engagement's tripartition in emotional, cognitive and physical.

Furthermore, the insight of VR ability to stimulate independent learning and problem solving, through its ability to allow an immersive, first-person experience, makes studying the virtual reality as problem-solving stimulator really interesting. Thereby a brief analysis of problem solving has been proposed too.

2.2 | ENGAGEMENT

The engagement has been widely investigated in the literature since is a key variable in many fields. When engaged, individuals should be attentive, emotionally connected and fully concentrated on their performance, thereby they can get better outcomes in what they do (Kahn, 1990).
Bearing in mind the extent of this topic in the literature, in order to not digress from the core theme of this research, the following section will be focused on the Kahn tripartition of engagement, since describes the aspects of engagement more mentioned in the VR literature review, and thus likely the most significant to study in virtual experiences.

2.2.1 KAHN THEORY OF ENGAGEMENT

The first conceptualization of the engagement was the work of Kahn (1990), who described it as a unique and important motivational concept in an organization: "the harnessing of an employee's full self in terms of physical, cognitive and emotional energies to work role performances. People exhibit engagement when they become physically involved in tasks, whether alone or with others; they are cognitively vigilant, focused, and attentive; they are emotionally connected to their work and others in the service of their work" (Kahn, 1990).

The core of Kahn's engagement model is the employed (or not) of the individual's preferred self in his role performances. The preferred self alludes to the fact that people have dimensions of themselves that, given appropriate certain conditions, they prefer to use and express. When individuals display their preferred self into their performances, that connection fosters cognitive, emotional and physical engagement. They show "what they think and feel, their creativity, their beliefs and values, and their personal connections with others" (Kahn, 1990). Kahn also argued that there are three psychological conditions essential to create this condition: meaningfulness, safety, and availability. The meaningfulness condition includes all the work elements' perceptions, which should be meaningful in the employee's minds; social elements such as management style and organizational norms should foster a sense of safety, and individual distractions should be present to ensure availability (Kahn, 1990).
Khan conceptualization is central for the organizations since not only suggests a linkage between engagement and job performance but also represents an inclusive view of the

employee’s agentic self, stressing that engagement may provide a more comprehensive explanation for job performance effects.

This definition, declined in the organizational context, was then broadly studied and applied by several authors, both in the organizational field (May et al., 2004; Rich et al., 2010), and in many others, such as in marketing (Hollebeek, 2011; Harrigan et al., 2017; Dessart and Pitardi, 2019), in education (Sani and Hashim, 2016) and several other kinds of activity (competitions, games, etc..).
Generally speaking, engaged individuals are described as being psychologically present, fully there, attentive, feeling, connected, integrated, and focused on their performances. They bring their complete selves to perform, and consequentially this leads to improving their performances (Kahn, 1992).

The Kahn tripartition of engagement, as seen, consists of the distinction among the cognitive, emotional and physical engagement.

- *Cognitive engagement* indicates individuals’ mental dedication to what he experienced and is represented by a set of enduring and active mental states. These mental states can be mapped through a series of behavioural manifestations, such as attention and absorption (Harrigan et al., 2017). Attention refers to the level of focus, conscious or sub-conscious, the degree of attentiveness and connection that an individual has with the engagement object or the cognitive availability and amount of time spent thinking about and being attentive to it (So et al., 2014). Absorption goes further than attention, it refers to the sense of being fully concentrated and happily engrossed, is a state in which the individual is so immersed in what he is doing that he is unaware of how much time is devoting to it. It is the level of concentration and immersion with the engagement object (Harrigan et al., 2017).
  To sum up, the cognitive engagement refers to the state of mind that includes both attention ad absorption, in which the individual is fully concentrated, immersed, attentive, focused, absorbed on the engagement object.

- *Emotional engagement* is the individual’s summative and enduring level of emotions, it refers to the positive and negative responses subjects have and influences their attachment to and willingness to act (Harrigan et al., 2017). It is evidenced through enjoyment, enthusiasm and dedication for the engagement object. Enthusiasm is the intrinsic level of excitement and interest regarding the object (Calder et al., 2013); enjoyment includes the pleasure and happiness derived from interactions with the engagement object (Patterson, Yu, & de Ruyter, 2006); dedication means be strongly involved in one's work and experiencing a sense of significance, enthusiasm, and challenge.

- *Physical engagement* refers to an individual's energy. As the cognitive engagement, it can be recognized through other behavioural manifestations, such as the activation and the vigour (Harrigan et al., 2017). The activation concerns the subject's energy, effort and time spent on the engagement object (Hollebeek et al., 2014), instead the vigour denotes high levels of energy and mental resilience when interacting the object, and the user willingness to invest effort in such interactions (Dwivedi, 2015).

Table 4 summarizes for each engagement dimension its behavioural manifestations.

Table 4 - Engagement behavioral manifestations

Engagement dimensions	***Behavioural manifestations***
Cognitive engagement	Attention, absorption, concentration, immersion, focus
Emotional engagement	Enjoyment, enthusiasm, dedication
Physical engagement	Vigour, activation, effort

2.2.2 PROBLEM SOLVING

Virtual reality ability to immerse an individual within a situation, and let he decides, learns and acts in first-person enables him to build his experience, learn through situated learning and improves his problem-solving abilities (Lau et al., 2018; Wu et al., 2019). This discovery opened in the research a newsworthy area of study in VR potentialities. For this purpose, in the next section, a brief deepening on what is problem solving and which are the main variables impacting on it is proposed. The final aim is to understand which could be the correlation that enhances problem solving in a virtual experience.

A problem is defined as a "situation in which a goal is to be attained and a direct route to the goal is blocked" (Kilpatrick, 1985). Thus, for different individuals, the same task could be viewed as either an exercise or a problem, where a direct route to the goal is clear for an exercise. Mayer (1985) stated problem solving as "a series of mental operations that are directed toward some goal". Therefore, the problem-solving process could be a representation of an individual's own internal exploration towards an unknown path, instead of one's ability to directly retrieve known techniques.

The literature about problem solving is broad and dates back to '40s. The first problem-solving model was designed by Polya (1945) in the mathematics field, where he developed a four-step strategy for solving problems. The four phases were: understanding the problem, devising a plan, carrying out the plan, and looking review and respond, or extend. Nevertheless, this strategy was primarily suitable for solving simple word problems, those found in school textbooks, while problem solving concerned struggling with complex non-routine problems (English and Sriraman, 2010).

Despite the ground-breaking contribution of Polya's book, indeed, it seems that the teaching of heuristics and strategies has not made significant inroads into improving students' problem solving (Schoenfeld, 1992). The author posited that an explanation for this result is due to the little understanding of how individuals come to make decisions about when, where, why, and how to use heuristics, strategies, and metacognitive actions. Focusing on applying these strategies, without understanding how and why individuals make decisions about pathways for solving problems is non-productive (English et al., 2008). Therefore, many authors have begun to study possible factors that could influence problem solving, diverging from the heuristics strategies and from the mathematics filed. They started to consider psychological factors that could influence problem-solving results, and several areas where complex, non-routine, problem solving could be developed. Indeed, there is a significant difference between simple and complex problem solving. Complex problem-solving concerning reducing the barrier between a given start state and an intended goal. Anyway, start state, goal state, and barriers prove complexity, change dynamically over time, and can be partially unaware. In contrast to solving simple problems, with complex problems at the beginning of a problem solution the exact features of the start state, of the goal state, and the barriers are unknown. Complex problem solving expects the efficient interaction between the problem-solving person and situational conditions that depend on the task. It demands the use of cognitive, emotional, and social resources as well as knowledge (Funke, 2012).

One area in which complex problem solving could be developed is that of games, considered as situated problem-solving environments (Gee, 2007). It has been argued that *"games possess unique affordances to address complex problem-solving skill development that the current educational system is failing to provide drawing on a powerful pedagogy: situated learning"* (Eseryel et al., 2014). Games, indeed, may simulate real-world complexity and fast-paced processing in ways that traditional school learning scenarios cannot approximate (Spires et al., 2011). It has also been argued that game-based situated learning environments promote motivation and engagement (Gee, 2007). For this reason, it has been considered further interesting to study whether there was a correlation between engagement and problem solving.

Results indicated that engagement is a strong predictor of the problem representation, and the higher is the engagement, the higher is the outcome in solving complex problems (Eseryel et al., 2014). Besides, engagement is not only the best predictor in non-routine, but it is also the unique predictor of mathematics problem-solving performance (Lein et al., 2016). Going more in-depth, it was found a significant positive influence of another variable on the engagement: the self-efficacy (Eseryel et al., 2014).

Perceived self-efficacy is defined as people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves and behave (Bandura, 1997). A strong sense of efficacy enhances human accomplishment and personal well-being in many ways. People with high assurance in their capabilities approach difficult tasks as challenges to be mastered rather than as threats to be avoided. Hence, the stronger the perceived self-efficacy, the higher the goal challenges people set for themselves and the firmer is their commitment to them (Bandura, 1997). Indeed, it has been found that perceived ability provided the best prediction of achievement and cognitive engagement (Miller et al., 1996). An increase of self-efficacy leads to the raised of engagement and thereby to a higher effort in solving the problem, a more persistent in pursuing tasks and, finally, to better outcomes (Pajares and Graham, 1999; Nicolaidou and Philippou, 2003; Eseryel et al., 2014).

2.3 | RECAP AND THE RESEARCH GAP

The analysis of the literature gave newsworthy insights to study deeper the potential of virtual reality in influencing the engagement.

From the first part of the review, it has been found that VR has the ability to induce in the users the sense of being in the virtual environment, called "sense of presence". The sense of presence allows feeling in the synthetic experience the same emotions and sensations that the individual would have in a real situation. Consequentially to be immersed in the environment, together with the possibility to interact with it, leads the users to be engaged in what they do virtually. For this reason, the sense of presence could be considered a sort of key performance indicator of the virtual experience, where the higher is the sense of presence, the higher is the user's immersion and commitment in the virtual experience (Nowak and Biocca, 2003; Meehan et al., 2002).

The analysis highlighted three insights from the sense of presence:

- The *physical presence* immerses completely the users in the synthetic environment, making easier their engagement in the experience;
- The *social presence* leads to higher activation of the individuals due to the interaction with social actors (Skalski and Tamborini, 2007; Nowak and Biocca, 2003);
- The opportunity to explore a virtual environment causes the viewer to look around for information and pursues him to be more vested in it. His *self-presence* lead to take more ownership of the experience, and thus evoke emotional and cognitive engagement (YuMe & Nielsen, 2016).

All these considerations have led to a deeper analysis of the impact of VR on the users in several fields, focusing on his capability to engage them. Specifically, it has been considered VR influence on potential tourists, trainees and costumers.

The analysis confirmed the VR may be able to affect individuals' engagement (Nielsen and YuMe, 2016; Vesisenaho et al., 2019). Going more in-depth, it revealed that the virtual images can raise enjoyment, excitement, pleasure and interest, all attributes linked to the Khan's conceptualization of emotional engagement. In this respect, some researches directly affirmed that VR may increase the emotional engagement or involvement of the users (Nielsen and YuMe, 2016; Marasco et al., 2018; Vesisenaho et al., 2019). Furthermore, it has also been stated that VR may raise users' activation and attention, dimensions related to Khan's physical and cognitive engagement, respectively. Regard the latter, it has been argued that VR improves the topics' retention, increasing memory and cognitive engagement (YuMe & Nielsen, 2016; Upadhyay and Khandelwal, 2018).

Nevertheless, despite the several findings that can lead to consider a correlation between the use of virtual reality and the different kinds of engagement, in the literature we experience the lack of an extensive study on this relationship, that considers the engagements' components and how VR affects each of them.

For instance, from the literature could be hypothesized that emotional engagement is the most impacted since the majority of studies refers to its behavioural manifestations. Nevertheless, there are not extensive studies investigating the relationship between the use of VR and the three engagement dimensions or trying to understand whether which kind of engagement is more impacted. In this respect, the present research has set itself the objective of studying the relationship between engagement and virtual reality, going to further the correlation with each engagement's dimensions, according to Khan's tripartition. Below it is synthesized the first research goal:

1. Conduct an in-depth and empirical study on the impact of virtual reality on each component of Kahn tripartition of engagement:
    a. Analyse VR influence on *cognitive engagement;*
    b. Analyse VR influence on *emotional engagement;*
    c. Analyse VR influence on *physical engagement.*

Another relevant outcome arose from the literature, is the VR ability to actively engaged in a task through immersive, first-person experience, that enhances situated learning approaches and problem-solving abilities (Lau et al.,2018). This insight brought to investigate problem-solving literature and in doing so, it has been found a significant common ground with the games. Eseryel and colleagues (2014), indeed, stated that "games possess unique affordances to address complex problem-solving skill drawing on a powerful pedagogy: situated learning", while Lau and colleagues (2018) argued that VR enhances problem solving, through immersive, first-person experience, that enhances situated learning approaches, where users can explore new behaviours and be proactive.

As may be seen, both games and virtual reality are able to improve problem-solving skills, thanks to their peculiarity of immersing the individual in a situation and make him discover laws of cause-effect in a first-person experience (Youngblut, 1998). Going more in-depth, one reason behind the higher effectiveness in developing such capability is attributed to a higher level of the engagement in the individual, who becomes an active, rather than passive, subject in his learning. In fact, engagement is a strong predictor of the problem representation, and the higher is the engagement, the higher is the outcome in solving problems (Eseryel et al., 2014).

Considering the first aim of investigating VR relationship with the engagement, it becomes worthwhile understanding, in a second stage, another topic that the present literature is falling to provide: the correlation between problem solving and engagement in virtual experiences. If in synthetic experience the positive relation between problem solving and engagement would be maintained, and if VR would positively influence the engagement, it could be inferred that VR favours the development of problem solving thanks to its ability to highly engage users, bearing a relevant result in the problem solving filed. Furthermore, given the previous analysis on the Kahn engagement tripartition, it would become also interesting understanding whether there is some engagement component that impacts more significantly than the others. For this reason, a second research goal is formulated:

2. Conduct an in-depth and empirical study to investigate the correlation between *engagement* and *problem solving* in virtual environments. In detail, the engagement will be analysed following Khan's tripartition in:
    a. *Cognitive engagement;*
    b. *Emotional engagement;*
    c. *Physical engagement.*

Finally, the problem-solving literature revealed that perceived ability is the best predictor of achievement and cognitive engagement (Miller et al., 1996). An increase of self-efficacy leads to the raised of engagement and thereby to a higher effort in solving the problem and a more persistent in pursuing tasks (Eseryel et al., 2014). Therefore, it would be reductive to not consider this variable in the relationship between engagement and problem solving, since on the one hand, it could influence the correlation among the variables, on the other hand, it could be interesting understand if the VR ability to influence the engagement is able to vary the correlation between self-efficacy and engagement, for instance weakening it. In the last case, indeed, it could affirm that involvement given by a virtual experience would be able to change the approach towards difficult tasks in the individual. Therefore, the third and final research's goal is defined:

3. Conduct an in-depth and empirical study in order to investigate the relationship between self-efficacy and engagement in solving problems, in virtual environments. In detail, the engagement will be analysed following Khan's tripartition in:
    a. *Cognitive engagement;*
    b. *Emotional engagement;*
    c. *Physical engagement.*

3 | RESEARCH FRAMEWORK

While the Literature Review was focus on understanding the possible VR effects on users and its potentialities, with the final aim to find a noteworthy gap in the literature, this chapter starts from the gap to lay the groundwork for empirical research. This section, indeed, is dedicated to the translation of the three research goals previously formulated, into questions to which the present research aims to answer. Afterwards, nine hypotheses have been formulated to answer the questions, which will be tested empirically in the next section. To simplify the understanding, the hypotheses are representing in two different models.

3.1 | RESEARCH QUESTIONS

As seen in the previous chapter, the main aim of this research is to investigate the impact of virtual reality on each component of the Kahn tripartition of engagement. This goal rises from the fact that in the literature are present many studies that analyse the VR impact on different variables referable to Khan subdivision, such as the attention and the absorption for the cognitive engagement (Hanson & Shelton, 2008; Lee et al., 2017), the enjoyment and pleasure for the emotional (Pantelidis, 2009; Pantano and Corvello, 2014; Marasco et al., 2018) and activation and commitment for the physical engagement (Youngblut, 1998; Lau et al., 2018). Nevertheless, none of these studies wondered whether it made sense to investigate father the VR influence on each kind of engagement. An in-depth study on the engagement tripartition, indeed, could be interesting to understand more accurately how the VR influences individual, with the final aim to figure out where and how is more meaningful use this technological tool. Therefore, the research goal aims to answer whether VR is able to engage individuals so much to have them being psychologically present, fully there, attentive, enthusiastic, enjoyed, energetic, bringing their complete selves in the virtual environment. In other words, the present study has to answer whether the VR is able to rise all the engagement components or just some of them. Therefore, the first research question is formulated:

Q1. Considering the three engagement dimensions (cognitive, emotional and physical), does the virtual reality have a different impact across engagement? Is there some engagement component is more affected by virtual reality?

Since subjects immerse in a first-person virtual experience has been demonstrated that enhances their problem-solving abilities (Lau et al., 2018), the second research aim is to investigate the relationship between engagement and problem solving in virtual environments. This second goal changes interest based on the results of the previous one since it could reveal an indirect relationship between engagement and problem solving. Anyway, for the moment just the first relation is considered and thereby, the first step is to answer whether in virtual environments exists a variation in the relationship between engagement and problem solving. Furthermore, given the tripartition of engagement analysed above, it becomes worthwhile to understand whether there is one component with a greater impact than the others. Therefore, the second research question is formulated as follow:

Q2. Does the relationship between problem-solving and engagement have a positive correlation in virtual environments? Is there some engagement component that influences the relationship more significantly than the others?

Finally, the third goal is to analyse the relationship between self-efficacy and engagement in problem-solving contexts in virtual environments. Considering that an increase of self-efficacy leads to higher engagement and effort in solving the problem, that often results in better outcomes (Pajares and Graham, 1999; Nicolaidou and Philippou, 2003; Eseryel et al., 2014), the aim is to understand whether, with the use of virtual reality, variations in the relation between perceived ability and the effort in problem-solving are present; whether the hypothesized impact of VR on engagement strengths or weakens such relation; whether one component of engagement plays a central role. Therefore, the third and final question is formulated:

Q3. Does the relationship between self-efficacy and engagement in solving-problem have any impact in virtual environments? Is there some engagement component that is influenced more significantly than the others?

3.2 | Research hypothesis and model

3.2.1 Research Question 1

The potential of VR is often associated with its power to provide users with the feelings of presence and immersion (Slater and Wilbur, 1997; Nowak and Biocca, 2003; Skalski and Tamborini, 2007). In particular, HMDs are able to immerse users in real contents. This immersion in virtual environments can, at its best, capture users' attention in a way that causes them to dive inside the simulated world and allows their involvement. Indeed, VR has been reported to capture attention in a way that improves intervention outcomes in a clinical context as well (Narraro-Haro et al., 2016). The immersive power of VR can also induce learners' engagement in learning activities, thereby causing the learners to engage in deeper cognitive processing of the learning material (Hanson & Shelton, 2008; Lee et al., 2017). As previously seen, attention and absorption are dimensions related to the cognitive engagement theorized by Kahan (1990), thereby it is reasonable to affirm that if such dimensions increase, it raises also the cognitive engagement. Two empirical research comes useful to further strengthen this assumption: one led by YuMe and Nielsen (2016) in which they directly affirm that VR contents may not only activate the cognitive engagement but also sustain it longer compared to a traditional flat-screen content; the other conducted by Vesisenaho and colleagues (2019) sustaining a rise of the cognitive engagement during the VR experiences. Given all these considerations it is reasonable to formulate the first hypothesis:

H1. Virtual reality is able to enhance cognitive engagement

The other great potential of the sense of presence is that the virtual representations seem so realistic as to induce users the same emotions they would have in a real situation (Meehan et al, 2002). The virtual images, indeed, based on the interest generated, are able to affect the individuals' emotional involvement, defined as the degree to which an individual is emotionally engaged in a behaviour (Marasco et al., 2018). This VR capability enables to enjoy potential tourists with a virtual tour (Pantano and Corvello, 2014), or enhance students in learning contents (Youngblut, 1998). It has been argued, for instance, that at every level of education, virtual reality has the potential to make a difference, to lead learners to new discoveries, to motivate and encourage and excite (Pantelidis, 2009). An experiment in business classrooms, indeed, showed that participants in the VR condition rated their enjoyment and interest to be higher, rather the ones with the traditional flat-screen format (Lee et al., 2017). Furthermore, VR impact on the emotional involvement may be matched both psychologically, assessing it with a self-report questionnaire and physiologically and through heart rate variability (Vesisenaho et al., 2019). The use of virtual reality has the potential to transform how contents are delivered: making training more dynamic, immersive and exciting (Upadhyay and Khandelwal, 2018) or a media content more emotionally engaging, up to 30% more than a normal TV multimedia content (YuMe & Nielsen, 2016). Overall, it is reasonable to formulate the second hypothesis:

H2. Virtual reality is able to enhance emotional engagement

Finally, the other great VR feature is the unique capability of allowing a first-person experience, that enhances situated learning approaches, where users can explore new behaviour and be proactive. This approach leads to an increment of the users' activation and commitment (Youngblut, 1998; Lau et al., 2018). Even if there is not much evidence as in the previous two hypotheses, it is recurrent in the literature that an exploratory approach leads to a higher user's activation, hence a greater activation could associate to the individual physical engagement. For this reason, the third hypothesis is formulated as follow:

H3. Virtual reality is able to enhance physical engagement

Figure 11 presents the Research Model 1 with the first three hypotheses.

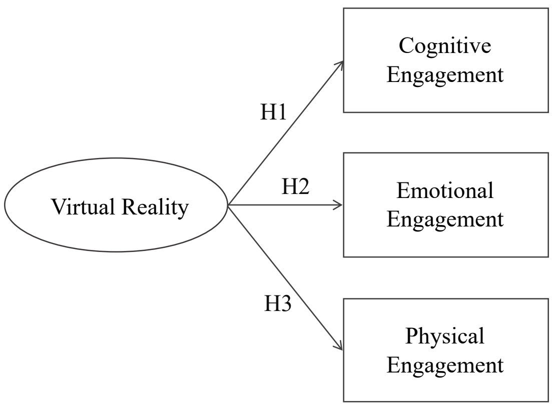

Figure 11 - Research Model 1

3.2.2 Research Question 2

Researches on complex problem solving revealed that engagement is the strongest predictor of problem solving. Individual more involved, indeed, raise significantly their effort, up to achieve better outcomes (Eseryel et al., 2014; Lein et al., 2016).
Likewise, subjects immerse in a first-person virtual experience has been demonstrated that enhances their problem-solving abilities (Lau et al., 2018). The use of virtual reality, indeed, provides new possibilities for the development of problem-solving abilities by providing users with a richer situation, making the contents more interesting and interactive, improving motivation and attention, and encouraging to discover and explore their own knowledge (Wu et al., 2019). Considering these findings, it is reasonable to assume that in virtual environments, as in real ones, exists a positive direct relationship between engagement and problem solving. Furthermore, it will be hypothesized a positive correlation with all the Khan engagement elements, in order to discover whether one of them will result in more impacting than the others. Overall:

- ***H4. In virtual environments, cognitive engagement is positively associated with problem solving***
- ***H5. In virtual environments, emotional engagement is positively associated with problem solving***
- ***H6. In virtual environments, physical engagement is positively associated with problem solving***

3.2.3 Research Question 3

In studying complex problem-solving contexts, it can’t be left out the perceived self-efficacy, considered a substantial influencer of commitment in solving problems, especially of the cognitive engagement (Miller et al., 1996; Eseryel et al., 2014). The stronger is the perceived self-efficacy, the higher are the goal challenges that people set for themselves and the firmer is their commitment to them (Bandura, 1997). Therefore, an increase of self-efficacy leads to higher engagement and effort in solving the problem, that often results in better outcomes (Pajares and Graham, 1999; Nicolaidou and Philippou, 2003; Eseryel et al., 2014). In virtual environments, it was never tested this relationship, anyway, since it has been argued more than once, that virtual reality is able to reproduce the same feelings that the individuals would have in a real situation (Meehan et al, 2002), it is reasonable to assume that such relationship doesn’t undergo variations.

Furthermore, even here, in order to investigate whether there is an engagement dimension influencing more than the other such relationship, it will be hypothesized a positive correlation with all the Khan engagement elements, expecting a greater impact on the cognitive one (Miller et al., 1996). Overall:

H7. In virtual environments, self-efficacy is positively associated with cognitive engagement
H8. In virtual environments, self-efficacy is positively associated with emotional engagement
H9. In virtual environments, self-efficacy is positively associated with physical engagement

In conclusion, Figure 12 exhibits the last hypotheses represented in Research Model 2.

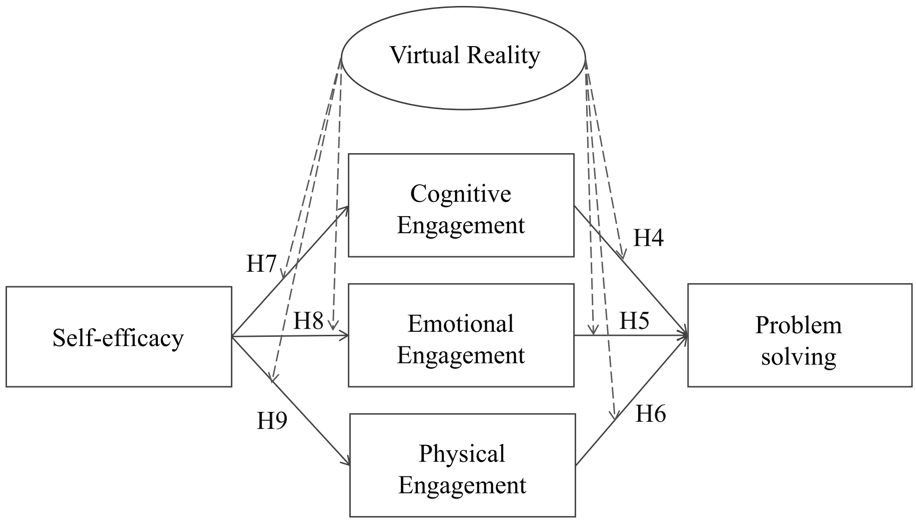

Figure 12 - Research Model 2

4 | RESEARCH DESIGN

The following chapter presents the empirical research made to test the hypotheses previously formulated, with the ultimate goal of generating empirical evidence within the field.

First, it explains how empirical research was designed: starting from the selection of the research setting and the reasons behind the choice; up to the construction of the questionnaire which was used for data collection. Subsequently, all the analyses made to verify the hypotheses are shown, together with some theoretical mentions that justify the reasons for the choices. The results conclude the chapter, introducing the following one, where the conclusions of the analyses will be drawn.

4.1 | RESEARCH SETTING

The first step to solve, in order to test empirically the hypotheses, was to find an appropriate experience. The experiment, indeed, had some constraints that limited the choice of the context of the study. It has been firstly needed an experience allowing the assessment of complex problem solving, engagement and self-efficacy; secondly, to verify whether virtual environments would enhance the engagement, it should be observable both in VR and in reality; last but not least, it needed an experience enough widespread in virtual reality, in order to have a relevant sample to observe.

The best filed chosen, capable of satisfying all these constraints, has been one of the escape rooms. Escape rooms, indeed, are games of problem solving, in which a team of players cooperatively discover clues, solve puzzles, and accomplish tasks, in one or more rooms, in order to progress and achieve a specific goal in a limited amount of time. The goal is to escape from the site of the game. Escape rooms usually begin with a brief introduction to the rules of the game and how to win. After this, the clock starts, and players have usually 60 minutes to complete the game. Challenges in an escape room based more on mental than physical, and it is not necessary to be physically fit or dextrous. If a team gets stuck, there is a mechanism in place for the players to ask for hints. These clues can be delivered using paper, video, audio, or a gamemaster out of the room. If the players are unable to solve the game's puzzles within a time limit, the team is typically notified by the game's operator and escorted out of the room. If players achieve the goal within the time limit, they win the game.

For their game mechanisms, the escape rooms were defined as situated problem-solving environments, in which players are immersed in a culture and way of thinking and have to challenge their problem-solving abilities (Dede, 2009; Gee, 2007).

The escape rooms are physical places set up according to a theme such as prison cells, Egyptian pyramids or space stations, anyways in the last years were developed also virtual escape rooms, that have the same logic of the real ones but, through HDMs and controllers, are played in a virtual world. Furthermore, virtual escape rooms, although not yet massive, are widespread enough to have locations in which players can go and play, allowing the collection of a good sample of data. All these considerations made the escape room the perfect environment to test the hypotheses.

As previously seen in the literature review, the key performance indicator of virtual experiences is the sense of presence (Meehan et al., 2002; Nowak and Biocca, 2003), that is strictly related to the computer display ability to deliver an inclusive, extensive, surrounding and vivid illusion of reality (Schnack at al., 2019; Skalski and Tamborini, 2007). For this reason, to have the best results in terms of sense of presence, a professional virtual reality arcade that used the latest technologies released on the market in VR fields was selected: VRzone. VRzone specializes in the creation of VR events B2B and, under the name Wakanda, becomes a B2C VR game room. The firm operates with the latest VR headsets of the best world producers such as Oculus Rift and HTC Vive, using wireless HSDs that, combined with accurate tracking of the position, eliminates the user's disorientation and allows complete interaction with the virtual space and total freedom of movement. Furthermore, the games present in VRzone are developed by the best VR game producer, Exit-VR, whose virtual escape rooms won the Best VR Game Awards. This choice was really important for the purpose of the experiment, since a low-level HDM, such as the Google cardboard, would not permit the complete user immersion in the virtual environment, thus limiting the possibility of being fully engaged (Skalski and Tamborini, 2007; Schnack at al., 2019).

In Table 5 are described the main virtual escape rooms used for the experiment.

Table 5 - Virtual escape rooms descriptions

Name	***Description***
Huxley	Year 3007: the world as we know it no longer exists. Humanity has been replaced by machines, what was once green is now destroyed. You are the last survivors and you have a mission: to help Huxley and reverse the apocalypse.

Escape the lost pyramid	February 1928. An expedition led by Sir Beldon Frye disappears somewhere in the Sinai Peninsula. Using the simulation reconstructed from their DNA memory, your team will put themselves in the shoes of the explorers. Find out what happened to the expedition and more importantly: locate what they were looking for.
Space Station Tiberia	The largest meteorite ever discovered by man is on a collision course with Earth; the impact is expected in an hour and will destroy all life on the planet. Your task is to fly to the space station, restore the skipped functionality and activate the anti-meteor laser beam.

Finding real escape rooms was by far easier since are very widespread in Milan. In order to allow a fast and, above all, autonomous data collection, it have been selected seven escape rooms around Millan. This choice, indeed, allow delegating the survey administration to the gamemasters, enabling me to be completely dedicated to the unique virtual escape room present in Milan. In the Table 6 are exhibited the main traditional escape room used for the experiment.

Table 6 - Traditional escape rooms descriptions

Name	***Description***
Il Sottosopra *La casa degli Enigmi*	Time is the key to everything; we are only its pawns. There are infinite parallel universes in which space-time changes and are connected in some way with each other. A grain of sand in one dimension can become a desert in another. There was an event that shocked the blaze of things. Will you be able to redistribute the balance between the various dimensions?
The pyramid *Trap Milano*	The Pharaoh Hor was so proud of his intelligence who spent 25 years and to build a pyramid, in which he invited the sovereigns to try their hand at the task of getting out of it before succumbing to hunger and thirst. The ruler who managed to get out of the Pyramid would become Emperor of all Egypt.
Antarctica *Trap Milano*	A radio signal from S.O.S. was recorded last night by an international research station located in Antarctica. The President himself called us. We don't know what they were studying over there, but what is certain is that its importance goes beyond our initial expectations. He asked to assemble the best task force for a "maximum security" issue. We are not sure what you will face, but what we do know is that you will only have 60 minutes to do it.

4.2 | EXPERIMENT DESIGN

The escape room players, both of the virtual and of real one, have been invited to complete an online questionnaire after the game experience. For this reason, participants were not randomly assigned to the treatment conditions, but unconsciously self-selected based on the escape room played (real or virtual). This leads to classifying the present experiment as a quasi-experiment (Podsakoff and Podsakoff, 2019), defined by Grant and Wall (2009) as *"a study that takes place in a field setting and involves a change in a key independent variable of interest but relaxes one or both of the defining criteria of laboratory and field experiments: random assignment to treatment conditions and controlled manipulation of the independent variable"*. This kind of experiment has the advantages to be less susceptible to criticisms about artificiality and demand characteristics, where being participants less aware of the experimental conditions than in a laboratory experiment, are less subject to some forms of participant reactivity. However, the drawback of this choice is that the two groups have pre-existing differences, for instance, players who decide to play with VR are likely more attracted by virtual reality and can be considered the early adopters of VR (Podsakoff and Podsakoff, 2019).
The survey was accessible through a QR code with a brief explanation of the reason for the questionnaire next to it and administered through www.Qualtrics.com platform. The QR code was provided by the gamemasters in the real escape rooms; while, as anticipated, in the virtual one, due to the small numbers of people attending this kind of escape and the and the uniqueness of the place in Milan, it was provided by me, to increase as much as possible the response rate. The survey was available both in Italian, given the majority of Italian native speakers in the escape rooms, but also in English, in order to access as wide a public as possible. In fact, there were foreign players in the virtual escape room.
In order to try to speed up the data collection, several VR game rooms around the world, providing the same games developed by Exit-VR, have been contacted. Nevertheless, the only ones who answered were one in Bari, one in Lugano and one in Sidney, but all of them, given the novelty of the place and the difficult workers' organizations, weren't able to administrate the questionnaire.
The participation was voluntary, and the respect of players' privacy has been ensured following the principles of the G.D.P.R. regulation on digital privacy protection. The survey administration lasts just over 2 months, from November 7th till January 19th, in order to reach an acceptable number of answers.

The questionnaire was divided into five main sections of questions: control variables; escape room data; self-efficacy questionnaire; engagement questionnaire.

4.2.1 CONTROL VARIABLES

The initial part of the survey was dedicated to collect information regarding players, such as the age, the gender, the education and whether they have precedent experiences with an escape room in general. Afterwards, two specific questions about the game perception have been asked: one about the general game satisfaction; the other about the time pressure. Both the questions were administrated as statements to evaluate with a 5-points Likert scale. The reasons behind such questions are different: the first was demanded since the satisfaction of the game could influence the level of engagement; the second aimed at verifying the role of the time pressure in problem solving.

Finally, only for the virtual escape room survey, two specific questions about virtual reality has been added: the first to know whether players have previous experience with VR; the other to verify the presence of nausea or illness during the experience. The presence of nausea, indeed, is a possible collateral effect of VR and could influence the experience perception, for this reason, it was important to verify this condition.

4.2.2 ESCAE ROOM DATA

After a brief section to gather some information about the players, it has been questioned some data about the escape room and its resolution modalities. Going more in-depth, it was requested:

- The name of the escape room
- The number of players in the team
- The resolution time or the failure
- The number of hints required

This information was essential to operationalize the players' problem solving, and it has been asked to virtual players likewise the real ones.

4.2.3 SELF-EFFICACY QUESTIONNAIRE

In order to measure the perceived self-efficacy, some considerations are important to take into account. First of all, self-efficacy is concerned with people's perceived capability to produce given attainments (Bandura, 1997). For this reason, the items that measure it should be phrased in terms of can do rather than will do. Can, indeed, is a judgment of capability; will is a statement of intention. Perceived self-efficacy is a major determinant of intention, but the two constructs are conceptually and empirically separable (Bandura, 2006). Another important distinction concerns performance outcome expectations. Perceived self-efficacy is a judgment of capability to execute given types of performances; outcome expectations are judgments about the outcomes that are likely to flow from such performances (Bandura, 2006). Finally, preliminary instructions should establish the appropriate mindset that participants should have when rating the strength of belief in their personal capabilities. People are asked to judge their operative capabilities as of now, not their expected future capabilities. This is important because it is easy for people to imagine themselves to be fully efficacious in some hypothetical future (Bandura, 2007). Bearing in mind all these considerations, it was chosen a scale developed by Miller and colleagues (1993) to evaluate students' perceived ability in mathematics and subsequently used in many other studies. Of course, the scale has been slightly modified to best fit with the context. In detail, all the explicit references to mathematics abilities have been substituted with references to the escape rooms studied within the research. The players evaluated their self-efficacy through a five-point Likert scale ranging from "Completely disagree" to "Completely agree", preceded by an instruction to encourage to be as objective as possible (Table 7).

Table 7 - Self-efficacy questionnaire items

Variable	*Questionnaire items*
Instructions	*Please rate how much you agree with the following statements about your current abilities in escape rooms. Try not to be modest and be as objective as you can.*
Self-efficacy	1. I have a good understanding of the escape room's puzzles 2. I am confident I have the ability to understand the puzzles of an escape room 3. I am certain I understand the problems presented in an escape room. 4. I am confident about my ability to solve the puzzles of an escape room. 5. Compared with other players in my team my skills are weak. 6. I think I am doing better than other players in my team.

7. Compare to others in my team, I think I am good at playing an escape room
8. I am confident that in the escape room I can perform as well or better than other players

4.2.4 ENGAGEMENT QUESTIONNAIRE

As already seen in the literature review, to measure the engagement it was considered the tripartition defined by Khan (1990). Nonetheless, Khan (1990) defined the engagement in its dimensions but didn't measure them empirically. Therefore, in order to test empirically the hypotheses, the Rich and colleagues' (2010) scale has been used, since is the scale that best represents the Khan's dimensions. It is based on a self-reporting questionnaire, with six items per each engagement layer. The items were built by studying the engagement measures present in the literature at their time and reviewing them to fit better Khan's conceptualization, starting from engagement behavioural manifestations. For instance, physical engagement measure was developed by rearranging Brown and Leigh's (1996) "work intensity," which the authors defined as the "energy exerted per unit of time". They significantly modified the items to promote greater conceptual correspondence with Kahn's conceptualization of the physical engagement dimension, for example widening the focal situations and the circumstances in which could express the effort. To measure the emotional aspect of engagement, the starting point was Russell and Barrett's (1999) research on core affect, defined as a somewhat generalized emotional state, consisting of two independent dimensions: pleasantness (feeling positive) and activation (a sense of energy). To be consistent with Kahn's description, Rich and colleagues (2010) wrote items that refer to emotions reflecting both high pleasantness and high activation, such as enthusiasm, excitement, energy, interest. Finally, the cognitive aspect of engagement was assessed widening Rothbard's (2001) measure, which includes both attention, understood as the level or amount of focus, and concentration and absorption, the level of engrossment or the intensity of the focus and concentration. Although Rothbard distinguished between these two facets in her analyses, the dimensions were strongly related, for this reason, they did not maintain the distinction. Rather, they refined six items from Rothbard's scale to promote conceptual consistency with Kahn's description of the cognitive aspect of the engagement.

Thanks to all this work, Rich and colleagues' (2010) scale was used by several authors as Job Engagement Scale for measuring the Kahn's (1990) engagement dimensions and it has been chosen for this research as the best representative of Khan (1990) theory. However, in order to be applied to the present study, the scale has been slightly modified to best fit with the context. Going more in-depth, all the explicit references to the job place have been substituted with references to the escape. Table 8 exhibits set of eighteen items chosen, for each of which the players have been asked to evaluate how much their behaviours were characterized by those manifestations through a five-point Likert scale ranging from "Completely disagree" to "Completely agree".

Table 8 - Engagement questionnaire items

Variable	*Questionnaire items*
Cognitive engagement	1. I worked with intensity on complete the game
	2. I exerted my full effort to complete the game
	3. I devoted a lot of energy to solve the game's puzzles
	4. I tried my hardest to perform well on this game
	5. I strived as hard as I can to complete the game
	6. I exerted a lot of energy on this game
Emotional engagement	1. I am enthusiastic about the game
	2. I felt energetic when playing
	3. I was interested to solve the game
	4. I am glad of my participation
	5. I feel positive about my participation at the game
	6. I am excited about my involvement in the game
Physical engagement	1. In the escape room, my mind was focused on the game's puzzles
	2. I paid a lot of attention to the game's puzzles
	3. I focused a great deal of attention on solve the game' puzzles
	4. I was absorbed by solving the game's puzzles
	5. I was concentrated on solving the game's puzzles
	6. I devoted a lot of attention to solve the game

4.3 | Data analysis

This section aims to show the procedure used for the validation of the research hypotheses. The data were downloaded in an excel format, afterwards, all the answers were converted in a numeric format, even the categorical variables, in order to analyse them easily through SPSS Statistics. All the analyses have been entirely run with SPSS Statistics. During these passages, the fifth items of the self-efficacy (*Compared with other players in my team my skills are weak*) was translated to have, as the other items, the maximum value in correspondence with a high perceived self-efficacy. After having analysed the population through some descriptive statistics, analyses were performed to verify the hypotheses, which are presented in the following lines.

4.3.1 Factor Analysis

The first step to analyse both the engagement and the self-efficacy was to lead the factor analysis to reduce the items measured to fewer latent variables that share a common variance, known also as reducing dimensionality (Yong and Pearce, 2013). It was used a Principal Axis Factor method, based on the notion that all variables belong to the first group and when the factor is extracted, a residual matrix is calculated; the factors are then extracted successively until there is a large enough of variance accounted for in the correlation matrix (Tucker & MacCallum, 1997). Principal Axis Factor is recommended when the data violate the assumption of multivariate normality (Costello & Osborne, 2005). Factors were rotated orthogonally with Varimax technique, that minimizes the number of variables having high loadings on each factor and works to make small loadings even smaller. This process makes easier to identify variables' belonging to each factor (Yong and Pearce, 2013). Finally, the factor score, so the variable describing how much an individual would score on a factor, was calculated with the regression approach since produces unbiased scores that are correlated only with their own factor (Yong and Pearce, 2013).

In order to ensure that variables in each proposed construct (Khan (1990) engagement dimensions and self-efficacy) were internally consistent, reliability assessment was carried out using Composite Reliability (CR), Chronbach's Alpha and Average Variance Explained (AVE). Indicators loadings of CR and CA above 0.7 are commonly accepted as implying that variables are internally related in the manner expected, while the AVE should be higher than 50% (Hair et al., 2011, Liu et al., 2004).

When this initial phase has been ended, two different procedures were used to validate the two models.

4.3.2 MODEL 1

The first three hypotheses were assuming that who plays in virtual reality engages himself differently from who plays without it. Therefore, it needed to test whether existed a significant difference in each of the Khan's engagement dimensions between the two groups of players. For this purpose, it was used an independent t-test, that compares two groups on the mean value of a continuous, normally distributed variable, in order to determine whether the means of the two sets of data are significantly different from each other. The model assumes that a difference in the mean score of the dependent variable is found because of the influence of the independent variable that distinguishes the two groups. As seen, t-test requires normal populations, anyway for moderately large samples, the t-test is relatively robust to moderate violations of the normality assumption. In large enough samples, the t-test asymptotically approaches the z-test and becomes robust even to large deviations from normality (Lumleye et al., 2002). Many studies have tried to assess what concretely means "large enough" and a number of authors have examined the level and power of the t-test in fairly small samples: Barrett & Goldsmith (1976) examined the coverage of the t-test in three small data sets and found good coverage for sample sizes of 40 or more; Sullivan & d'Agostino (1992) found that t-tests produced appropriate significance levels even in the presence of small samples (50 or less); Sawilowsky & Hillman (1993) showed that power calculations based on the t-test were appropriate, even when the data were decidedly non-Normal in sample sizes up to 80 observations. All these considerations made the t-test good model to catch potential differences between the two groups of players.

4.3.3 MODEL 2

The fourth, the fifth and the sixth hypothesis aim to test whether exists a positive relationship between each engagement dimension and the problem solving, operationalized in clues and resolution time. Times and clues were divided into three sub-groups in order to have enough observations for each one. In detail, resolution time was divided in:

- Less than 50 minutes, considered high problem solving;
- Between 51 and 60 minutes, the average time for complete an escape room, thereby an average problem solving
- Not completed, thus the failure of the game and a low problem solving.

The clues, instead, were grouped in:

- 0-1clues: very low request of help, thus a high problem solving;
- 2-3 clues: the average request, therefore an average problem solving;
- 4 or more clues: a request for help exceeding the hints generally given, thus a low problem solving.

Given these classifications, to test whether players experienced different levels of engagement on the basis of their problem solving it was used a one-way Analysis of Variance (ANOVA). The ANOVA, or F-test, is used for examining the differences in the mean values of the dependent variable associated with the effect of the controlled independent variables, after taking into account the influence of the uncontrolled independent variables. It is based on the law of total variance, where the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In its simplest form, ANOVA provides a statistical test of whether two or more population means are equal, and therefore generalizes the t-test beyond two means. The ANOVA analysis assumes the independence, normality and homogeneity of variances of the residuals. Nevertheless, it has been chosen for its robustness. It has been demonstrated, indeed, that the F-test is robust to slight, moderate, and severe departures from normality, with various sample sizes (equal or unequal sample size) and with same or different shapes in the groups (Blanca et al., 2017). As the goal of the experiment is analyse the differences in the relationship in virtual environments, the analysis was performed times: one with the whole dataset, regardless the kind of the escape room played; one just with the players of the virtual escape room; one only with the data of the real escape room.

Finally, the correlation between self-efficacy and each engagement dimension was analysed using the Pearson correlation test. Like the other methods, also the Pearson correlation was chosen for its robustness since it has been demonstrated that us a valid technique even when the sample size is very small. David (1938), in fact, argued that a sample size of 25 observation is enough; Bishara and Hittner (2012), after having compared different correlation methods, concluding that Pearson correlation test is the most robust among all, especially when the sample size is small till a minimum of 5 observations. Pearson correlation is a bivariate analysis that, under the assumption that both variables are normally distributed, measures the strength of association between the two variables and the direction of the relationship, verifying the presence of statistical evidence of association. While the statistical evidence is assessed through a two-tails test, the R coefficient (Pearson's R) measures the strength of the correlation between the two variables. To assess the strength of the association, the R coefficient should be greater or equal to 0.3 for a weak association and a minimum of 0.5 for a significance association (Stander and Rothmann, 2010). Analogously to the previous analysis explained, also in this case, Pearson's R were calculated both in the whole population, regardless of the experience played and in the two specific groups of players.

5 | EMPIRICAL RESULTS

This section aimed just to show the results, without drawing conclusions from them. These are presented in sections, corresponding to the ones of the analyses done. In detail, after a brief introduction of the descriptive statistics, the factor analysis' results are described, following by the ones of the two models.

5.1 | DESCRIPTIVE STATISTICS

Overall, 163 observations have been obtained, 75 in the virtual escape room and 85 in the traditional one. Since the research goal is studying the differences in using virtual reality, the descriptive statistics will show the two sub-sample (virtual and real) by comparison. While the two populations are equilibrated in terms of gender (VR: F 40% M 60%; Real F58% M 42%); the first difference comes out with the age, where the virtual players are on average younger, as exhibits in Figure 13 and Figure 14.

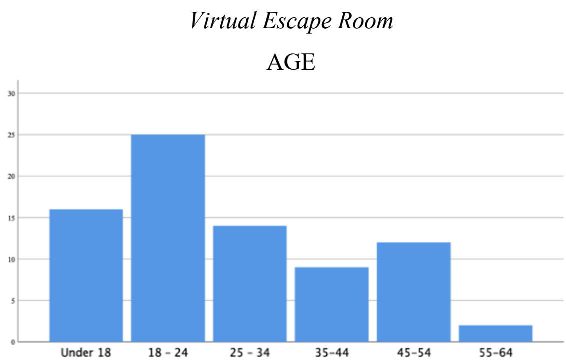

Figure 14 - Population age (VR)

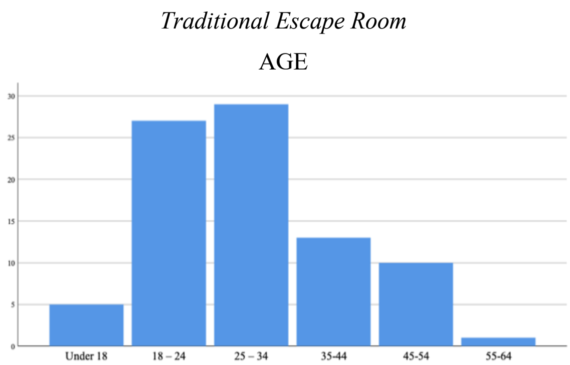

Figure 13 - Population age (real escape room)

Generally speaking, the escape rooms are played by the last generations, the so-called Y and Z, but with a slight difference between the two experiences. In detail, the virtual escaper room seems to be more attractive to Generation Z, while the oldest millennials still prefer traditional escape rooms. Therefore, the level of education is slightly higher in the traditional escape room, with a prevalence of people having completed a bachelor's or a master's degree. The previous experience in playing escape rooms is not a differential and in both the groups almost a half had already tried an escape room. An interesting difference is instead the variation of the time pressure. Indeed, if in the traditional escape room the perceived time pressure is strong, as it can be expected from a time-limited game; it is poorly perceived in the virtual escape room, almost as if in virtual reality the perception of a real dimension, like time, was more difficult. Finally, concerning virtual escape rooms, just 17% of the people feel sick during the game, nevertheless, this does not influence their engagement (verified with a t-test).

5.2 | Factor analysis

The first step of the analysis was to reduce the dimensionality of the variable verifying the internal consistency of constructs. Table 9 presents the results of the factor analysis. The items are indicated with the name of the variable measured, follow by the number of the construct (*VariableName_#Item*).

Table 9 - Factor Analysis results

Items	***Cognitive Factor Loading***	***Physical Factor Loading***	***Emotional Factor Loading***	***Self-efficacy Factor Loading***
Cognitive_3	,875			
Cognitive_5	,810			
Cognitive_2	,783			
Cognitive_6	,782			
Cognitive_1	,777			
Cognitive_4	,717			
Physical_5		,834		
Physical_2		,788		
Physical_6		,782		
Physical_4		,777		
Physical_3		,752		
Physical_1		,709		
Emotional_4			,821	
Emotional_5			,796	
Emotional_6			,791	
Emotional_3			,731	
Emotional_1			,702	
Emotional_2			,640	
SelfEfficacy_1				0,726
SelfEfficacy_2				0,732
SelfEfficacy_3				0,665
SelfEfficacy_4				0,645
SelfEfficacy_5				0,649

SelfEfficacy_6	0,617
SelfEfficacy_7	0,652
SelfEfficacy_8	0,596

The first check to the validity of the analysis is given by the factors loading resulted by the extraction with the varimax rotation. In order to be considered reliable, all the construct should score a factor loading higher than 0.6 (Hair et al., 1998). As it could be expected, given the high validity of the scales chosen, all the indicators loadings are acceptable, a symptom of high construct reliability. Furthermore, the results exhibit in Table 10 strength such consideration.

Table 10 - Analysis of internal consistency's results

Factors	***CA***	***CR***	***AVE***
Physical engagement	0.917	0.900	60%
Emotional Engagement	0.877	0.884	56%
Cognitive Engagement	0.945	0.910	63%
Self-efficacy	0.873	0.861	44%

Cronbach's alphas (CA) and Composite Reliability (CR) values revealed high internal consistency for all the factors outscoring the value of 0.8 and being close or upper the value of 0.9 (George and Mallery, 2003). Furthermore, in support of the constructs validity, each factor indicates values for the average variance extracted (AVE) above the required limit of 50% (Homburg and Giering, 2001). The only loading under the value desired is the AVE of the self-efficacy, anyway the good score of the CA and CR are enough to affirm an acceptable internal consistency. Therefore, the scales have good convergent validity reliability (Zhou, 2018).

5.3 | Model 1

Afterwards having built the engagement factors, it was possible to analyse the engagement making a comparison between the two groups of players, the one who plays with virtual reality and the other solving a traditional escape room. Table 11 shows some descriptive statistics of the two populations.

Table 11 - Players' engagement descriptive statistics

Format	***Variable***	***N***	***Mean***	***Sn deviation***
Virtual Escape Room	*Cognitive Engagement*	78	-0,0474349	1,10975338
	Physical Engagement	78	0,0955899	1,0252293
	Emotional Engagement	78	0,1134593	0,97424349
Real Escape Room	*Cognitive Engagement*	85	0,0435285	0,89198745
	Physical Engagement	85	-0,0877178	0,97406201
	Emotional Engagement	85	-0,1041156	1,01764153

As can be seen, the extent of the two-sample size is pretty much the same. The average of cognitive engagement is slightly superior in the players of traditional escape rooms, while the other two engagement dimensions are somewhat higher for the virtual players. Nevertheless, in order to verify whether the differences in the means of the two groups were significant, an independent t-test analysis was led. The results are exhibits in Table 12.

Table 12 - t-test results

Variable	***Equal variance***	***F***	***Sig.***	***t***	***df***	***Sig. 2-tailed***	***Mean difference***
Cognitive Engagement	assumed	3,524	0,062	-0,579	161	**0,563**	0,09096
	not assumed			-0,574	147,757	0,567	0,09096
Physical Engagement	assumed	0,739	0,391	1,17	161	**0,244**	0,18331
	not assumed			1,168	158,013	0,245	0,18331
Emotional Engagement	assumed	0,198	0,657	1,392	161	**0,166**	0,21757
	not assumed			1,394	160,704	0,165	0,21757

For all the three engagement dimensions the assumption of equal variances holds (p > 0.05), thus the results take into considerations are the ones of each first line. The Sig. (2-tailed) represent the significance level, also called "p". In order to reject the null hypothesis that the population means are equals, it is necessary a p-value lower than 0.05. In the experiment, all the engagement dimensions present a p-value higher than 0.05, thereby is not possible to reject the null hypothesis. This result implies that the two groups of players experienced the same level engagement, in all its different aspects, regardless of the kind of escape room played. Therefore, all three hypotheses of Model 1 (H1, H2, H3) have been rejected.

5.4 | MODEL 2

The second model was examined in two different steps: one dedicated to the relationship between engagement and problem solving; the other aimed at studying the role of self-efficacy. Both the analyses have the final aim of comparing such relationships in the two environments, real and virtual, in order to study whether there are significant differences. Starting from the relationship between the three engagement dimensions and the problem solving, operationalized in clues and time, the first interesting step is to observe the distribution frequencies based on the resolution time and the requested clues, shown in Table 13 and in Table 14.

Table 13 - Resolution time's frequencies

Sample	***Less than 50'***	***51'-60'***	***Not completed***
Whole sample	36%	30%	34%
VR sample	63%	26%	12%
Real sample	11%	34%	55%

Table 14 - Clues' frequencies

Sample	***0-1 clues***	***2-3 clues***	***4 or more clues***
Whole sample	17%	45%	38%
VR sample	31%	42%	27%
Real sample	4%	48%	48%

The most impacting difference is observable in the first table, where while in the traditional escape room the major part of player fails in completing the game; in VR there is the opposite situation and the greater slice of population solve the room in less than 50 minutes. Concerning the clues, the distribution is more equilibrated, even if, even here, in the traditional escape room a lower percentage of people is present in the "high problem-solving category". These results give already noteworthy insights that it will be important taking into account.

After having studied the descriptive statistics, it was performed an ANOVA analysis on the whole population, regardless of the game experience. Figure 15 summarized the results found.

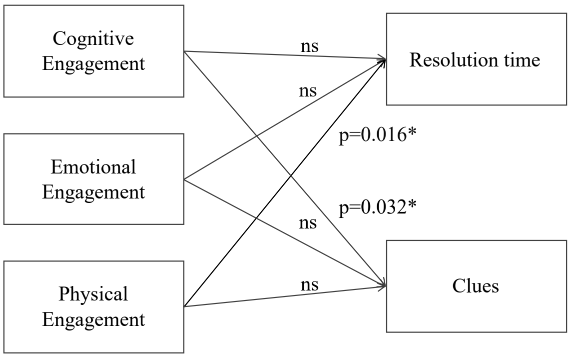

Figure 15 - Problem-solving results

The only significant relations found are the ones between cognitive engagement and clues and resolution time and physical engagement. Both the relationships are positive, thus at a high level of problem solving correspond highly engaged people. In detail, players who asked fewer hints were significantly more cognitively engaged than the other with F(2,160)=3.53, p=0.032; while playas who completed the room faster, thus demonstrating a greater problem solving, were significantly more physically engaged, with F(2,160)=4.26, p=0.016.

Nonetheless, as anticipated, these results consider the whole group of players, without investigating the differences between the two kinds of experiences (virtual and real). To accomplish this purpose, the same analysis was repeated considering the two groups separately, to assess whether the use of virtual reality would change some paths. Figure 16 and Figure 17 exhibits the two results.

Virtual escape room

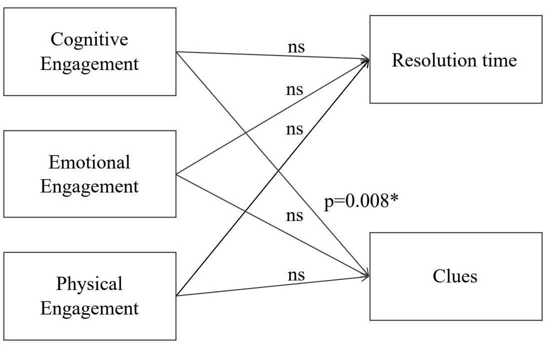

Figure 17 - Problem solving results in VR

Real escape room

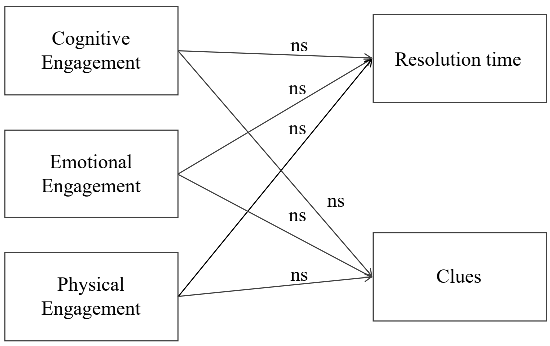

Figure 16 - Problem solving results in real escape room

The first thing that can be noticed is that in both the samples the relation between resolution time and physical engagement becomes not significant. In order to investigate the reason, a comparative analysis of the engagement trend during the resolution time was led. Figure 18 shows this analysis graphically.

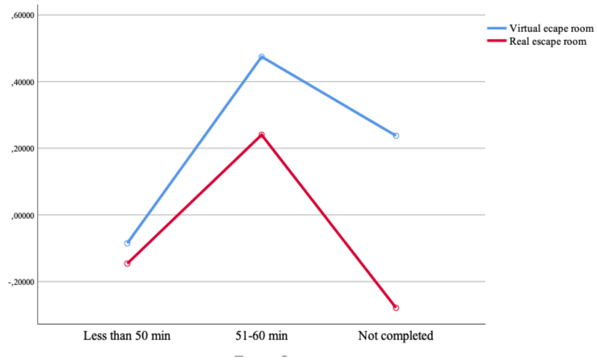

Figure 18 - Physical engagement means per resolution time

The engagement trend is the same for both players. Furthermore, it was divided the dataset into the three groups of players on the basis of the resolution time, afterwards, it was used the t-test to verify whether there were differences in the engagement means between virtual and real players, in each of the three groups. In all the three cases, there was no significant difference, therefore the engagement trend is the same and the means at the three levels too. This could explain why in the whole dataset there is a significant relationship that in the two samples is not present: in the two sub-groups the sample size is not enough to have significant relations, but having the same paths, the sum of the two produces significant results in the whole dataset.

The other difference regards the cognitive engagement, whose relationship with the clues is significant both for the whole population and specifically for the virtual player, while in the traditional escape room there were no significant paths. As in the previous cases, further investigation has been done in other to understand better variation. Figure 19 exhibits the trends of cognitive engagement in the two samples.

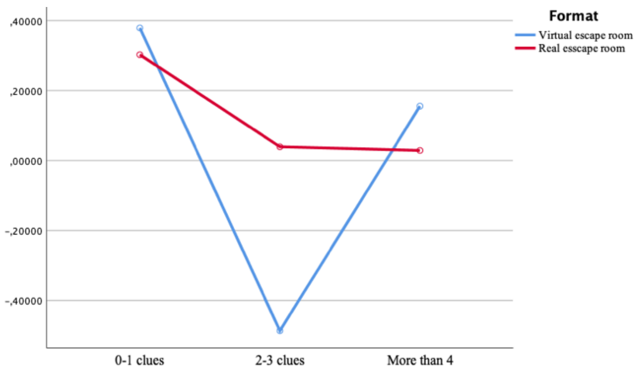

Figure 19 - Cognitive engagement means per clues

As it can be seen, in this case, the first thing that can be noticed is that in the virtual experience there is a grader engagement fall in the 2-3 clues group; while the cognitive engagement in the real experience is almost the same in all the clusters. Going more in-depth, with the same procedure explained before, but dividing the dataset on the basis of the clues required, it resulted that the cognitive engagement of who asked 2-3 clues in VR is significantly lower than the cognitive engagement of who asked the same amount of clues in the traditional escape room (p=0,049*). Therefore, in conclusion, while in the traditional escape room there are not variations of the cognitive engagement linked to the request of clues, in virtual reality such relationship exists and is strong. Anyway, the cognitive engagement trend has not a clear interpretation.

The second part of the analysis concerns the relation between the three engagement dimensions and the self-efficacy. The results of the Pearson's correlation in the whole population are presented in Figure 20.

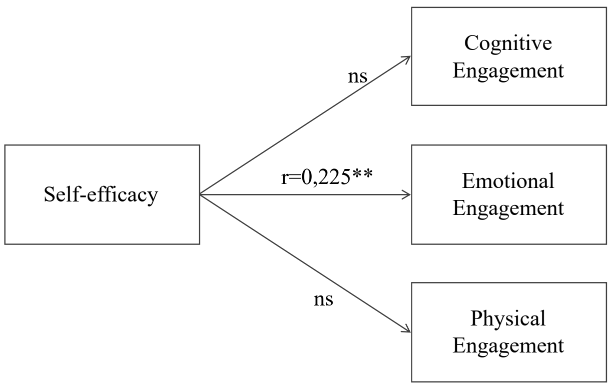

Figure 20 - Self-efficacy results

With $p < 0.01$, it can be concluded that the only significant relationship is between emotional engagement and self-efficacy and it is positive; thereby a rise in the perceived ability corresponds to a rise in emotional involvement. However, again, the testing on the whole sample does not consider that respondents were exposed to different experiences. Therefore, the analysis was repeated in the two different groups of players. Figure 21 and 22 show the results obtained.

Virtual escape room

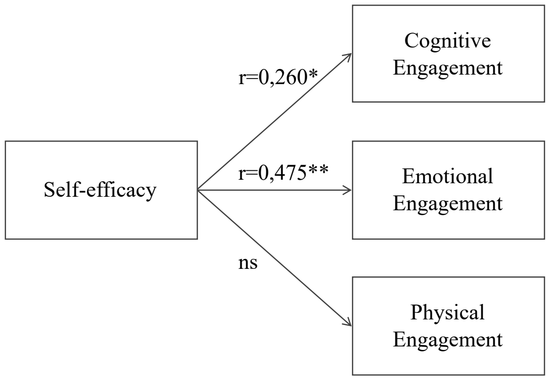

Figure 22 - Self-efficacy results in VR

Real escape room

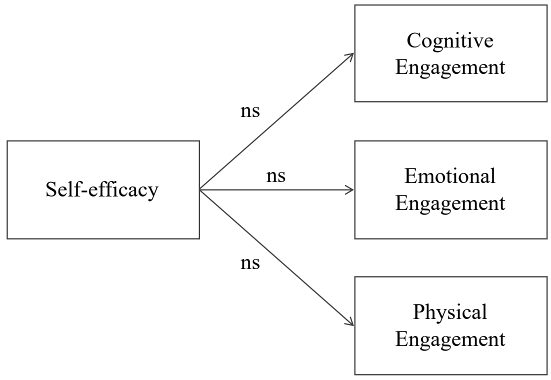

Figure 21- Self-efficacy results in real escape room

Firstly, it can be noticed that the positive relationship between emotional engagement and self-efficacy becomes even stronger in the virtual players, going from a Pearson's R equal to 0.225 in the whole sample to an r=0.475 in the virtual subgroup, confirming the validity of H7; on the other hand, the same relationship gets not significant in the traditional escape room's players. Another noteworthy difference is the correlation between engagement and self-efficacy, with $p < 0.05$ and r=0.260 it becomes significant for the virtual escape room (H8), while remains not significant in the real one. These results are enough to affirm that in the virtual game the role of the self-efficacy in influencing the engagement is important and required peculiar attention. Nevertheless, the possible reasons being this will investigate in the next section.

6 | DISCUSSION

From the literature it was expected that immersion in virtual environments could capture players' attention so that it causes them to dive inside the simulated world, allowing higher involvement (Narraro-Haro et al., 2016) and causing them to engage in deeper cognitive processing (H1) (Hanson & Shelton, 2008; Lee et al., 2017). It also was expected that virtual images, were able to affect the individuals' emotional involvement, enhancing their motivation, excitement and enjoyment (H2) (Pantelidis, 2009; Pantano and Corvello, 2014; Marasco et al., 2018). Finally, it was expected that the unique capability of allowing a first-person experience, would enhance users' activation and commitment, therefore their physical engagement (H3) (Youngblut, 1998; Lau et al., 2018). All these hypotheses in the present empirical research are not proven, nevertheless, this can lead to interesting considerations. First of all, in the experiment, the difference between the two groups is just the introduction of the technology, while the experience lived, and logics of the escape rooms are exactly the same. In other words, the "meaning" of the experience, "the profound psychological and cultural reasons people use a product" (Verganti, 2011) does not change between the two groups. Verganti (2011) explains that meaning can imply an individual or social motivation. Individual motivation is linked to psychological and emotional meaning, thus what users intimately feel when they use a product; while social motivation regards symbolic and cultural meaning, so what the product says about the user to others. In the case of the experiment, virtual reality does not change the meaning of the escape room but just the way it is delivered, thus not "why play" and therefore the individual or social motivations, rather "how to play". Virtual reality, used in this way, becomes what is commonly known as "Technology-push innovation", that is, the result of dynamics of scientific and technological research (Verganti, 2011). This could be a reason why, in this empirical research, virtual reality is not enough to rise the no one of the three dimensions of the engagement, since it does not change the phycological and emotional meaning. The experiments in the field that demonstrated a rise of some behavioural manifestations of the engagement with the use of virtual reality, compared VR with the flat-screen format, thus with the difference of being immersed in the experience and living it. For instance, the experiment of Lee and colleagues (2017), made in a business classroom, compared a traditional educational video about Nepal, watched through the iPod Touch, with an immersion in Nepal using VR that taught the same contents but living them. In that case, was not surprising that the group in the VR condition rated its enjoyment and interest to be higher. The students not only used new technology, but they also lived a new experience, a new way of learning contents, active rather than passive. In this example, VR changed how the content was delivered, but also the meaning, where the educational content became from something to learn to something to live. This is what is defined as a "technology epiphany", the overlapping between technology push and design-driven innovation, that is an innovation of meaning (Figure 23) (Verganti, 2011). Therefore, it could think that technological innovation is not enough to increase users', but that a technological epiphany can succeed in this aim.

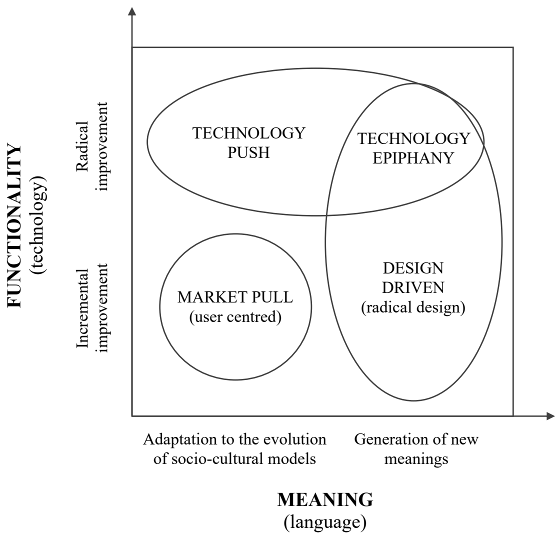

Figure 23 - Innovation Strategies and the Positioning of Technology Epiphanies

A well-known example of technology epiphany is the Nintendo Wii, the game console with motion-sensitive controllers that allows people to play games by making real movements. Before the Wii, games consoles were considered entertainment with a passive immersion into a virtual world, and firms, such as Sony and Microsoft further reinforced this meaning by developing consoles with more powerful graphics and performance. The Wii overturned this meaning: it stimulated active physical entertainment, in the real world, through socialization. "People did not ask for that meaning. But they loved it once they saw it" (Verganti). The experiment of Lee and colleagues (2017) contained exactly the same change of meaning. All these considerations bring to the conclusion, that even in the presence of great technological innovations, as could be the virtual reality, technology is not enough to fully conquer the users, and in the specific case, to increase their engagement. Anyway, following Verganti's (2009) theory, virtual reality has surely a set of disruptive new meanings that are waiting to be uncovered, and Lee's research confirmed it. Nevertheless, the experiment brings to another noteworthy conclusion: the simulation of real experience in virtual reality engages the users as much as live the corresponding real experience. In the experiment, indeed, the engagement means were the same in the real and virtual sample. This consideration is linked to a study made by Meehan and colleagues (2002), where they affirmed that the great potential of VR is that the virtual representations seem so realistic as to induce users the same emotions they would have in a real situation. This could explain why in the medical field VR is considered an excellent tool for treating anxiety or stress disorders, exposing gradually patients to the experience which causing then anxiety (Narraro-Haro et al., 2016). Therefore, for the same meaning, virtual reality, as technological innovation, is not enough to increase the participants' engagement, but still manages to engage users in the same way, acting as a valid reality simulator.

Another important result of the experiment regards the role of physical engagement in the relationship with problem solving (H6). Physical engagement, indeed, is the only engagement dimension that not change its trend between the virtual and the real experience and is positively correlated with the resolution time. This is a noteworthy result since demonstrated that among the three dimensions of engagement, physical engagement is the best predictor of performance (Lauring and Selmer, 2018) also in virtual reality. According to Schaufeli et al. (2002) individuals physically engaged are seen as being energetic, mentally resilient, and able to persist when difficulties arise. Physical engagement also entails a willingness to invest effort on the job. With regard to job adjustment and time to proficiency, vigorous employees have been found to have greater influence over events that affect their lives. Physically engaged individuals have been argued to have a high level of connectivity with their work tasks and being highly concerned with performance outcomes (Bakker and Demerouti, 2008; Christian et al., 2011; Britt et al., 2012). For instance, Lauring and Selmer (2018) demonstrated that having expatriate academics physically engaged will increase their possibility of performing well despite the novelty of working abroad. Bakker et al. (2004) showed that physically engaged employees received higher ratings from their colleagues on both in-role and extra-role performance, indicating that physically engaged employees perform well and are willing to go the extra mile. This may explain why both in VR and real escape room physical engagement is higher in who solve the room faster, without trend variations in the two formats and with a positive relationship in the whole dataset. Physically engaged individuals are the ones that make more effort in solving problems, despite the novelty of the context, so physically engaged individuals solve the room faster than others both in the real and in virtual environment, without differences due to the format utilized.

Finally, the last important conclusions of this work concern the role of self-efficacy, where the experiment demonstrated that only in VR self-efficacy is positively correlated with cognitive engagement (H7) and emotional engagement (H8), while in a traditional experience such relations do not exist. This result can be linked to a similar discovery made some years ago studying users' response to computers, and more recently to virtual online training. Searchers in the past noted that a large percentage of workers who used computers on a daily basis experienced some anxiety (Frank and Rickard, 1988; Hemby, 1998). Goldberg (1998) described such feelings as "high tech anxiety" and noted the difficulty of dealing with the constant effect and change of technological advances. This "high tech anxiety" was found out being negatively correlated to the computer self-efficacy, where computer self-efficacy (CSE) is a neologism defined by Compeau and Higgins (1995) as "a judgment of human's capability to use a computer". Furthermore, scholars found that computer self-efficacy affects the level of effort expended on a computer-related task and influences a person's tendency to engage in the task, as well as the level of exertion and endurance exhibited (Bandura, 1995; Muira, 1987). In other words, lower computer anxiety corresponds to higher computer self-efficacy and higher self-efficacy to a higher level of engagement (Durndell, and Haag, 2002). These studies were taken up more recently by Pellas (2014), who investigated empirically how students' personal factors can affect their engagement in online learning courses. The experiment involved 305 novice or expert students (153 graduates and 152 postgraduates) who enrolled in online courses at the university level and among the personal factors were verified the effects of computer self-efficacy. The research demonstrated that even in the online courses, computer self-efficacy was positively correlated with the engagement, more precisely, with cognitive and emotional engagement. These results are in line with the ones of the present study, therefore, considering that virtual reality is one of the high technologies of our era, it is plausible to think that exists "high tech anxiety" also in virtual environments. Such anxiety becomes an obstacle to the engagement, therefore only who has a high self-efficacy can also experience higher engagement. This would explain why in the traditional escape room there no correlation between engagement and self-efficacy is: no anxiety has to be to overcome to involve themselves, thus self-efficacy does not play an important role in determining engagement. Furthermore, the fact that just emotional and cognitive engagement are strongly related to self-efficacy, strengths the theory that individuals physically engaged are the ones who better react to new contexts. In this case, in fact, they were able to engage themselves in virtual reality, independently to their self-efficacy. To sum up, VR causes a sort of "high tech anxiety", for this reason,

it is needed self-efficacy to have positive attitudes towards the technology and be emotionally and cognitively engaged in the virtual experience. Physical engagement, instead, falls outside this reasoning, since individual physically engaged are the ones who better respond to new situations or difficulties.

7 | CONCLUSIONS

7.1 | THEORETICAL IMPLICATIONS

This dissertation is the first empirical research that investigates the relationship between the use of virtual reality and the three engagement dimensions, therefore it becomes really important to define the theoretical implications, in the hope to be useful for further studies.

The first theoretical contribution is the possible link between the engagement and the theory of technology epiphany. In the experiment, indeed, VR has been used just as technology-push innovation, without any change of meaning, resulting in equal engagement between the two groups; while the experiments in the literature that demonstrated a rise of attention, excitement or activation, used VR as technology epiphany (Nielsen and YuMe, 2016; Lee et al., 2017; Lau et al., 2018; Vesisenaho et al., 2019). Verganti (2011) explains that meaning can imply an individual or social motivation, thus if the motivations do not change, it can change the engagement. This partially reinforces the current knowledge on technology epiphany, applying such theory to one technology not consider yet and demonstrating that without changing the meaning the users do not fall in love with the innovative technology.

Another noteworthy implication is that virtual experience is able to engage individuals as much as the corresponding real one, considering all the three engagement dimensions. This enlarges the findings of Meehan and colleagues (2002), under which the degree of presence evoked by a virtual environment generates physiological responses similar to those induced by the corresponding real environment (Meehan et al, 2002). Due to this research, it is possible said that even the engagement, in all its dimensions, evoked by a virtual environment, is equal to the one induced by the corresponding real environment. Therefore, virtual reality becomes an optimum substitute whenever reality is not possible.

Finally, the last noteworthy contribution is the enlargement of the current knowledge about "high tech anxiety": it is not caused only by computer but also by virtual reality, and, more in general, by technological innovations. Virtual reality can cause difficulty due to dealing with the constant effect and change of technological advances (Goldberg, 1998). Such difficulty acts as an obstacle for engagement, and in detail for emotional and cognitive engagement. Only individuals with high perceived self-efficacy are able to engage themselves. People highly physically engaged falls outside this reasoning, since they are the ones who better perform despite the novelty of context. Therefore, physical engagement is less subjected to “high tech anxiety” and hence to self-efficacy, extending further the knowledge on this theory.

7.2 | Managerial implications

Confirming virtual reality as an optimum reality simulator, beyond contributing to the VR’s knowledge, may give noteworthy insights also to firms. VR’s ability to engage users as much as the corresponding real experience makes it an optimum tool to engage employees in a work in all the contexts in which live a real experience is impossible or difficult. Besides the already mentioned examples, such as in the medical field to simulate operations or treats mental disorders, or in the tourism to engage potential visitors in a potential destination, there could be a variety of other applications. For instance, VR could enhance the employees’ engagement in design or test new products or locations; it could improve workers training, both hand and soft, thanks to simulations of situations or role-play. It could also allow experiencing something with the eyes of "different" people, for instance, disables. There could be many new opportunities for companies as proposing new business, products and services. Anyway, these are just insights. The most significant knowledge that managers should take from this study is that VR is an opportunity only used in two ways:

- A substitution of reality only if the real corresponding experience is impossible or too difficult to realize: in this case, the content of the virtual experience could be the same as the real one and it is possible to gain the same engagement of the corresponding real experience.
- An innovation of meaning in all the other cases: it is not possible to require virtual reality an extra impact on users if the virtual experience is an equivalent version of the real one. Why would users prefer a virtual experience to a real one? It needs to give users good reasons to leave their reality behind and immerse themselves in a new one, it needs to give them a new meaning.

Once clarified this last point, assuming that virtual reality was implemented in companies, the other advice than this research may give to the managers is about how introducing VR with employees. It has been discovered that virtual reality can cause “high tech anxiety”, therefore it is important to first make people confident with this technology, trying to increase their perceived self-efficacy, so that they can engage themselves without inhibitions due to “high-tech anxiety”. In this process, a good choice could be starting from pilot projects with individuals who usually are physically engaged in their work, because, as seen, they are the ones who spend more effort despite the novelty of the contexts and who can achieve betterer results.

7.3 | Limitations

Of course, this research is not beyond limitations. First of all, being virtual reality not enough spread and known, few people play virtual escape rooms. This led to gather fewer data and have a smaller sample size. Sample’ size has created issues in particular in the validation of the research hypothesis linked to the problem solving (H4, H5, H6), where the tests used were less robust than the ones for the other hypotheses. The other relevant limitation of this research is the impact of common method bias in self-reporting questionnaire. Therefore, even if measures to reduce this risk have been taken, especially following Bandura’s (2006) indications for the perceived self-efficacy, the nature of the questionnaire is potentially affected by bias.

The other limitations are linked to the choice of a quasi-experiment (Podsakoff and Podsakoff, 2019), as the presence of pre-existing differences between the groups or the use of escape rooms which restricts the sample of players. This might not constitute an overwhelming concern for real escape rooms, as nowadays are very spread and the population is almost heterogenous. It could be a limitation in VR, where players are a restrict part of the population who knows VR, places in where play it and who is willing to try it. Besides, the low average age (mainly Z and Y generation) may further restrict the generalizability of the results to a broader population. Specifically, “high tech anxiety” might less affect younger players who decide to play with VR than older people who do not know well this technology. Hence, the influence of self-efficacy might be even greater for such populations. Finally, the choice of a game as experience for the experiment in study engagement can be misleading, since games are considered engaging for their nature, indeed, the average engagement means were high in both the sample.

7.4 | FUTURE DEVELOPMENTS

If on the one hand, this work is subject to limitations, on the other hand, there are some future developments that it is hoped will be meaningful for the next studies.

First, future research may enhance the generalizability of results by investigating a wider population, both in terms of size and heterogeneity. For instance, including more baby boomers and generation X and considering also people who do not know virtual reality well, with a field experiment base on randomly assigned participants. Besides improve the results of the present experiment, it could be interesting studying empirically the relationship between the use of virtual reality and the engagement dimensions but using VR as technology epiphany. For instance, compared VR with a flat-screen format, or even more challenging, compare VR with a real experience working on change the meaning in the virtual one.

Another interesting study regards the role of perceived self-efficacy in enhancing engagement. Therefore, it might be interesting to compare engagement results in a virtual experience of two groups: one group with training back to make the people self-confident with VR, the other without the training. In this case, it could be useful also measure the "high tech anxiety" of the groups.

Finally, the best wish that this research would like to do is that virtual reality will be studied in the future, not only as technological innovation, rather as a support and as an extension of people's potential, with a human-centric vision, and looking for significant meanings.

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