University of Tartu

Faculty of Social Sciences
School of Economics and Business Administration

Mehwish Peter and Mohammad Zaif Nawaz Khan

Impact of Virtual Reality on Learning Perception

Master's Thesis

Supervisor: Prof. emer. Tõnis Mets, PhD

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Mohammad Zaif Nawaz Khan Mehwish Peter

Abstract

This thesis studies the perception of learners towards virtual reality as a learning tool to understand whether the learners hold any positive or negative perception towards VR and to build further knowledge on how VR should be adopted as an aid for teaching in academic and vocational institutes. Mixed research was conducted, which included an experiment where participants (n=31) were asked to wear a VR HMD and experience a pedagogical simulation, and then respond to a questionnaire. Subsequently, an online questionnaire (n=144) was dispersed amongst VR and non-VR users, to measure similar attributes based on their experience with VR technology. The questionnaire consisted of Likert, semantic differential scale, and open-ended questions. The results show that the perception of VR as a learning tool, although mostly positive, differs according to the experience of the participants with VR technology. The participants from the experiment and with prior academic VR experience have a dominant positive perception towards VR, whereas those with entertainment and no experience show marginally lower positive perception.

Keywords: Virtual Reality, Perception, Academics, Learning Aid, Experiential learning

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Introduction

“The best way to learn is to do; the worst way to teach is to talk.” -Paul Halmos

Effective teaching is influenced by the tools used in imparting the lesson, as well as the engagement between the tutor, learner, and the concept being taught. The fact that practice paired with visual or physical experience is the best tool of teaching has been known for centuries. But it has taken us a long time to understand the importance of such direct experiences and include them in the imparted education in institutions. Bugelski, in 1956, found that lecture-based teaching methods may not be best for teaching factual curriculums (Bugelski, 1956). Samuel Johnson, the famous English writer, once said, “Lectures were once useful; but now, when all can read, and books are so numerous, lectures are unnecessary. I know nothing that can be best taught by lectures, except where experiments are to be shown” (Boswell, 1791). Unfortunately, due to the lack of technology and means re-living historical moments, exploring remote destinations, walking through a human body, or watching an experiment or surgery being conducted from someone else's point of view has been impossible until now. Two-dimensional maps and images, videos, and 3-dimensional simulations on a two-dimensional screen, scale models have been the only tools for explaining complex systems to students in multiple disciplines of education. For a very long time, academics have also struggled in increasing information retention, grasping concepts, and cultivating creativity and innovation. Subjects like physics, chemistry, and biology; skills like medicine, mechanical designing, machine, and vehicle operation, they all must be either visualized or made hands-on.

However, new technologies in merging and representing the 3D world into 2D environments or providing the depth and immersion of 3D through visual aids, have brought along significant opportunities in design, training, and education. One such increasing involvement of digital technologies is Virtual Reality (hereto referred to as VR), which has the potential to radically revolutionize future skill creation, academics, and learning methods. This is a part of a broader industry-wide change, where all industries are adopting digital technologies in novel ways and are embedding them within the society (Schwab, 2017).

There are countless ways VR can enrich and assist learning; many of them are apparent and studied, while some are yet to be realized. It allows learners to visualize and grasp concepts that were hard to visualize; theory for subjects mentioned earlier can now be paired with visualized 3D demonstrations and aids. Moreover, it makes learning an interactive and engaging experience through rich and engaging content. VR also eliminates the high investment, risk, and safety factors for skill training that is otherwise intensive on all fronts, to be carried out physically. It has widely been acknowledged through research and studies that virtual reality supports knowledge formation through hands-on experience and also promotes educational thinking (Bricken, 1991). Moreover, visualized and immersive 3D environments in VR removes the ambiguity that usually exists with a 2D representation of 3D objects.

When it comes to adopting digital technologies, academic or pedagogical institutions follow it similarly to society (Schuck & Aubusson, 2010). Hence it can be concluded that since VR has now been adopted into the mainstream, as an entertainment and skill enhancement tool, academics will soon follow. But the pressing concern is whether STEM education curricula need immediate adoption of VR as a tool or not, and to what extent. The rising demand for high-skilled STEM professionals in all economies worldwide for knowledge and service industries, building up those competencies, is a seemingly high priority matter (Powell & Snellman, 2004).

VR particularly shines in situations where physical presence becomes impossible, as physical interactions may endanger human lives or violate the law. During the current (2020) COVID-19 pandemic, call for VR adoption has gained prominence again as it safeguards from physical contact but still allows meetings, interactions, and activities in an immersive environment (Kelly, 2020). Teachers across the globe utilize virtual reality to take students on virtual tours, curtail lack of motivation due to social isolation, and engage homebound learners (Elise, 2020).

VR technology, just like any breakthrough technology, when introduced in an established industry faces criticism, concerns, and apprehensions. Most of these concerns are whether VR is useful or acceptable for pedagogical applications (Hussein & Nätterdal, 2015). Many studies have also been conducted that analyzed the application of this novel technology from the cultural aspect; technical challenges faced, the economic feasibility to adopt it for mainstream usage, as well as the required software development efforts and interfaces needed; the studies also observed the fear and attitudes of learners towards VR, and their intention to include it into their learning process (Alfalah, 2018; Bricken, 1991; Huang et al., 2013; Hussein & Nätterdal, 2015). Hence, it’s extremely crucial that we examine every aspect of virtual reality before it’s inclusion in academic environments, not just from technology and instructors' perspective, but also from the learners. As a negative perception, paired with apprehensions and fear may lead to inefficient adoption, usage, and even misuse. Hence, to incorporate this technology, there should be ample scientific base and information that could be used to educate the users, and to prepare them for the adoption of the technology in learning environments.

This thesis aims to evaluate the perception of learners towards virtual reality as a learning tool and to study the difference in attitudes according to their experience with virtual reality, and demographics. The intention is to understand, via prior literature, how virtual reality has been perceived and accepted in academics. The study builds upon the previous studies by filling the gap by observing the perception of the technology on a diversely VR experienced users. We also establish the control group through an experiment where participants experience VR in a controlled simulation. Other groups are studied through a self-assessment online questionnaire which is dispersed to VR users (academics and entertainment) and non-VR users. This understanding will establish a base for further studies to understand the aspects that form positive and negative attitudes and will also aid the adoption of VR in academic and vocational institutions for knowledge sharing, learning, and skill-building.

This thesis follows the conventional research method, starting with a literature review to understand that previous studies on VR, VR technology, and its acceptance in learning/pedagogical environments., followed by enumerating and explaining the research gap and tasks, establishing the framework, and methodology on how the data was aggregated. Subsequently, we will present the data and the analysis and then present the results and conclusion.

Literature Review

Virtual Reality (VR)

Virtual reality, a term coined in the early 80s by Jason Lanier, can be defined in multiple ways, the main difference, according to literature, depends on whether we look at VR from functional, application, or technology perspective (Fuchs, 2017; Fuchs et al., 2011). Moreover, VR technology has progressed to a stage where it is distinctly categorized: true virtual reality, mixed reality, and augmented reality. The creation of a simulated real world, as seen in figure 1, to immerse the user is known as true virtual reality. Whereas, the mixture of the artificial world with real-world immersion is mixed reality. The mixed reality and true virtual reality are distinct as they bring together the physical world and real-world (Fuchs, 2017; Fuchs et al., 2011).

Figure 1. Software engineer demonstrates a surgery simulator during a trade show in France (*Source: Barad, 2019*)

VR digital revolution that started with computers around the 1950s to the late 1970s in the field of technology continuously developed and evolved into many fields, subsequently including education. In education, technology led to teaching based on audio-visual sensory simulations, the most significant and prevalent is the conception of immersive virtual reality (VR), that can be traced at the time back around forty years ago. The first being, the introduction of *Sensorama*, an immersive multi-sensory technology that can be titled as VR. Due to fast progression, VR has led the world to innovative paths and exploited many new potential applications in education.

But it was not until the 80s that VR entered the arena of professional education. Biocca and Levy pointed out the very first use case of VR was in defense (Biocca & Levy, 2013), which was to train pilots in the small enclosed cockpits that fulfilled the purpose of a flight simulator for various pieces of training and exercises. Hence, no matter how virtual reality is defined, interaction, immersion, and simulation of the real and artificial worlds will always be associated with it. Moreover, besides the software that transforms the virtual reality, the associated hardware, head-mounted displays, and tracking equipment needs to considered while studying the interactions (Fuchs, 2017; Fuchs et al., 2011).

Virtual Reality (VR) Technology

Virtual reality glasses or head-mounted displays introduced less than a decade ago solved the problem of the inaccessibility and affordability of VR. The technologies like Google Cardboard and its many iterations provided access to VR experience and immersion for as low as 4 USD (Dougherty, 2015). Whereas HMDs like Oculus Rift and HTC Vive brought high-grade multi-sensory immersion and experience to homes, they mainly address physical movement, interaction, sight, and hearing. These technologies offer low-latency precise tracking, and the newer iterations of them are now offering high-quality wireless audio and visual delivery to enhance the interaction and to provide the freedom from wires (Oculus Blog, 2019).

Figure 2. HaptX Glove that provides finger tracking as well as haptic feedback (*Source*: *Nordrum, 2017*)

VR headsets are now also paired with trackable controllers (figure 2) that provide users a means to interact with the objects and surroundings, as well as manipulate them. This adds another layer of immersion and realism, enhancing the presence of users in the virtual environment. With a greater degree of freedom, users can move around, pick up objects, feel their feedback, and engage with them (Bacchus, 2018; Perret & Vander Poorten, 2018). Newer technologies even allow finger tracking, capturing the motion of individual fingers of the user (Fuchs, 2017).

Virtual Reality (VR) in Academics and Pedagogy

VR technologies proved to be valuable and beneficial in boosting learner's engagement as it allows the user to interact with Virtual objects and entirely immersed within the virtual environment and helps to neglect and abandon the physical environment around them.

Although there are different ways to immerse knowledge, different learning styles can have a different level of impact on the adequacy of VR in education.

Learning styles suggested as early as 1981 suggested incorporation of visual-auditory–kinaesthetic learning, encompassing three types of learning styles visual, auditory and kinaesthetic (Barbe et al., 1981), current VR technologies incorporated three of these eminent learning types and implemented in one application, as VR HMDs can render complex visuals, and allow audio, along with motion tracking, most common example being Oculus Rift (Allcoat & Von Muhlenen, 2018). Virtual reality leverages its users to select and interact with the learning events in their chosen manner. The features that put virtual reality on the upper hand are the pragmatic experience of the difficult and complex subjects that would be otherwise difficult to understand or illustrate using traditional avenues.

VR enables learning material in a 3D environment, which is interactive and capable of providing audio, visual, and even haptic responses. It can be very beneficial particularly for teaching complex subjects like chemistry, physics or astronomy where visualization makes the learning material more immersive and easier to understand A simple case study conducted by Bellamy & Warren mirrored real experiments using online interactive simulations, where results showed that 83 percent of the students found these online simulations very helpful and become active and ingenious in solving questions (Bellamy & Warren, 2011). These kinds of examples elevate education in many potential ways and advocate the uses of simulated environments.

However, concluding that the technology-savvy university current generation students are learning better is questionable, as found by Margaryan et al., as students usually find it difficult to understand the tools that could be adopted to aid their learning (Margaryan et al., 2011). It has also been found that the applications of VR in education have been severely limited, especially in teaching younger students of middle and high school; most applications have been found for adult training, including technical or medical education or vocational training (Freina & Ott, 2015).

VR in education is not applicable in all fields, and any application must consider space and context distinction for learning. The learning space is related to the set of objectives and exercises followed through by the learner. In contrast, the context is the various conditions that are interpreted differently by the different learner, by which they form their learning. In VR, space and context get merged quite often as the learner uses the context and environment to achieve set objectives (Bomsdorf, 2005). Moreover, from the perspective of academics and learning, VR technology arguably poses concerns regarding reality and cognition (Shin, 2017). Whereas VR acts as a learning and immersion tool, the user of the tool can acquire VR technology acquires crucial skills that increase learning, cognition, ideation, visualization, and experimentation (Shin, 2017).

Learning, though, is also not only one simple process rather it involves a hierarchy of stages, composing of six points that include a cognitive procedure that ranges from modest to very difficult (from remember, understand, apply, analyze and evaluate to create) (Allcoat & Von Muhlenen, 2018; Cullinane, 2009). Certain concrete examples are: VR is less helpful for learning instruments that require tactile reaction like a guitar (Camp & Schnader, 2010; Scott, 2008). Although not many empirical studies have been conducted on learning instruments through VR, although studies have been conducted to measure the training imparted in the medical field, which also found no benefits of VR based simulations (Engum et al., 2003).

Prior Research on Virtual Reality Acceptance

Several types of research have been carried out on the usage of VR technology in education and academics. While some researches were empirical, others explored the reasons and avenues to use virtual reality in education and training, building a conceptual framework on when to apply the technology (Pantelidis, 2010). It was also concluded that VR should not substitute critical areas where real experiments and training are essential, utilizing VR in such fields can lead to physical and emotional damage (Pantelidis, 2010). Huang *et al.*, in their empirical study on the attitude of acceptance of VR based learning systems, the study utilized the technology acceptance model (TAM) based questionnaire and found positive results demonstrating acceptance of VR technology amongst the group (Huang et al., 2013). Baxter *et al.*, in their empirical research, also found predominant positive views amongst high school students towards virtual reality, indicating novel pedagogical cases of VR in academics (Baxter & Hainey, 2019).

Moreover, amongst instructors, the attitude and thoughts were also found dominantly positive. The research showed that usage of VR was found to be non-obtrusive, and easy to learn, as well as that it promoted collaboration (Alfalah, 2018). In specific use-cases, research has shown that students with special needs, subjects requiring rehabilitation, and adolescent learners behave positively and learn more effectively with VR based tools (Sik-Lányi et al., 2006).

Rationale

In the purview of the literature mentioned, the impact of VR has been notably observed on education and learning, notably it has been observed in particular skill areas such as medicine, aviation, or industry and only with a homogenous population of participants with no distinction according to their experience with VR. Hence, the perception of learning has not widely been observed on a diverse set of learners and VR users. Also, while there are a lot of studies already done on the adoption (Straub, 2009; Sugar et al., 2004) and impact of the VR technology for learning and education (Engum et al., 2003; Martín-Gutiérrez et al., 2017; Pantelidis, 2010), and not enough about learners perception about VR as a tool for learning. Moreover, although it has been studied how students perceive technology in general (Adams, 2007; Duncan, 2005), there needs to be an understanding towards how different learners perceive VR technology as an aid for the learning process, especially in the field of technical education, training, and fields requiring practical experience and creativity.

In conclusion, the gaps in previous studies and the reason for this study are:

- Find how VR based learning is perceived in previous literature
- Establish a control group, with a pedagogical experience with VR, through a simulation
- Explore the perception of virtual reality-based learning in diverse groups (experiment and online questionnaire based self-assessment)
- Explore the difference of perception based on gender and age
- And, explore the demographical factors that affect learning perception

Conceptual Framework

Experiential Learning Theories

Many learning theorists have different perspectives and viewpoints about the terms “Learning” therefore, it is impossible to have one desirable explanation or unique concrete definition. Other than the diverse interpretation, learning has many different styles that have different aspects and metrics to measure effectiveness for each of them. Whereas there are many behavioural learning theories, this study is more fundamentally related to experiential learning.

It has been claimed by academics and researchers repeatedly that learning by experience is most crucial for the psychological development of humans (Vygotsky, 1978). Some of the notable educationists have also developed theories for experiential learning, establishing the guiding principles for the same. Piaget, Dewey, Lewin, and Festinger are the most notable ones. Piaget, in his book - *The psychology of intelligence,* found, in children, that experience shapes intelligence. According to him, intelligence was not shaped by internal personal characteristics, but was rather "a product of the interaction between the person and their environment." (Piaget, 1950). Lewin, in his research, mentioned, "learning is best facilitated in an environment where there are dialectic tension and conflict between immediate, concrete experience and analytic detachment" (Lewin, 1964).

Deriving from the earlier authors, a major development was made by Kolb in framing experiential learning theory. Initially, Kolb and Goldman (1976), and further Kolb (1984) established the Experiential Learning Framework (ELM), that was based on six prepositions, derived from the work of John Dewey, Kurt Lewin, Jean Piaget, Lev Vygotsky, William James, and Carl Jung (A. Kolb & Kolb, 2011):

1. Learning involves thinking, feeling, perception and behavior, and forms "a holistic process of adapting to the world, because it involves the integrated functioning of the person" (A. Kolb & Kolb, 2011).
2. Learning is to be taken as a process and not a set of concrete objectives or outcomes. Criticism and reaction to the effectiveness of learning is the best way to improve learning.
3. Learning is not just the absorption of new information, but the process of re-learning as well. Learning involves reshaping and removal of pre-conceived notions and ideas about the topic being learnt. Along with the creation of filtered and refined ideas.
4. Learning is a social process of creating individual knowledge created and recreated based on personal knowledge and human interaction.
5. Learning requires resolving conflicts between dialectically opposed ways of understanding the world. The learning process is a process in which the student "will move back and forth between opposing ways of reflection and action, feelings and thinking" (D. Kolb, 1984).

6. Learning is an interaction between individual and environment, involving interchanging of new experience and concepts with existing experiences and concepts.

Kolb's ELM framework is based on the idea that learning is a process and not a set of pre-set objectives or outcomes; the framework is based on a four-process design divided into two key dimensions, see figure 3, that define the interaction of the learner with the learning environment.

One dimension is information grasping, represented in figure 3 on the x-axis, where the learner forms an understanding and concepts of the events and subject in discussion. The second dimension is information transformation, represented in figure 3 on the y-axis, where the learner transforms the experience into observations and knowledge.

Experiential learning is then characterized in terms of a four-stage cycle that covers the four learning modes that come from the four intellectual processes described. Figure 3 presents the ELM in terms of the two key dimensions of grasping and transforming. Concrete experience (CE) is a mode in which people grasp experience through apprehension and rely on their feelings to initialize or motivate learning.

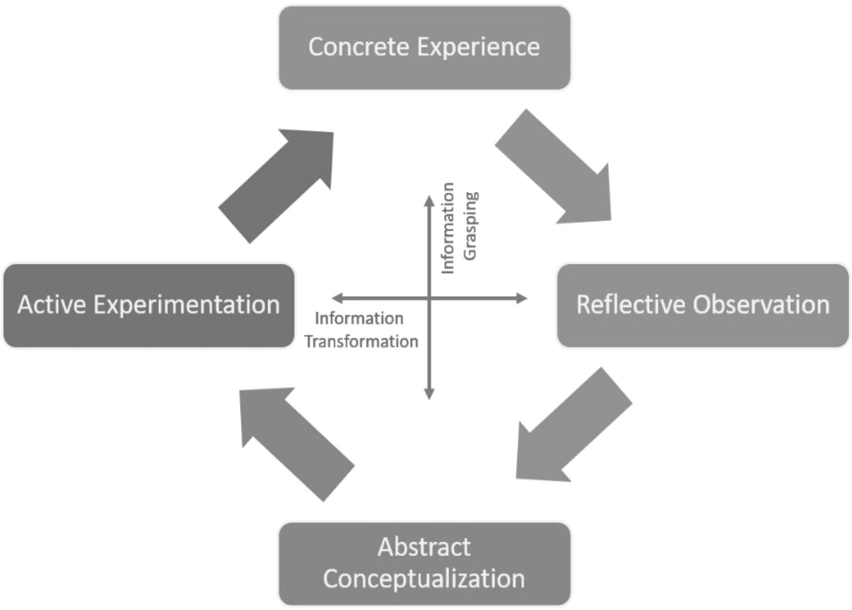

Figure 3. Kolb's Experiential Learning Model (*Source: D. Kolb, 1984*)

Abstract conceptualization (AC) is a mode in which people grasp experience through comprehension, and thinking is the main strategy for learning. Reflective observation (RO) is a mode in which people transform experience through intention and during which learners learn by watching others. Active experimentation (AE) is a mode in which people transform experience through extension and during which people learn by doing. Learners go through all four of the learning stages, but each learner tends to emphasize one or more of the four modes of the learning process at any given point in their learning activities. This emphasis is claimed to determine the learning style of the individual (D. Kolb, 1984).

Furthermore, Kolb’s model is not the only model, there exist more models on experiential or diverse learning, but they are also not without any criticism and require extensive instrumentation for measurement to measure any impact or learning style (Curry, 1990; Felder, 1988). Moreover, all the related models are more and less share similarities in dimensions to Kolb’s model.

Concrete Experience

Out of the four learning environments: symbolic, perceptual, affective, and behavioral, identified by Kolb, affective learning was observed to emphasize concrete experience, where students physically can experience the feeling of being a professional in a field by being in the environment and experience the simulations. Affective learning environments include field or practical exercises and simulations (Mendoza-Gonzalez, 2016). No correlation or causality was made between the environments (D. Kolb, 1984). Information in such an environment is typically delivered informally (D. Kolb, 1984).

Reflective Observation

Reflections on the observations by a learner during or after the activity is an inherent part of Kolb’s theory (Horton-Deutsch & Sherwood, 2017). Schön suggests that there are two kinds of reflective observations, one that is during the event or task, and another that happens post, the post-task reflection is known as *reflection-on-action*, where the learner analyses the perspective, theory, and makes sense of the event (Horton-Deutsch & Sherwood, 2017).

Abstract Conceptualization

The processes of reflecting upon the experienced event, what was learnt, and relating it to the theoretical concepts, in conceptualization, they interpret the events and activities about the concepts, observations, and ideas from peers (Noonan & Gaskell, 2015). The goal is to form concepts that the learner can utilize in the future (A. Kolb & Kolb, 2011).

Methodology

Research Design

Perception measurement was done using a mixed-method research approach, which uses both qualitative and quantitative elements in the questionnaire; the questions can be closed or open-ended (Clark & Ivankova, 2016). The open-ended questions provide an added context and valuable insight into the views of the participants concerning their usage of VR for learning.

The research included two stages, first the study of a group of participants from Estonia who participated in a simulation and then were asked to fill a physically disseminated questionnaire.

The second stage involved a questionnaire that was disseminated to an international user group, including VR users, non-VR users, and students of academic institutions. The groups either had pedagogical VR experience or no pedagogical experience, including completely no experience or gaming/entertainment-based experience. The questionnaire was disseminated digitally and was completed by respondents via Google forms. Overall, no hypothesis was tested as the aim of the study is to ascertain the perception of virtual reality as a tool in learning amongst different user groups.

Perception Questionnaire (Online)

The study examined the perceptions of VR and non-VR users towards VR technology as a learning tool. An online questionnaire, designed to study the users of the technology with pedagogical, entertainment, and no prior experience, was disseminated via social media channels, including a group of VR forums. The participants were sent a URL to the Google forms questionnaire, where questions for different groups were presented according to their experience with the technology. Except for concrete experience, the other two elements of the Kolb's model was common for all three groups in the online questionnaire.

Virtual Reality Simulation

To study the impact of VR based teaching on learning perception, a second group was selected to study the perception of VR based learning based on a guided simulation. The content is chosen with the following considerations:

- It introduces the participants to an educational topic that can be visualized.
- Some concepts can be abstracted.
- The duration is suitable for a first-time VR experience.
- It consists of animations and 360-degree freedom for exploration.
- The simulation is guided with fixed playback speed, non-interactive to maintain the duration and experience.

Keeping in mind the above considerations, *What Happens Inside Your Body?* (Life Noggin LLC, 2015) was chosen as the simulation content; it was chosen because of free availability and easy access on the YouTube VR platform. The simulation takes the respondent through a voiced and visualized guided journey of the human body, starting with respiratory, as seen in Figure 4, and forth to the circulatory system, to the digestive system and visual system, and then lastly to the nervous system.

Figure 4. Simulation - What Happens Inside Your Body? (*Source: Life Noggin LLC, 2015*)

Oculus Rift, figure 5, as the VR HMD of choice due to its affordability and ease of setup, as well as low physical discomfort for beginner use. The HMD also comes with a two-camera tracking system that provides ample room for freedom and movement tracking. Although the HMD provides the possibility of interaction with the environment using the two hand-held controllers, the controllers, owing to the nature of the simulation, interaction using controllers was forbidden.

Figure 5. Oculus Rift VR HMD
(*Source: "Oculus Rift," 2019*)

Participants

The simulation study, figure 6, consisted of 31 participants from Estonia, mainly consisting of IT professionals and students. Hence, it's assumed that they have high to moderate level experience and knowledge of computers and technology. All the participants were university graduates with at least a bachelor's degree. To eliminate the bias towards the chosen content, no medical students were included in the study.

The participants were chosen using random sampling and with a diverse age and gender group. All subjects were over the age of 18 and provided consent to participate in the study.

Demographics

Participants were asked to provide basic demographical data including their age, gender, and whether they had any previous VR experience (crucial to know reflective observation such as discomfort levels) on the questionnaire.

Simulation Design

The participants are briefed about the simulation before handing over the VR HMD. The participants were given 5 mins to get comfortable with the HMD and observe and adjust the discomfort (if any). The duration of the simulation was limited to 5 minutes, and no playbacks or repeat attempts were granted. The simulation duration was limited to a short time due to health and safety guidelines that specify to limit the virtual environment exposure to no longer than 10-30 minutes (Stanney et al., 1998).

Figure 6. Participant of the simulation experiment, wearing the Oculus Rift HMD

Method of evaluation

A post-simulation questionnaire was given to participants upon the completion of the simulation to measure their learning and perception of the two dimensions of Kolb's learning theory. The questionnaire consisted of 15 items, including six items that measure the concrete experience, three items for reflective observation with three more open-ended questions for the same, and three items to measure abstract conceptualization. No items measured active experimentation as the simulation was guided, and no experimentation or interaction was involved (see Limitations).

Table 1 lists all the questions that were framed to study the elements under Kolb's model, and the supporting sources that helped substantiate the question statements.

Elements	Questionnaire Statement	Supporting Source
Reflective Observation	• The method is helpful • The method is motivating • The method is consistent with my preference	(Horton-Deutsch & Sherwood, 2017; D. Kolb, 1984)
Abstract Conceptualization	• I can retain more information • I can explain what I have learnt	(A. Kolb & Kolb, 2011; Noonan & Gaskell, 2015)

	• I am confident that I understood	
Concrete Experience	Semantic scale measuring environment, discomfort, interest	(Engum et al., 2003; D. Kolb, 1984; Mendoza-Gonzalez, 2016)

Table 1. Observed elements, supporting questions and sources

Concrete Experience

To measure the grasping of information by the study participants, the experience was studied in terms of environment design, guided simulation, physical discomfort, and more. A 5-point semantic differential scale was used to measure the perception of experience on the following six dimensions using polar adjectives:

- Enthusiasm (Stimulating - Boring)
- Difficulty (Easy - Difficult)
- Interest (Interesting - Boring)
- Usefulness (Helpful - Useless)
- Duration (Just Right - Too Long)
- Physical Discomfort (Comfortable - Uncomfortable)

Reflective Observation

To measure information transformation, post-simulation reflection was observed using 3-components on a 5-point Likert scale; the components asked the participants to evaluate their perception on:

- Helpfulness in understanding the topic
- Motivation to pursue the topic further
- Consistency with the preferred learning method

Abstract Conceptualization

We also measure the perception of the participants of their ability to abstract the concepts that are taught using the VR teaching method. It was measured using 3-components on a 5-point Likert scale; the components asked the participants to evaluate:

- Retention of information taught
- Ability to explain it to others
- Confidence in the understanding of information learnt

Qualitative comments on the teaching method

The participants could also give qualitative feedback upon the completion of the simulation.

These questions were open-ended and included:

- The aspects of instruction that the participants liked
- The aspects of instruction they did not like
- The aspects they would change about the method

These questions give an insight into the perception that is otherwise not included in the other components and is subjective to the interpretation. They are noted to expand and understand the issues, advantages, and possibilities for improvement in future studies.

Data Analysis

The quantitative data gathered was analyzed using MS Excel and SPSS (Statistical Package for Social Sciences). Non-Parametric analysis was done to analyze the data because of the low sample size and non-normality of the data. As our survey data has a low sample size and it is asymmetric around the mean (non-normality), hence it's ideal to use non-parametric estimates. Unlike parametric tests such as t-test, non-parametric tests do not hold any assumptions on the distribution of data (Scheff, 2016).

- Frequency distribution, mean, median, and variance of the responses
- Mann-Whitney U test: Used to assess the difference between the two groups. This is a non-parametric test alternative to the Parametric t-test.
- Kruskal-Wallis H test: When population/sample related assumptions are not met, the parametric tests should not be used. In this analysis, the Non-parametric alternative

of Parametric ANOVA was used, which is the Kruskal-Wallis H test, to assess the difference between more than two groups.

- Post-Hock test: To identify the relevant groups having significant differences concerning the central measure of tendency.
- Word cloud plot of the qualitative feedback

Data

175 valid responses of observations were collected from the experiment and online questionnaire. Table 2 shows the composition of the 31 experiment respondents, 144 respondents of the online questionnaire (21 with academic experience, 73 with gamin or entertainment experience, and 50 with no VR experience). The distribution and frequencies of the observations are presented below.

Demographical data and distribution

Question	Options (Code)	Frequency	Percentage
Experiment			
Gender	Female (0)	12	38.7%
	Male (1)	19	61.3%
Age Group	>30 (0)	22	70.9%
	31-40 (1)	8	25.8%
	41< (2)	1	3.2%
Median Age	27	2	6.4%
Headset	Oculus Rift	31	100%
Online Questionnaire – Academics			
Gender	Female (0)	12	57.1%
	Male (1)	9	42.9%
Age Group	>20 (0)	6	28.5%
	20-30 (1)	10	47.6%
	30< (2)	5	23.8%
Median Age	23	1	4.7%
Headsets	Dell Vision	2	9.52%
	Google Cardboard	3	14.29%
	Lenovo Explorer	1	4.76%
	Oculus Go	1	4.76%
	Oculus Quest	1	4.76%

	Oculus Rift	2	9.52%
	Playstation VR	6	28.57%
	Samsung Odyssey	1	4.76%
	Samsung Odyssey +	1	4.76%
	Skullcandy	1	4.76%
	Sony	1	4.76%
	Valve Index	1	4.76%
Online Questionnaire - Gaming/Entertainment			
Gender	Female (0)	15	20.5%
	Male (1)	58	79.5%
Age Group	>20 (0)	10	13.6%
	20-30 (1)	50	68.4%
	30< (2)	13	17.8%
Median Age	25	4	5.4%
Headsets	Dell Vision	2	2.74%
	Google Cardboard	2	2.74%
	Google Daydream	1	1.37%
	HTC Vive	7	9.59%
	HTC Vive Pro	1	1.37%
	Lenovo Explorer	1	1.37%
	Microsoft Hololens	1	1.37%
	Not sure	4	5.48%
	Oculus Go	3	4.11%
	Oculus Quest	4	5.48%
	Oculus Rift	11	15.07%
	Oculus Rift S	4	5.48%
	Playstation VR	16	21.92%
	Samsung Gear VR	1	1.37%
	Samsung Odyssey	12	16.44%
	Samsung Odyssey +	1	1.37%
	Smartphone VR headset	1	1.37%
	VR Box	1	1.37%
Online Questionnaire – Neither			
Gender	Female (0)	15	30%
	Male (1)	35	70%

Age Group	>20 (0)	5	10%
	20-30 (1)	37	74%
	30< (2)	8	16%
Median Age	24	5	10%
Headset	None	50	100%

Table 2. Data distribution and demographics of all participants in various studied groups

Some of the observed demographic characteristics conform with the global VR statistics; for example, there is a big disparity between the genders of VR users. In 2019, in the gaming and entertainment sector, only 14.3% of total VR buyers were females (Staton, 2019). Similarly, the observed data shows 20% of VR users' gender as female in the same VR industry. The VR headset usage also displays a similar trend; the top 3 VR manufacturers were Sony, Samsung, and Oculus, with a cumulative share of 27%, followed by HTC (Neilsen, 2017). A similar trend was observed through the data by online questionnaires. The average age of the sample VR users is also very similar to the data observed by Neilsen in 2017, where they found that majority of VR users are in the age group of 18-34, which is 34% of the population.

Around 50 participants of the online questionnaire, i.e., 35% of the total observed sample size, had no experience with VR technology whatsoever. In contrast, in the US, the biggest market of VR technology in the consumer electronics domain has a population of 49.2 million is expected to have experienced VR at least once (approx. 14% of the total population) (emarketer, 2017).

Results

Concrete Experience

According to the theoretical framework, affective learning was observed to emphasize concrete experience, where students physically can experience the feeling of being a professional in a field by being in the environment and experience the simulation. Out of all other learning environments listed by Kolb, VR fits effective learning the most, as it provides the experience of immersion and physical presence. We divided the physical or concrete experience into a set of measurable characteristics and asked participants to input their experience on a semantic scale using polar adjectives.

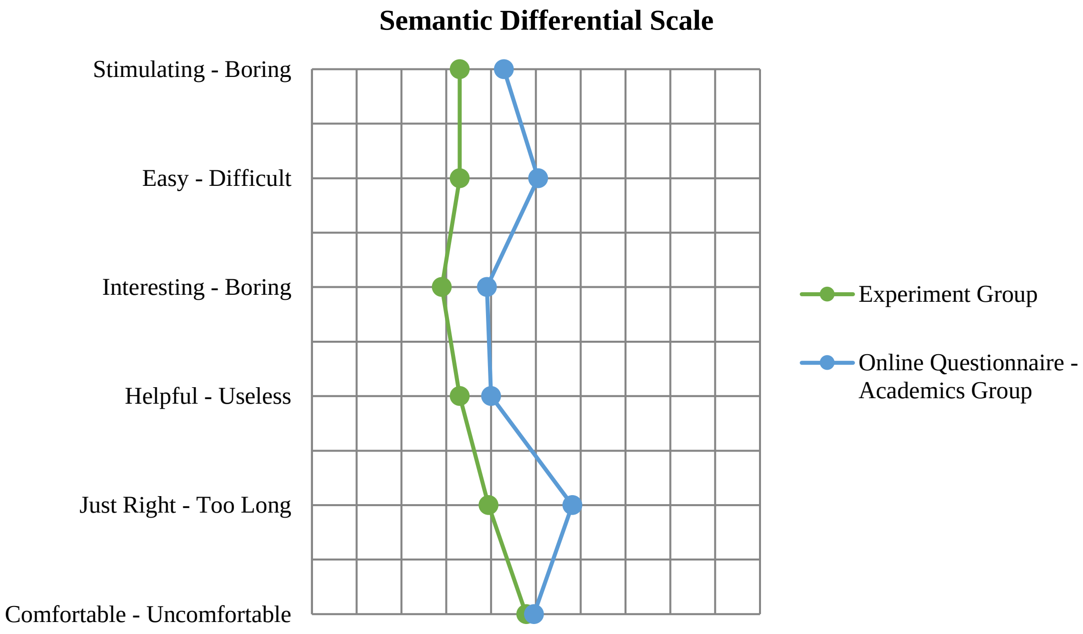

Figure 7. Data plot displaying the difference in concrete experience characteristics of two groups

In the two groups, where the concrete experience was studied due to the presence of pedagogical VR based learning experience, a similar trend was observed. Upon evaluating all participants for concrete experience on the 5-point semantic differential scale composing 6 question components. Most participants agreed with the statement that the teaching method was stimulating rather than boring.

Most of the participants found the method easy to grasp, and the same number of participants found it interesting. Almost 90% of the participants found the teaching method helpful in understanding the topic discussed. 26% of the participants didn’t approve of the duration of the simulation, considering it either too long or not long enough. Most importantly, the same level was observed in both groups; most participants found the simulation moderately comfortable, whereas the rest found it either discomforting or had no observation to report.

In summary, most of the participants showed favorable outcome towards positive adjectives, as in figure 7, whereas in terms of dimension discomfort for the VR experience was most prominent.

Reflective Observation

As per Kolb, reflective observation forms during and post-learning, hence a post-simulation or VR experience questionnaire that studies attitude towards the method and related characteristics, was deemed most suitable. The distribution of reflective observation shows the predominantly positive perception of VR based learning.

In the experiment group, figure 8, most of the participants found the teaching method helpful, with a mean score of 4.1, a similar result was observed in the academic and gaming/entertainment group of the online questionnaire (approx. mean score 4.0, figure 9 and 10). Whereas, there is a significant difference between other groups and the group with no VR experience, as the mean helpfulness score in that group was observed as 3.7, figure 11.

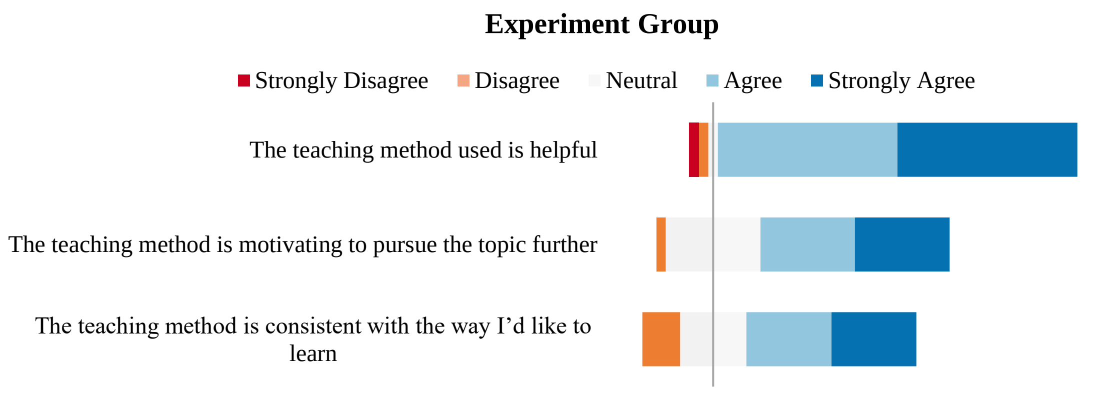

Figure 8. Frequency distribution of reflective observation questions - Experiment group

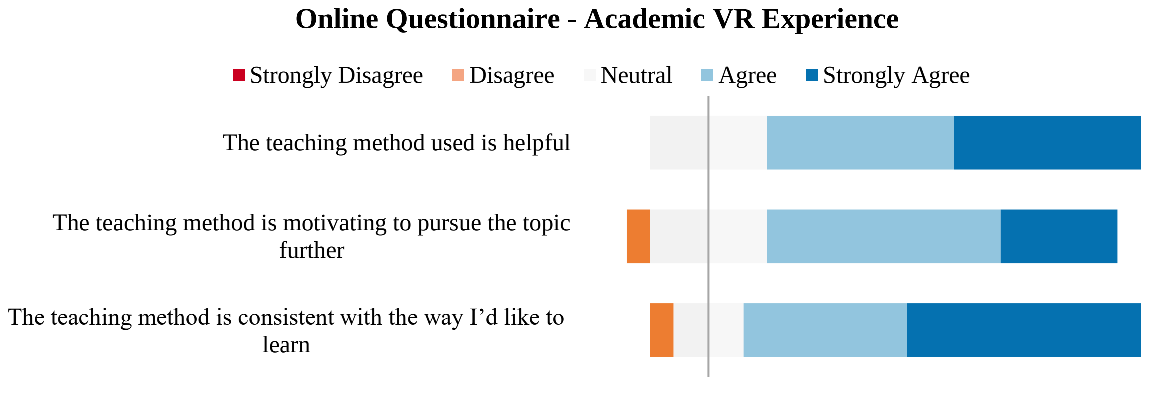

Figure 9. Frequency distribution of reflective observation questions - Online Questionnaire- Academic group

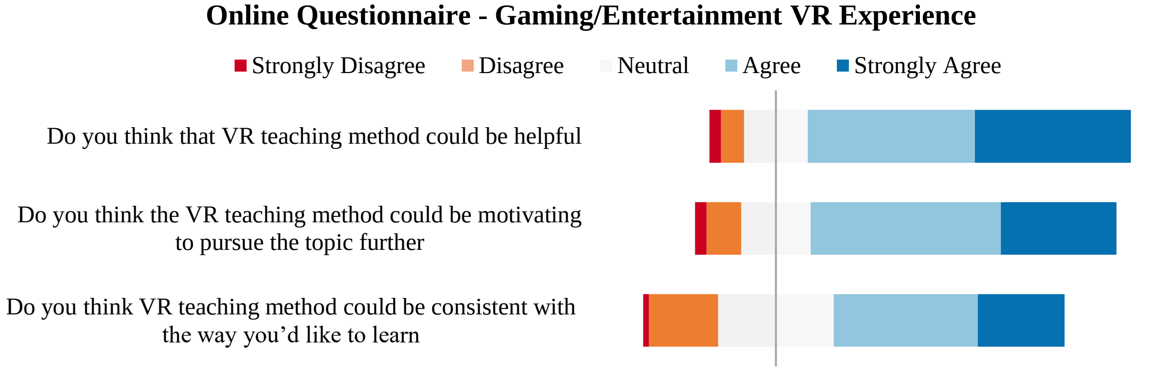

Figure 10. Frequency distribution of reflective observation questions - Online Questionnaire- Gaming/Entertainment group

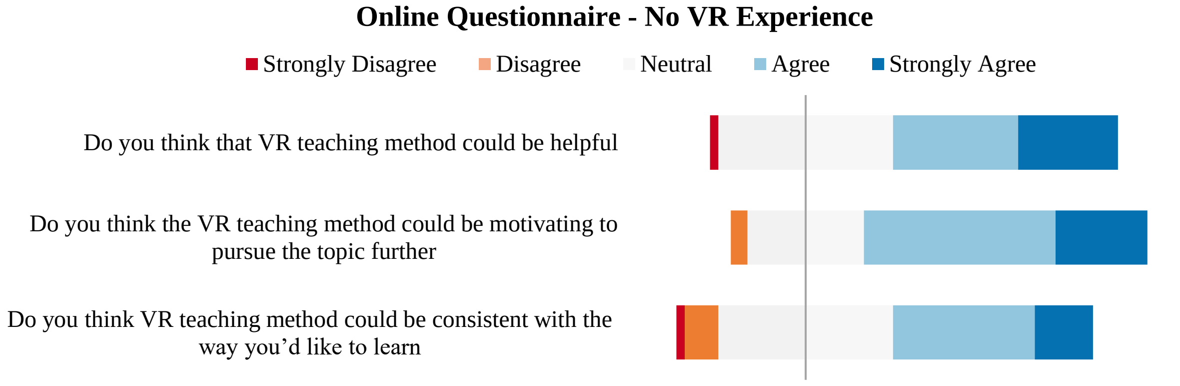

Figure 11. Frequency distribution of reflective observation questions - Online Questionnaire- No VR experience group

A similar result was obtained for motivation and consistency, where the group with no VR experience showed a lower mean score than other groups, i.e. 3.86 for motivation and 3.50 for consistency. In comparison, the experiment group had a mean score of 3.96 and 3.90, respectively.

Abstract Conceptualization

According to Kolb, the goal of abstract conceptualization is to form concepts that the learner can utilize in the future, relating to what was learnt, observations, and retention of the concepts. Hence the following questions analyzed the how information was received and whether the concepts were understood and retained enough to be imparted further.

The experiment and online questionnaire - academic group, showed a higher positive result, with mean scores of over 4 for all questionnaire (figure 12, 13).

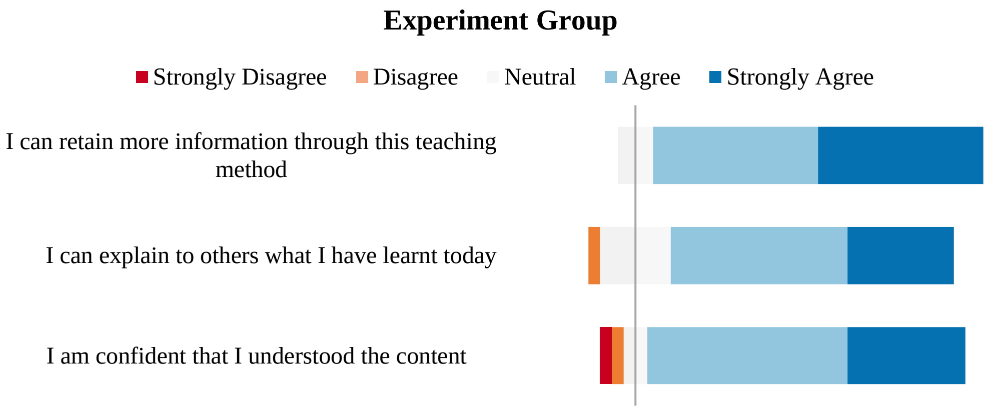

Figure 12. Frequency distribution of abstract conceptualization questions - Experiment group

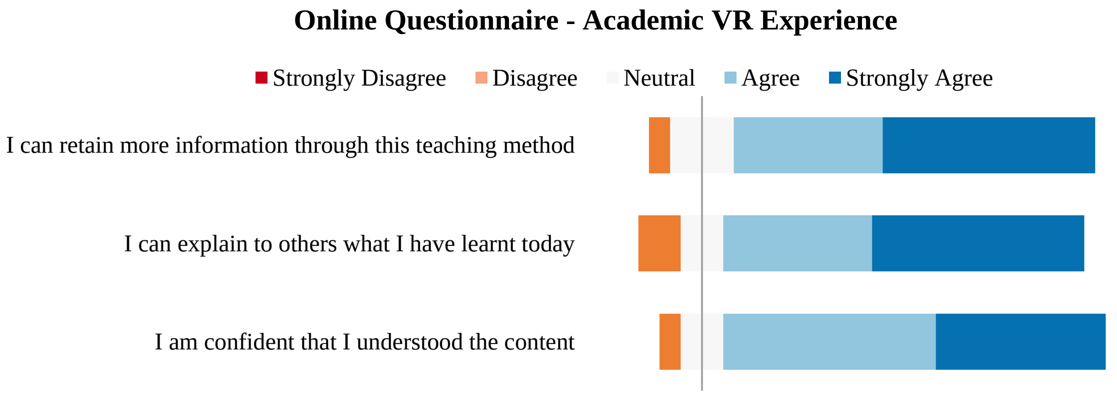

Figure 13. Frequency distribution of abstract conceptualization questions - Online Questionnaire- Academic group

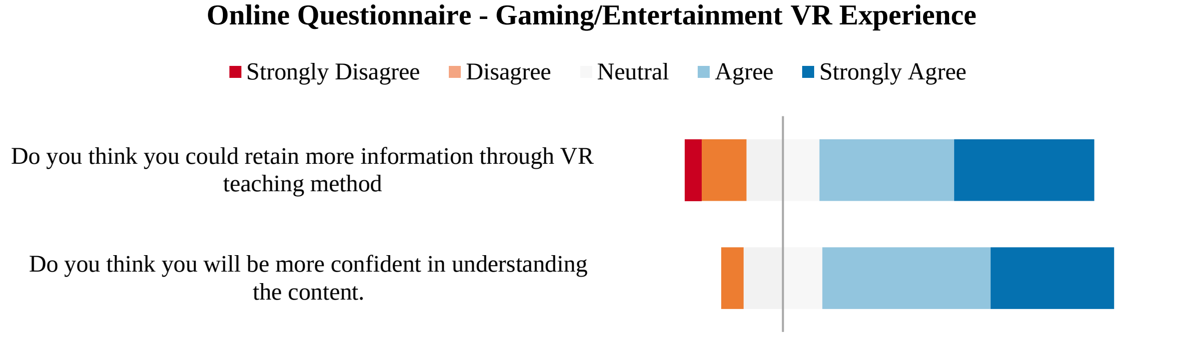

Figure 14. Frequency distribution of abstract conceptualization questions - Online Questionnaire- Gaming/Entertainment group

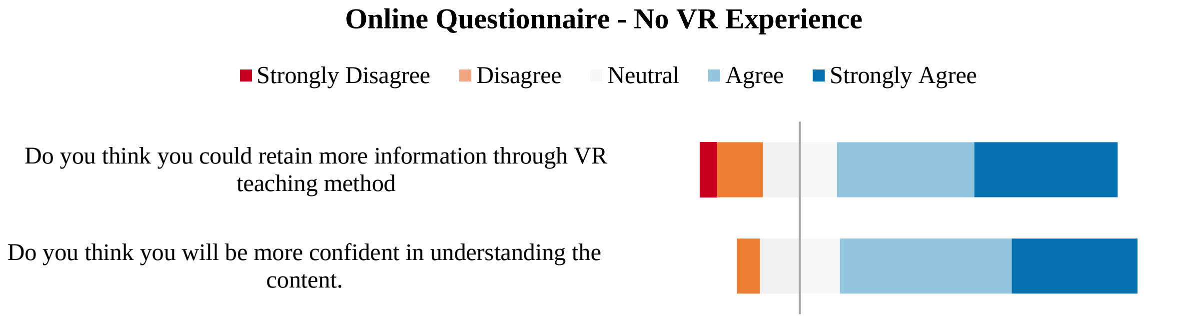

Figure 15. Frequency distribution of abstract conceptualization questions - Online Questionnaire- No VR experience group

The groups without pedagogical experience differed from the other groups; the mean score for the sample population with Gaming/Entertainment Experience was 3.8, figure 14, whereas for those with no VR experience was 3.6, figure 15, displaying a comparatively lower positive perception than other groups.

Comparison Between Groups

Using Kruskal-Wallis analysis, which is the non-parametric alternative for ANOVA, we analyzed the four observed groups on abstract conceptualization, and reflective observation (Appendix -2), the observed probability (p=0.0359) showed that there is a significant difference between the groups, as p was calculated to be less than 0.05.

Furthermore, through Post-hock analysis, to identify the significantly different groups, we observed the following:

Dunn's Pairwise Comparison of score1_y by group
(Bonferroni)

Col Mean-Row Mean	Experime	Academic	Gaming G
Academic	-0.151001 1.0000		
Gaming G	1.193223 0.6983	1.205351 0.6842	
Neither	2.454559 0.0423	2.321940 0.0607	1.663193 0.2888

Table 3. Post-hock analysis of the four observed groups

The results show a significant difference between the experimental group and the group with no experience with VR technology and tools; similar difference was also observed in the group with academic experience with VR and the group with no experience. Whereas, the moderate difference was observed between a group of participants who have used VR for gaming or entertainment and groups with pedagogical experience with VR technology. Hence, groups with VR experience ranked their perception higher than the one without any VR experience whatsoever.

Gender and Age differences

In the experiment group, no significant differences were found according to gender and age ($p < 0.05$). Although, a significant difference was found based on gender in the online questionnaire group with pedagogical experience of VR ($p = 0.0201$, $<= 0.05$). The results show that the male population agreed that VR is more helpful in learning than females. Whereas, for other factors, there was no significant difference according to gender.

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test
```

gender_1	obs	rank sum	expected
0	12	102	132
1	9	129	99
combined	21	231	231

```
unadjusted variance      198.00
adjustment for ties      -31.37
                        ----------
adjusted variance        166.63

Ho: ishelp~l(gender_1==0) = ishelp~l(gender_1==1)
             z =  -2.324
    Prob > |z| =   0.0201
```

Table 4. Mann-Whitney test to study the gender difference in the online questionnaire – Academic group, measuring helpfulness of the VR method

```
Kruskal-Wallis equality-of-populations rank test
```

age_1	Obs	Rank Sum
0	6	42.00
1	10	104.00
2	5	85.00

```
chi-squared =     7.262 with 2 d.f.
probability =     0.0265

chi-squared with ties =     8.630 with 2 d.f.
probability =     0.0134
```

Table 5. Kruskal-Wallis test measuring the difference between age groups of online questionnaire - Academic group (0 = <20, 1 = 20-30, 2= >30)

A similar difference was also observed in the same group (online questionnaire – academic group) based on age; upon post-hock analysis, it's found that people in the age group less than 20, and those more than 30 have a differing opinions towards the agreement whether VR based learning is helpful.

Qualitative Feedback

After the mixed questionnaire on the Likert and semantic differential scale, some of the participants of the experiment group offered feedback on the three open-ended questions. In contrast, the online questionnaire participants responded to the two questions posed at the end of the questionnaire. We analyzed the feedback received by keywords, filtering them with the common phrases from the English dictionary. The keywords are then summarized and presented in the form of word clouds. The first question was - *What did you like in the VR method of teaching the most?* the feedback on this question was received from the respondents from the experiment group, and the online questionnaire – academic experience group, the keywords with the highest frequency were *interesting, easy, learn*. New, the positive keywords represent the positive perception of the participants, which is in conformance with the observed results from the quantitative questions.

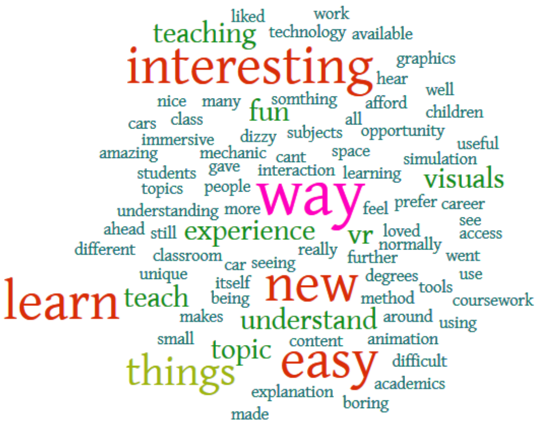

Figure 16. Word plot of the respondents, from the experiment group and questionnaire group with the pedagogical experience, answering what they liked

The same groups of participants were also asked - *What aspects of teaching did you not like and Why?* This question highlighted some of the key concerns associated with the usage of VR. With a frequency of 4 and 3, *disorientation and duration* of the simulation were the most noted factors.

Figure 17. Word plot of the respondents, from experiment group and questionnaire group with the pedagogical experience, answering what they disliked

The last open-ended question amongst the pedagogical experiment group, asked - *What would you like to change in the teaching method?* The feedback highlighted the limitations of the experiment in the respective group, where the participants highlighted the duration and lack of interaction, which would also be part of the *active experimentation* in the Kolb's learning framework.

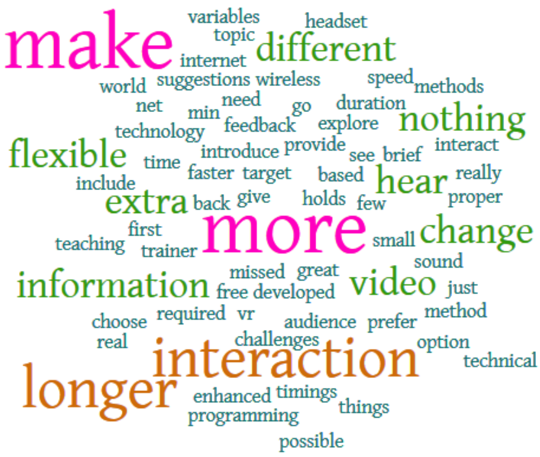

Figure 18. Word plot of the respondents, from the experiment group and questionnaire group with the pedagogical experience, answering what they would change

Amongst the participants, with no pedagogical experience with VR, consisting of gaming and entertainment users, and participants with no experience. The qualitative feedback for *Do you think VR can be a beneficial method for teaching? Why or why not*, was as follows:

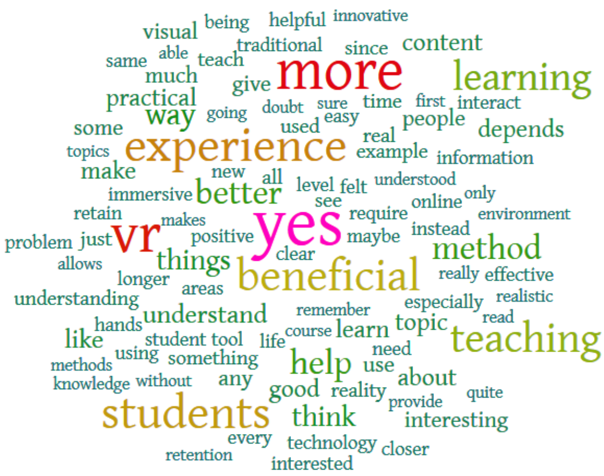

Figure 19. Word plot of the respondents, from questionnaire group with gaming or no experience of VR, answering if they find VR teaching beneficial

The dominant response was *yes, beneficial, and experience.* This highlights the positive perception and attitude of the respondents, even with no academic/pedagogical experience of VR.

Limitations

Our study has some limitations which must be considered when interpreting the results. Firstly, the experiment sample was small and may not be fully representative of the overall group of learners. However, these findings are largely consistent with other similar studies (Ai-Lim Lee et al., 2010; Huang et al., 2010).

Moreover, it must also be noted that the experimental simulation observations might be skewed due to the nature of the participants, as they are largely confined to the context of Estonia, and predominantly VR users, possessing education, or work in the field of computer sciences. Future replication of the study should involve different learning contexts, to identify the impact on different domains and make a general conclusion applicable to an average learner.

Furthermore, another major limitation of our study was active experimentation is not being analyzed, no physical interaction with content has been incorporated as the simulation was guided. However, former research showed benefits to the teaching methods which incorporated physical training (Bertram et al., 2015; Çakıroğlu & Gökoğlu, 2019). In the future, additional empirical work concerning active experimentation can be explored.

Additionally, in this study, the experiment group omitted any students or learners with past medical education experience as the content for the experiment was medical but doing so might have introduced another bias. Also, due to the nature of the chosen demographics, there might be a predisposition towards technology in general. For future studies, the focus could incline towards general topics, like tourism, history, or museum walks, to derive a wider conclusion applicable to the general populace.

Also, exposure of short duration may not be enough to gather an insight into the learning perception of a learner. However, most participants had never experienced VR before this study, which may also have contributed to an increased positive perception due to the novelty of the technology and the excitement of the learner.

Discussion

As VR technology becomes more and more prominent and accessible, there is going to be increased adoption of it in the field of education and training, especially outside of the common fields that have already seen a respectable level of VR usages such as medicine, defense, and engineering. The possible potential of VR based teaching and learning in universities, schools, vocational training centres is immense. Hence, it's critical that the focus not only lies on the measurable outcomes or objectives but also on the learning process, such that it is carried in the learning context and learning environment. It's also highly important that the learners understand the utility of VR technology and use it efficiently to aid their learning process (Bomsdorf, 2005; Margaryan et al., 2011).

This mixed study aimed to find the impact of VR on the learning as perceived by the learner, differing according to their experience with VR tools, appears to be overwhelmingly positive on three out of four groups of Kolb's ELM, it should be interpreted accordingly. A good perception does not necessarily correlate with good performance or better outcomes. Hence it's highly important that the experimentation stage of Kolb's model, with fixed tasks and objectives, is also included while testing the impact in future studies. Further analysis of qualitative feedback also indicates that the perception and performance might also be impacted by the skill level of the learner in terms of both technology and subject.

There are also some other factors that should be evaluated, such as how an average learner reacts to different VR HMDs; how VR HMDs and technology can be improved to meet the cognitive and physical needs of the learner, and the content design that can improve the learning performance (Burdea & Coiffet, 2003). These factors, along with the myriad of findings through related research will help educators. They will play a significant role for VR technology developers. VR content producers to understand, develop, and impart suitable content and lessons to the students and learners, also improving the overall learning (Burdea & Coiffet, 2003).

Conclusion

The main purpose of our thesis was to explore the participants' perception, consuming VR technology from learning discernments based on Kolb's learning theory. Moreover, the thesis intended to identify the learner's attitude, and any differences amongst the participants in terms of their experience with the technology, towards VR as a learning tool. This is considered as an initial step in implementing the VR technology as an educational tool in academic and vocational institutions and can also act as an initiator for further research to build knowledge and experience of implementing the technology to its fullest potential.

To conduct this study, the questionnaire was adopted from an experiential learning framework and previous studies on the same topic. It was modified to achieve the intended goal of this thesis. Most participants of our study, after analysis of the result, seem to be familiar with the use of VR technology in some capacity. The participants also showed a predominantly positive response towards VR technology and reflected how beneficial it could be in a pedagogical context. Although the results do show several optimistic perspectives, nonetheless due to the small sample size and the demographics of the participants, it may not be an accurate representation of the total population. But the results observed are similar to the previous studies (Alfalah, 2018; Baxter & Hainey, 2019; Huang et al., 2010, 2013). There were many participants who never had any encounter with VR still contemplated VR as an aided and appropriate tool to be integrated with pedagogy.

Based on the observations and the previous literature, the following can be concluded:

1. The previous researches, mostly focused on specialised skilled areas such as medicine, have shown that although learners perform better on VR based learning, there are apprehensions towards the approximate reality that VR creates, cost effectiveness of the hardware, and applications in diverse fields.
2. Through the empirical analysis and group-vise comparison, significant difference was observed between the groups that differed based on their experience with VR.

Hence, it can be established that the learner's attitude towards virtual reality-based learning differed on their experience with the technology.

3. Participants with experience with VR rated their perception more positively than participants with no experience with VR whatsoever. Within the first group, participants with pedagogical experience rated their perception higher than those with gaming/entertainment experience.
4. Through qualitative feedback and observation of concrete experience, it can also be concluded that learners show most apprehensions in terms of the comfort and duration when it comes to their experience with VR technology.

Although our study has few limitations, and we merely measure the perception of users and not the actual outcomes with VR as a learning aid. The still established useful insights exhibit why virtual reality should be integrated with academics as well as how beneficial it could be than old traditional avenues. However, we fulfilled all the gaps which we stated earlier in our study. Although, one major limitation, i.e. the lack of active experimentation, in our experiment could unlock several variables to determine different perspectives as to whether VR technology can enhance the learning experience with physical interactions as well. Different learning theories can be used for further research, along with an active experimentation variable. Additional empirical research can also be undertaken with different attitude behavior theories, which are also considered as an alternative of (TAM) Technological acceptance model, like cognitive load theory, capacity information processing theory, and information processing theory. The implementation and adoption of VR in academics require additional empirical research to identify its benefits for educational purposes.

Further Recommendations

Even though this study has some contribution, the topic needs further investigation to assess learners and instructor's perceptions towards VR as a teaching and learning aid.

1. This study has provided baseline data, but it was carried out in a limited capacity, in restricted geography (experiment group), age groups, and location. It is recommended that other studies include wider demographics and participants with a diverse background

2. The topic and content of simulation should also be varied to control any bias that may arise due to previous experience and pre-conceived notions about the subjects.
3. In-depth qualitative interviews could be conducted to understand the attitude and perception and enrich the results.
4. In terms of abstract conceptualization, outcomes can be measured by asking questions related to the content, and hence performance of the groups can also be measured.
5. Besides learners, instructors can also be studied to understand their perception of adopting VR in their curricula.

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Appendix

Questionnaire – Experiment / VR Academic Experience

(After finishing the simulation, please fill this form to the best of your understanding)

Gender: M / F / Other
Age:

Previous VR Experience: Y / N

Evaluate your experience in terms of the following statements:

(On the 5-point scale, where 1 = Strongly Agree, 5 = Strongly Disagree, please mark your)

Statement	1	2	3	4	5
The teaching method used is helpful					
The teaching method is motivating to pursue the topic further					
The teaching method is consistent with the way I'd like to learn					
I can retain more information through this teaching method					
I can explain to others what I have learnt today					
I am confident that I understood the content					

I found the teaching method to be:

(Rate the following attributes on the 5-point scale)

Stimulating	___	___	___	___	___	Boring
Easy	___	___	___	___	___	Difficult
Interesting	___	___	___	___	___	Dull
Helpful	___	___	___	___	___	Useless
Just Right	___	___	___	___	___	Too Long
Comfortable	___	___	___	___	___	Uncomfortable

Your observations (Please provide your feedback)

What did you like in the way you were taught?

What aspects of teaching did you not like?

What would you change in the teaching method?

Group-wise Comparison based on questions below:

1.The teaching method used is helpful 2.The teaching method is motivating to pursue the topic further 3.The teaching method is consistent with the way I'd like to learn 4.I can retain more information through this teaching method 5.I am confident that I understood the content	**Score A**

Groups Coding:

"0"- Experimental Group

"1"- Academic Group

"2"- Gaming Group

"3" - Neither Group

```
Kruskal-Wallis equality-of-populations rank test
```

group	Obs	Rank Sum
Experimental Group	31	3138.00
Academic Group	21	2171.00
Gaming Group	73	6446.50
Neither Group	50	3644.50

```
chi-squared =     8.499 with 3 d.f.
probability =     0.0368

chi-squared with ties =     8.554 with 3 d.f.
probability =     0.0359
```

Since the p-value (0.0359) is less than 0.05, there is significant difference between few groups. To determine which groups differ we will have to do post hock analysis shown below.

The Groups "Neither" and "Experimental" differ significantly in their aggregate response towards the use of VR in teaching.

Comparison of Experimental and Academic group based on the questions below, is as follows;

I found the teaching method to be (Stimulating - Boring): I found the teaching method to be (Easy - Difficult): I found the teaching method to be (Interesting - Dull): I found the teaching method to be (Helpful - Useless): I found the teaching method to be (Duration Just right - Too Long): I found the teaching method to be (Comfortable - Uncomfortable):	**Score B**

```
Two-sample Wilcoxon rank-sum (Mann-Whitney) test

       group |      obs    rank sum    expected
-------------+---------------------------------
Experimental |       31      1108.5       821.5
Academic Gro |       21       269.5       556.5
-------------+---------------------------------
    combined |       52        1378        1378

unadjusted variance     2875.25
adjustment for ties      -27.62
                      ----------
adjusted variance       2847.63

Ho: score2_b(group==Experimental Group) = score2_b(group==Academic Group)
             z =   5.378
    Prob > |z| =   0.0000
```

There is significant difference between the Experimental and Academic group. The Experimental group found it more positive (or more concordant) than the Academic Group.

Abbreviations List

Abbreviation	Explanation
AC	Abstract conceptualization
AE	Active experimentation
ANOVA	Analysis of variance
CE	Concrete Experience
ELM	Experiential learning Model
HMD	Head Mounted Display
RO	Reflective observation
STEM	Science Technology Engineering and Mathematics
SPSS	Statistical Package for Social Sciences
TAM	Technological acceptance model
VR	Virtual Reality

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