Title : A framework for immersion in virtual reality

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A Framework for Immersion in Virtual Reality

by

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Abstract

The purpose of this research is the creation of the framework for immersive Virtual Worlds (VW) development and evaluation of factors affecting user's immersion experience in 3D virtual worlds.

Three experiments have been conducted to evaluate different aspects of the immersion experience in virtual reality. The first experiment aimed to explore the influence of communication on users whilst performing certain activities in a virtual world. The second experiment evaluated how the real-world environment affects users in a virtual world. The third experiment examined the aspect of mobility as a main contributor to a user's distraction. The fourth experiment partly confirmed previous findings and added new factors, affecting immersion experience.

The results of all experiments formed a framework, containing factors which users considered as affecting them during their activities in virtual worlds.

During the experimentation phase of this research a combination of qualitative and quantitative methods was used. The Grounded Theory (GT) methodology was applied for data analysis in qualitative part.

The major contribution of this research is the framework of factors for building immersive 3D virtual environments. Another contribution is the evaluation of factors affecting users in such an environment.

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1 Introduction

1.1 Background to and purpose of this research

This research explores the factors which potentially might affect immersion in Virtual Reality (VR) accessed through stationary or mobile devices and addresses the issues of constructing immersive virtual worlds by providing a robust framework to assist VW developers.

In recent years, virtual environments have become a more and more prominent part of the educator's "toolbox" to design and implement student activities. While in the context of (recreational) games immersion is an important factor, the situation concerning educational activities is less clear and it might be questioned if and how immersion happens when users work in a virtual environment to perform a task (Kanamgotov *et al*., 2012).

Bredl *et al.* (2012) concluded that when students are immersed in a virtual world, they have increased motivation for learning through this world, while they are more likely to be engaged in educational activities. Childs (2010) on the other hand, finds a positive correlation between the development of the sense of presence and the satisfaction felt by students during the execution of an educational activity in-world. Combining this statement with what was mentioned above, it can be deduced that immersion in the virtual world is necessary if educational activities are to be thought really pleasant for students.

Kostarikas *et al.* (2016) carried out a study on the educational use of Second Life and realized that the students under observation developed a sense of presence within the world, they became immersed and did not hesitate to cooperate in-world with their – unknown until then – fellow students. The same research also suggests that lack of familiarity with the world of Second Life causes insecurity to new users and acts as a barrier to students' way towards immersion.

Hockey *et al.* (2010) emphasize that the advantages that Second Life has, as an immersive virtual environment, are not exclusive to this specific world. On the contrary, immersion is a feature of any virtual world that provides opportunities for direct visual contact with the subject taught and interaction with the environment

and other users. This view can lead us to the conclusion that such immersive experiences may be provided by other platforms as well, since they share many common features with Second Life, concerning its context and function. Ridgewell *et al.* (2011) report that the OpenSim technology, for instance, creates an environment which may accommodate engaging, playful educational activities that lead to the immersion of students into the world. Zhao *et al.* (2010) also suggest the use of OpenSim technology for the creation of immersive virtual environments, which are characterized by plausibility, interactivity, and ability to engage students.

Despite the fact that the topic of immersion in virtual worlds in general has been investigated extensively and in detail, literature search revealed that there are few studies focusing their interest on the development of practical tool which can assist virtual world developers in building immersive environment for users. Thus, the development of such a tool is viewed as task of importance and justifies the necessity of this research.

In order to achieve the goals of this research, four experiments were designed and conducted, combining quantitative and qualitative methods (see sections 1.3 and 4).

1.2 Aim and Objectives

This research explores different aspects of immersion experience within a dynamic, non-game virtual environment, where the user does not have to follow predetermined scenario and has more flexibility to choose their activity pattern in the virtual world. Previous attempts (Pausch and Proffitt, 1997; Cox and Cairns, 2006; Jennett *et al.*, 2008) have been performed in a static game virtual environment, where the user is performing a task within a prewritten, predetermined scenario.

The aim of this research is to study and understand what affects the immersion experience of users in virtual reality. This aim is achieved through these two objectives:

- To identify factors potentially affecting immersion
- To develop a framework that can be used for the creation of immersive virtual worlds

In order to meet aims and objectives, four experiments were designed and conducted.

1.3 Experiments

The shape of Experiment 1 was outlined in October 2011, when the whole research process was started. Back in 2010, similar research was conducted by Dr Marc Conrad at the University of Bedfordshire, exploring the influence of the population of the virtual world on users' activities. Experiment 1 was viewed as a continuation of that research, addressing the question of how users' immersion would be affected if the in-world population decreased significantly (see section 4.1.1). Nineteen participants were recruited from the students of the University of Bedfordshire; the regular classroom was chosen as a venue to bring the experiment setup as close as possible to the regular environment that the students used to work in. The virtual environment of ReactionGrid was chosen as a virtual venue for this experiment. The task was to spend in the virtual world as much time as participants wanted but not less than 30 minutes and then for them to answer the questions presented in a form of online questionnaire. It was learnt as a result of Experiment 1 that the initial idea of immersion drop due to in-world population drop was confirmed and the population of the virtual environment was identified as one of the factors, potentially affecting immersion. For more details about Experiment 1, see section 4.1.

Experiment 2, as a natural continuation of Experiment 1, sought to explore the influence of the real physical world's distractions as another factor which could affect immersion experience in the virtual world. The real-world noise became apparent as a factor of distraction when the first ideas of mobility as a present and future driver of modern computing came up to my mind. Mobility as a phenomenon is regarded as a complex of factors of disturbance and physical-world noise is one of them since users are normally using mobile devices in different places and some of them are not necessarily quiet. Thus, the noise in the real world became a factor to be considered. Since the population as a factor playing a part in users' immersion had already been explored in Experiment 1, it was logical to move to the next step and put the factor of real-world noise under test.

Twelve participants were recruited among students and staff members of the University of Bedfordshire. To address the main question of the experiment, two venues were chosen – the "quiet" office environment vs "noisy" bar. The virtual campus of Carleton University (Canada) was used as a place for virtual activities for participants. The data for this experiment was collected through a series of individual semi-structured interviews and analysed using Grounded Theory methodology. As a result of Experiment 2, it was concluded that real-world noise does not play that significant a role as a factor of disturbance in users' immersion in a virtual world. For more about Experiment 2 and its results see section 4.2.

Experiment 3 was conducted under the pressure of relocation to Russia to a different technical infrastructure and cultural environment. It was decided therefore to use this as an opportunity to get more data, presumably different from what had been collected before. By this time, two factors had been already identified – "population" and "noise" – and the question "What's next?" naturally appeared on the agenda. Continuing exploration of mobility as a new way of computing and considering how it might influence users suggested that the search for the next experiment should be done in this direction. Since normally there are too many factors of influence for mobile device users, it was decided to follow grounded theory guidance and to use the "what if" approach, keeping one's mind open for any possible data outcome. That shaped the general idea for how to set up and conduct Experiment 3, putting participants in the most "natural" environment for mobile device users and "keeping eyes open" (Charmaz, 2009) for any possible outcome. Twenty-six participants were recruited in Russia with different backgrounds. Typical places for mobile device users, such as a bench in a park or street café, were used for this experiment. The Sims 2 virtual environment was presented to participants as a virtual venue. The outcome of data analysis indicated that the most influential factors, determined by the participants, lies in the field of psychological immersion rather than technical constraints, which presumably should affect users in typical mobile device usage situations. For more about Experiment 3, see section 4.3.

Experiment 4 was initially designed to get a separate set of opinions from virtual world builders for all the results obtained from all previous experiments. The results

of all three previous experiments were summarised and formed a framework of factors potentially affecting users of virtual space. The framework aims to provide VW designers and developers with a useful and practical tool they could utilise whilst building a virtual environment. Thirty-one participants were recruited for Experiment 4 among students of the University of Bedfordshire. The factors identified in previous experiments were presented to participants as a whole framework. A regular university classroom was chosen as a physical venue and an OpenSim-based space as a virtual venue. The reason for such choices lies in the assumption that normally virtual reality designers are working in regular office or lab environments utilising virtual platforms similar to OpenSim. The task outlined to participants was also chosen according to the idea or typical virtual space design activities. Data was collected in the form of focus group discussions and finally, an additional set of new, unexpected factors appeared on the stage as a result of this experiment and data analysis under grounded theory. Some factors, which were identified in Russia as factors of importance met with negative response from participants in England, arguing, that these factors did not affect them at all. For more about Experiment 4, see section 6.

1.4 Grounded Theory: The preliminary insight

Grounded theory was used in the experimental phase of this research for data analysis. The reason for such a choice was predetermined by the nature of the studies, when very little is known about the phenomenon and there is a need to deduce data and following theory from users' opinions and knowledge they share through the individual interviews rather than testing initial hypothesis through the experiments (Glaser and Strauss, 1967; Charmaz, 2006; Birks and Mills, 2011). Grounded theory methodology was used in Experiment 2 and Experiment 3 of this research and generally shaped the whole course of study, suggesting the shape of the next experiment based on the outcome of the previous one. The structure of this thesis is also outlined under the guidance of GT, placing section "Literature Review", for instance, at the end of the thesis after experimental part description in order to avoid "contamination" of data analysis by initial knowledge, coming from early literature review (Glaser and Strauss, 1967). For more about grounded theory see sections 3.5 and 7.1.

2 Preliminary Literature Review

This section describes in brief what the phenomenon of immersion is and how it is defined by different authors in the literature. It is necessary to outline the importance of providing the literature review only on a preliminary basis at this stage. Since the whole study is conducted under the guidance of grounded theory, the latter suggests to postpone full literature review until the initial analysis of data is finished and the first categories have started to emerge (Glaser, 1998; Glaser and Strauss, 1967; Charmaz, 2006; Birks and Mills, 2011). Thus, following that guideline, the full literature review is provided in chapter 7.

2.1 Definition of immersion

Immersion, according to Brown *et al.* (2004), denotes a "sense of being there" or a "Zen-like state where your hands just seem to know what to do, and your mind just seems to carry on with the story". As a phenomenon to describe the immersion experience this is not something new and applicable only to the virtual environment. We can feel immersed while reading books (Nell, 1988), watching films (Bazin, 1967) or doing something else, no matter what but it needs to involve us fully in order we, as "users", could achieve that state of the mind. With the relatively recent advent of virtual worlds (VW), however, the phenomenon described received a new momentum, involving the user through not only observation of the material, but while actively interacting with environment, establishing the cybernetic circuit between the user and the VW. This phenomenon is described as "presence" and "immersion". Though both definitions are widely used and have been discussed for decades, there seems to be a lack of consensus achieved so far (Ermi and Mäyrä, 2005; King and Krzywinska, 2006; Tamborini and Skalski, 2006; Brown and Cairns, 2004; Jennett *et al*., 2008). Nevertheless, the phenomenon these two terms have been enlisted to describe is crucial to our understanding of the relationship between user and virtual world, as it represents one end of a continuum of intensity of involvement with virtual worlds and addresses the very notion of being in the context of such simulated environments. As Calleja (2014) argues, the main challenge and confusion between two terms is "based on a number of challenges they pose to a clear understanding of the phenomenon they have been employed to

describe" (Calleja, 2014, p. 222), since neither of the terms fully and adequately describes the relationship between the user and virtual environment, assuming that the human being interacts with the virtual environment in a unidirectional manner, that there is a certain split between the user in his real world ("here") and the virtual counterpart he interacts with ("there"). Both definitions, "presence" and "immersion", are used frequently and interchangeably, though there is a certain level of contradiction between them. Slater and Wilbur define immersion as a technological feature, an option which belongs to the side of "technicalities", rather than the state of the mind: "A description of a technology . . . that describes the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the sense of a human participant" (Slater and Wilbur, 1997, p. 3). In contrast, Witmer and Singer describe the immersion as "a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences" (Witmer and Singer, 1998, p. 227) which aligns quite closely to Slater and Wilbur's definition of "presence". Moreover, Calleja (2014) introduces a "more productive and precise" definition, where "the virtual world assimilated into the user's consciousness as a space that affords the exertion of agency and expression of sociality in a manner coextensive with our everyday reality" (Calleja, 2014, p. 222) which he calls "Incorporation".

The evaluation of which of the definitions describes the phenomenon more precisely lies beyond the scope of this research and in order to avoid further confusion in the terminology, the term "immersion" is used throughout this thesis, denoting the user's involvement into his activities within a virtual environment.

2.2 Virtual Worlds

This is how Heim (1998), cited by Damer and Hinrichs in *The Oxford Handbook of Virtuality* (2014, p. 17) definesvirtual reality as an environment: "Virtual reality is a technology that convinces the participant that he or she is actually in another place by substituting the primary sensory input with data received produced by a computer . . . when the virtual world becomes a workspace and the user identifies with the virtual body and feels a sense of belonging to a virtual community." Virtual

reality has its own prehistory, going back to the late 1950s, when Morton Heilig created the first virtual environment, called “Sensorama” (Damer and Hinrichs, 2014), which introduced multisensory (or multimodal) immersive virtual space (see Figure 1).

Figure 1. The Sensorama of Morton Heilig (Heilig, 2014)

It is a simulator for one to four people that provides the illusion of reality using a 3-D motion picture with smell, stereo sound, vibrations of the seat, and wind in the hair to create the illusion. Parts of the Sensorama are two other inventions which made it possible, the Sensorama Motion Picture Projector and the Sensorama 3-D Motion Picture Camera. Visual environments have developed from the original online games of over 40 years ago. Multi User Dungeon (MUD) games were developed in the 1970s (Bartle, 1990). By the 1990s, fully graphical multimedia MUD Object Oriented systems had been developed along with Multi Player Online Games (MMOGs). One of the most widely known MMOG is World of Warcraft with over 11 million active subscriptions (Duncan *et al*., 2012).

2.2.1 Habitat

Habitat, as Wikipedia suggests, is “a massively multiplayer online role-playing game (MMORPG) developed by LucasArts” (Wikipedia, 2016). Developed by Randy Farmer and Chip Morningstar in 1985, Habitat probably could be called a cornerstone in all further multiplayer games or speaking more broadly, multiuser environment development, establishing a new approach and vision to be adopted much later by major players in the virtual world market. Habitat, unlike many previous attempts from other laboratories, was built on a platform of inexpensive home computers coupled with an ordinary commercial online service (Morningstar and Farmer, 1991). As these authors outline in their seminal article “The Lessons of Lucasfilm’s Habitat”, presented at The First International Conference on Cyberspace, hosted by the University of Texas, the essential lesson learned from Habitat creation and use, was that “cyberspace is defined more by the interactions among the actors within it than by the technology with which it is implemented” (Morningstar and Farmer, 1991, p.1). Another core statement, made by the authors, was that they see cyberspace as necessarily a multiple-participant environment, where the most important factors are the capabilities available for them, the characteristics of other people around them in cyberspace and the ways these participants can affect each other (p.1).

The creation of Habitat was inspired by Vernor Vinge’s novel *True Names* published in 1981, “as well as by many fond childhood memories of games of make-believe, more recent memories of role-playing games and the like, and numerous other influences too thoroughly blended to pinpoint” (Morningstar and Farmer, 1991, p.2). Since the initial purpose of Habitat was home entertainment, all users in Habitat’s cyberspace are called “players”.

In order to provide functionality for a multiuser environment, Habitat consisted of two major parts: frontend and backend systems. The player’s home computer served as a frontend, communicating with the centralised backend system over a commercial packet-switching data network. The user interface was provided by the frontend, which also generated the real-time display, translating inputs from the player into requests to the backend. The backend maintained the whole cyber world,

informing the player through the frontend about constantly changing state of the cyber world. Players could interact not only with the cyber world, but also with each other as enabled by the backend. Figure 1 represents a scene from the Habitat world as it could be seen by the player on his frontend display (Morningstar and Farmer, 1991).

Figure 2. A typical Habitat scene (Morningstar and Farmer, 1991)

Habitat was the first virtual world where the term “avatar” was introduced. Authors used the ancient Sanskrit term originally used to define the earthly incarnation of godly powers for the visual embodiments of users. Morningstar and Farmer used a similar descent of a human identity into a graphic representation in a virtual world (Heim, 2014). The scene presented in Figure 1 consists of different objects, such as trees, houses, mail box, etc. and two avatars, who are having conversation. Their dialogue can be seen on the upper portion of the screen. Avatars in Habitat can also move around, manipulate objects and produce some gestures under the control of the players behind them.

The world of Habitat consists of discrete locations called “regions”. At the prototype level, as the authors of Habitat point out, there were around 20,000 regions in total. Four adjacent regions form an area which is accessible by the avatar walking through it. Each region contains a set of objects that define an avatar’s behaviour and the scene that the player can see on the screen (Morningstar and Farmer, 1991).

The whole concept and vision of how cyberspace should be organised and implemented could be taken literally as a motto for any cyberspace designer working on virtual world development. Many elements of this approach to cyber environment creation have been adopted by Linden Lab’s Second Life as the most successful implementation of online-based cyberspace (see section 2.2.7) and by its clones, proving the concept outlined by the creators of Habitat.

2.2.2 Worlds Chat

The first commercially developed, public, multiuser internet virtual-world platform was Worlds Chat created by a San Francisco start-up company called Worlds Incorporated (Damer and Hinrichs, 2014). Worlds Chat launched online in the spring of 1995; a screen capture is shown in Figure 3. Entering the beautifully designed 3D space station was a compelling experience. Because Worlds Chat was online and inhabited by other users, it was somehow elevated over the typically solo experiences of VR and single-player games. The first few users to step into this new space wandered around entranced, not yet understanding social norms, such as “Is it polite to simply pass through other people’s avatars?”

Figure 3. The World Chat, created in 1995 by Worlds Incorporated (Damer and Hinrichs, 2014)

During the following years, the world of virtual reality grew significantly, accumulating research in such fields as computer graphics and animation, image processing, CAD software, flight simulators, etc. (Damer and Hinrichs, 2014).

2.2.3 Cave

The CAVE™ (Cave Automated Virtual Environment) system is the most advanced and powerful projection virtual reality system on the market. It is configured as a room-sized, cube-shaped facility with stereoscopic graphics projected onto every surface so the images completely surround the users. It was invented at the University of Illinois at Chicago's Electronic Visualization Laboratory. Rather than having evolved from video games or flight simulation, the CAVE has its motivation rooted in scientific visualization. The CAVE is a multi-person, room-sized, high-resolution, 3D video and audio environment. In the current configuration, graphics are rear-projected in stereo onto three walls and the floor, and viewed with stereo glasses (see Figure 4).

Figure 4. Example of CAVE room (Business Green, 2011)

As a viewer wearing a position sensor moves within its display boundaries, the correct perspective and stereo projections of the environment are updated by a supercomputer, and the images move with and surround the viewer. Hence, stereo projections create 3D images that appear to have a presence both inside and outside the projection-room continuously. To the viewer with stereo glasses the projection screens become transparent and the 3D image space appears to extend to infinity. For example, a tile pattern could be projected onto the floor and walls such that the viewer sees a continuous floor extending well outside the boundaries of the projection-room. Three dimensional objects such as tables and chairs would appear to be present both inside and outside this projection-room. To the viewer these objects are really there until they try to touch them or walk beyond the boundaries of the projection-room. Specifically, the CAVE is a theatre 10x10x9 feet, made up of three rear-projection screens for the front, right and left walls and a down-projection screen for the floor. Computer-controlled audio provides a “sonification” capability to multiple speakers. A user’s head and hand are tracked with Ascension tethered electro-magnetic sensors. Stereographics’ LCD stereo shutter glasses are used to separate the alternate fields, going to the eyes. Normally, a Silicon Graphics

Power Onyx with three Infinite Reality Engines is used to create the imagery that is projected onto the walls and floor (Virginia Tech, 1998).

2.2.4 Oculus

Since the invention of the CAVE room, there were constant attempts to decrease the significant cost (about one million USD) of this type of virtual environment and make it more affordable. One of the important steps was the invention of head mounted displays (HMD) (see Figure 5).

Figure 5. Head Mounted 3D Display (Oculus, 2014)

New trends, such as the increased availability of wireless networks, miniaturization of electronics and sensing technologies, novel input and output devices, gave rise to these kinds of user interfaces (Cakmakci and Rolland, 2006). A head-mounted display is generally a display that the user wears on his head. Mostly, these HMDs are placed or attached on helmets or even on goggles. Whilst the user moves his head, the display remains in front of his eyes. Mostly, all HMDs consist of a screen

for each individual eye and that is what creates a sense of the user's presence in VR (Virtual Reality, 2009).

2.2.5 The Sims

As Wikipedia (2014) indicates, The Sims is a life simulation game, developed by Will Wright in 2000 and released by Electronic Arts. It can be viewed as further development of computer-based virtual worlds. The game had an isometric projection and featured daily activities of virtual characters – the Sims, taking place in an imaginary virtual town (see Figure 6). The user creates those virtual characters, or avatars as they could be defined in modern terminology, choosing their personality, clothes, hairstyle, etc., applying settings, predefined by the system. This type of game can be referred to as sandbox games, where there are no predefined goals. Though the system suggests to you what to do next, there is a certain level of flexibility in the way of achieving those goals, viewing the whole process as the creation of your own world of people, their needs, desires and living environment from scratch.

Figure 6. A typical Sims house as it is seen in a viewer (The Sims, 2014)

It is interesting to point out that Will Wright came up with the idea of creation of such a simulation after he lost his home during the Oregon firestorm of 1991. He also viewed the computer games as a valuable part of the educational process at schools and universities (Seabrook, 2006). Since the first release, The Sims gained

huge popularity, recently releasing the fourth edition and becoming the most popular game of all times, selling worldwide more than 175 million copies (CNN, 2013).

2.2.6 Online virtual environments

The further development of virtual worlds moved from 3D web-based environments to take the shape of Multi-User Virtual Environments (MUVEs), e.g. Second Life or Active World, which enable multiple simultaneous users to interact with such environments through the user's graphical representation called an "avatar" The user is able to access contexts, build up structures, experience problems, similar to the user's real life or communicate with other users (Dieterle and Clarke, 2005). As Mennecke (2008) argues, the virtual world is also a computer-based simulated environment but not necessarily with multiple users, logged in simultaneously. A virtual world could also be accessed off-line from a standalone computer or tablet PC and the Sims might be a good example of such an environment. A MUVE, in contrast, needs online interaction with other users and it has attracted not only gamers but also business and academic researchers (Duncan *et al.*, 2012).

2.2.7 Second Life

The development of Second Life (SL) was probably one of the keystones in further progression of virtual worlds, dating back to 2003, when Linden Lab launched the first version. In the following decade, researchers, educational institutions, businesses and individual users showed a great interest in that environment as a platform which opens new possibilities for all kind of activities, e.g. representing your business, providing a virtual interactive space for your online classes, creating your own virtual community or just socialising with other people (see Figure 7).

Figure 7. A screenshot of the typical Second Life virtual place (Wikipedia, 2014)

Based on mark-up languages such as HyperText and Virtual Reality Mark-up languages, Second Life allows creation of 3D structures, using primitive building blocks, called “prims” and display of those structures on the web (Duncan *et al.*, 2012), making them accessible to users through its own browser or viewer .

As an environment, SL contains many objects, resembling those in real life, such as private houses, buildings, lakes, rivers, oceans and islands, created by users. Users access this world using avatars as their graphical representations, which in fact are library elements, offered by the system to users upon registration as a default option, to be modified later by users to a certain extent if they wish to do so. To build a structure in SL the user must purchase an island, using virtual money, provided by the system - Linden Dollars, which have an exchange rate with real-world currencies. The regular access to SL (without building options) for the regular user is free.

Within its ten years of existence, according to Second Life statistics, 36 million user accounts were created, having about 400,000 accounts created daily, with 1.2 million daily transactions for virtual goods, generating US$3.2 billion in total (Linden Lab, 2013). Such popularity subsequently led to growing usage of SL for different purposes: business, educational or social community usage (Duncan *et al.*, 2012).

2.2.8 OpenSimulator

Second Life is not the only choice and option for virtual world developers and users. The most popular alternative is probably OpenSimulator or OpenSim based virtual worlds. OpenSim is an open source multi-platform, multi-user 3D application server (OpenSimulator, 2014a). The virtual worlds created on OpenSim platform have features similar to SL structure and handling – the worlds can be accessed by the standard SL viewer or similar and interacted with through the avatar; the virtual spaces can be allocated to users and the structures can be built, using prims (see Figure 8).

Figure 8. A screenshot of the typical OpenSimulator virtual place (OpenSimulator, 2014b)

The significant difference between SL and OpenSim based worlds is the population: the most popular amongst them is the OSGrid, with total approximate number of users not exceeding 64,000 users. There are other virtual worlds based on OpenSim technology, such as Avination (25,860 users) or 3D Rock Grid (10,043 users) as reported by OpenSimulator's monthly updated usage statistics (OpenSimulator, 2014). As can be seen, the population of these three most active OpenSim based virtual worlds falls far behind of the population of Second Life with its

approximately 36 million registered users (Linden Lab, 2013). The role of population in users' interaction and involvement is discussed further in this thesis.

2.2.9 Carleton Virtual

Carleton University's virtual campus or Carleton Virtual (CV) represents another form of online virtual world, hosted by individual universities. It is a 3D virtual environment that resembles the real campus of that university, situated in Ottawa (Canada) (see Figure 9).

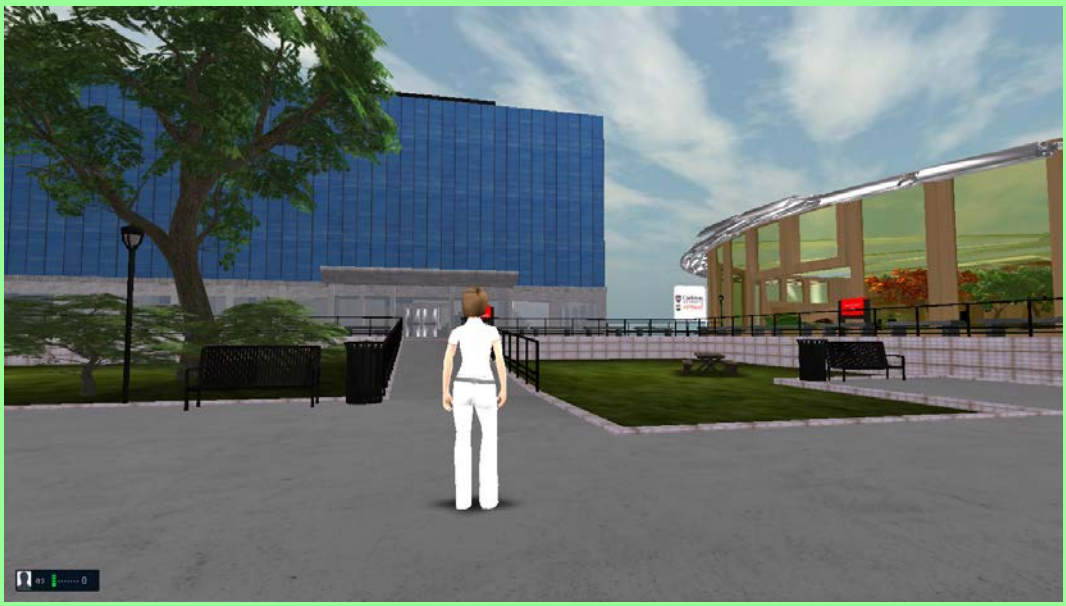


Figure 9. Carleton Virtual Campus Centre (Kanamgotov, 2014)

Originated by cooperation of the School of Information Technology of Carleton University and software company Avaya, CV became the place to explore virtual platforms in education, and for creating a simulated environment and experiences that otherwise could not be created and accessed due to the financial, geographical, logistic and other restrictions. The campus features university buildings, including learning centre, library, classrooms, meeting rooms, etc., which can be used by students and staff members for lectures, presentations, social interactions and other activities (Contact North, 2014). The virtual campus was created using web.alive technology and can be accessed through a regular web browser, such as Internet Explorer or Mozilla Firefox, using an avatar as a means of communication with other users. The avatar can be modified by the user, choosing gender, skin colour,

clothes and other options, similar to Second Life avatar modification. Communication with other avatars on-site may be maintained using voice or through the local chat facility.

2.3 Mobility

Mobility as a factor plays a more and more prominent role in the ways of modern computing and communication. With the advent of mobile devices (e.g. smart phones, tablet PCs) the landscape of online communication via instant messengers and social networks is changing rapidly. According to Adobe 2013 Mobile Consumer Survey results, in 2012 there were 121 million smartphone users and 94 million tablet users in the United States alone, representing a 31% and 180% increase over 2011, respectively. Mobile devices have changed the way consumers interact with businesses, and today's digital marketers must understand how consumers use different devices to be able to build and optimize mobile marketing strategies that deliver the right mobile experience to each mobile user (Adobe survey, 2013). The number of UK adults using smartphones increased from 51% in 2013 to 61% in 2014. The number of UK users using tablets to go online has almost doubled, increasing from 16% in 2012 to 30% in 2013 (Ofcom, 2014).

While e-mail (64%) and games (56%) are the most popular activities amongst mobile device users (Adobe survey, 2013), the educational aspect of the mobile devices usage cannot be ignored. According to Teach with Tablets (2014), Professor Steve Higgins, School of Education, Durham University, in his *Technology in Schools Survey Analysis* in March 2011 reports the findings of a 2010 survey, which polled 277 primary, secondary and further education (FE) teachers, educational advisors and other stakeholders. Over 50% of those polled believe mobile devices would become an important part of the teaching tool kit in the next five years: 54% saw pupils' personal devices playing a 'large role' in schools within 5 years; 60% saw the technologies role of engaging pupils out of class as essential; 6% of pupils were using tablets presently and this was forecasted to be 22% by 2015. Adobe (2013) in its survey reports 18% of users, aged from 18 to 64, were using their tablets for educational purposes. In higher education (HE), the trend seems to be the same – the popularity of mobile devices such as smartphones and

tablet PCs is growing among students. It seems it is no longer the case of counting computers in universities but rather examining how they are being used in order to deliver teaching and learning. In part, this is in response to demand from students, who have increasingly high expectations in terms of IT infrastructure, internet access and the ability to use their own devices to access their institution's networks. A recent survey of universities asked about which technologies were starting to make new demands in terms of support required for users: the influence of Web 2.0 was felt to be the most challenging, with mobile technologies ranking second. Mobile phones are being used in some universities to access the Virtual Learning Environment (VLE) systems and to send/receive administrative communications. A survey by Blackboard revealed that only 14% of FE and HE students are provided with services delivered to their mobile devices through an online learning environment customised for a mobile phone. The search over available resources did not return UK nationwide statistics, but the results of polls taken by individual universities suggest that mobile phone ownership is almost ubiquitous amongst students, and a significant proportion own a smartphone. Thus, 49% of students of the University of Edinburgh (survey of 2,000 students) had smartphones; 40% of students of Trinity College Dublin (survey of 2,250 students) had internet-enabled phones; 78% of Kent University students (survey of 270 students) had wireless access, 68% collected email via phone (GSMA, 2011). The University of Manchester (see Figure 10) also undertook similar research in 2013, confirming the general trend.

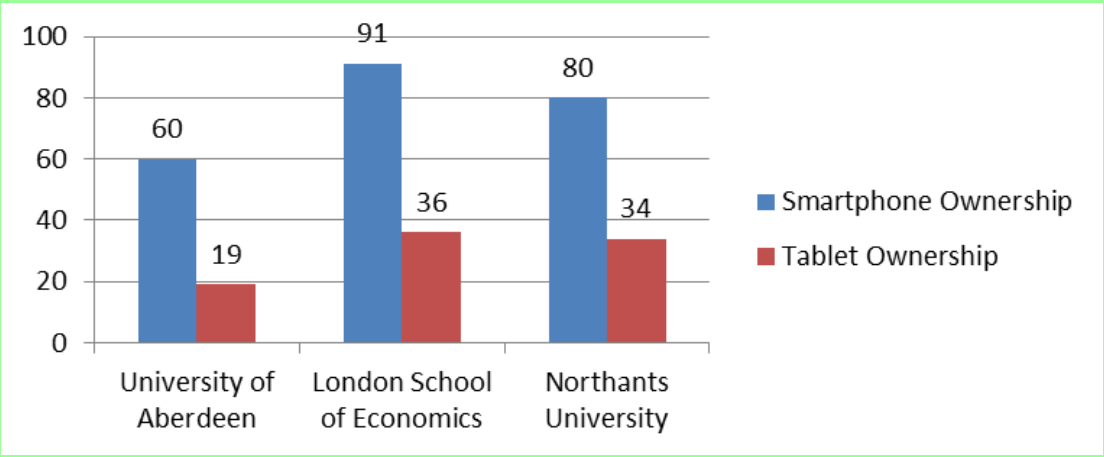


Figure 10. The usage of mobile devices among students of the University of Aberdeen, London School of Economics and the University of Northampton (Teaching Innovation, 2014)

The most recent data available were the device ownership figures at the University of Northampton; the survey ran between November 2013 and January 2014. As the price of tablets continues to fall it is to be expected that there will be a continued increase in ownership (see Figure 11) (Teaching Innovation, 2014).

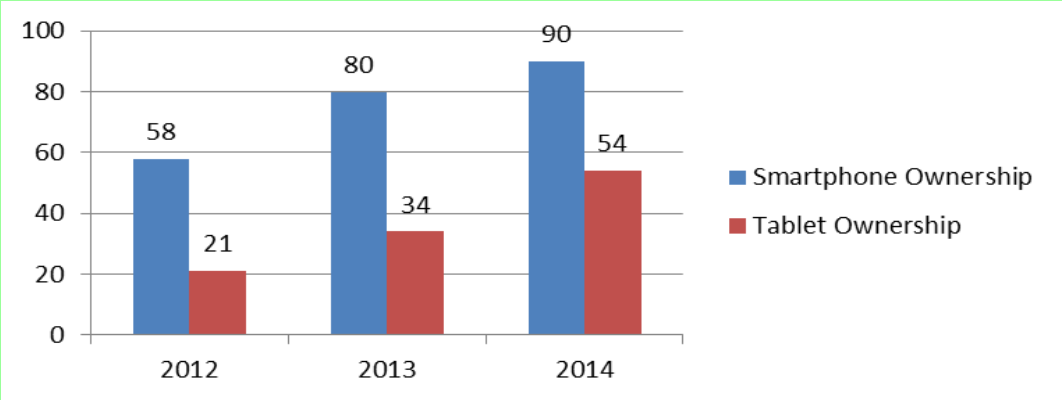


Figure 11. Comparison of device ownership 2012–14 University of Northampton (Teaching Innovation, 2014)

The necessary and emerging commercial sector to supply the mobile education ecosystem is quite fragmented. A few major international players, such as Pearson, Sony and Apple, see the potential in the UK market. Sony's approach, for instance, would include among others, bringing textbooks to life with rich media (i.e. Second Sight) or tapping into new technology trends, i.e. augmented reality, user-generated content, or 3D as per report by GSMA, from back in 2011.

Hence, mobility is a factor which is shaping the computing and communications of nowadays and should be considered as one of the aspects potentially influencing the user's experience, also from the achieving immersion perspective. That was the reason why mobility was taken into consideration while designing Experiment 3 of this research.

2.3.1 Summary

As can be seen from Table 1, some of the virtual world platforms were used in this research, some were not. Considering the reasons why this or that particular platform should be chosen for experimentation, the most important factor was applicability to the aim and objectives of this research (see Table 1).

Table 1. Comparison of different types of virtual environments and their usage in this research

System	Features	Applicability	Used in
	3D display accessible		
CAVE	Highly immersive 3D space, normally used for professional purpose simulations	Not applicable	Not used
HMD	Portable 3D device, used for simulations and games	Not applicable	Not used
	2D display accessible		
Second Life	Most well-known online based 3D environment. Accessible through regular 2D displays.	Applicable	Not used
Sims	Similar to Second Life environment, but runs locally, does not require full time internet connection.	Applicable	Used
OpenSimulator	Similar to Second Life, but can be installed and operated individually on university server	Applicable	Used
ReactionGrid	OpenSim based technology, but run and supported by dedicated provider.	Applicable	Used
Carleton Virtual	Carleton University run and operated platform, based on web.alive technology.	Applicable	Used

CAVE Room, for instance, provides an excellent immersive environment, but it is not applicable to this particular research due to the different type of virtual environment provided by that system. Head Mounted Displays (HMD) is another example of a highly immersive device which utilises a 3D display but is not in use in regular classrooms and hence, is out of scope of this research. Second Life was not used in this research in spite of the fact that it is the most popular platform for virtual world hosting. However, it has been utilised in Conrad's (2011) research and results of his studies served as a foundation for further investigations of other

factors potentially influencing immersion (see section 4.1). The updated version Sims 2 for mobile devices was used for this research. Though in fact it is a game, it is designed intentionally not to have a strict goal, so the player (user) does not need to follow one predetermined scenario, though the system provides the user with a hint for what to do next. This type of game is called “sand box”, where the user is more or less free in making decisions. Thus, the Sims 2 environment has been considered suitable for this research and used for Experiment 3, providing the platform for true mobile usage. That allowed utilising a mobile device, such as the 7-inch Android tablet in the typical environment, where mobile devices are normally used such as outdoor or indoor venues, different from home or office environments (see section 2.2.5).

OpenSimulator provides a platform for hosting a 3D virtual world, created and customised according to the users’ needs with the opportunity to be installed and operated on a local server (see section 2.2.8). This platform was used for this research in Experiment 4. For evaluation of factors, potentially affecting immersion, Sims 2 environment was used (see section 4.3.3). OpenSimulator’s virtual world allows retesting those factors under different test conditions, which involved the actual virtual world building process.

ReactionGrid, as one of the VW platforms, is also based on OpenSimulator technology, but unlike the latter it could not be installed on the local server since it is owned and operated by ReactionGrid Company as a dedicated provider at the time when Experiment 1 took place (see section 4.1.3). This platform was used in Experiment 1 since the environment met the test conditions – to provide less populated virtual worlds compared to such in Second Life with the same type of access and handling.

Carleton Virtual is based on web.alive technology (see section 4.2.1). This platform was used in Experiment 2, allowing use of less strict hardware requirements with handling similar to ReactionGrid, which was important for maintaining test conditions, combining the use of office and non-office environments (see section 4.2.4).

3 Methodology

The methodology used in this research combines qualitative and quantitative approaches, based on interviews and surveys. Both methods are well described in the literature (see Arksey and Knight, 1999; Birks and Mills, 2011; Boeije, 2002; Bryman, 2001). McLeod (2008), for instance, outlines that the qualitative approach views human behaviour from the informant's prospective where data are collected through observations and interviews whilst quantitative methods discover facts about phenomena and data are gathered through measuring things. Thus, the combination of both methods increases the validity of the results (McLeod, 2008).

3.1 Constant Comparative Method

The Constant Comparative Method (CCM) constitutes the very core of qualitative research, based on Grounded Theory, developed by Glaser and Strauss in 1967. It utilises coding and analysing methods at the same time in order to develop concepts from the data (Taylor and Bogdan, 1998). The CCM consists of four stages: "(1) Comparing incidents applicable to each category, (2) Integrating categories and their properties, (3) Delimiting the theory, (4) Writing the theory" (Glaser and Strauss, 1967, as cited in Kolb, 2012, p.105). The researcher starts with the raw data which in the process of applying the CCM gets the shape of more systematized information and finally, new theory emerges, grounded in the data collected.

Data can be collected through document collecting, observations, interviews or using other data gathering methods (Bogdan and Biklen, 2006). Written documents, for instance, can provide rich data; the researcher examines the documents in order to understand participants' experience and behaviour. Documens collection might have additional value when combined with observations and interviews. Observation is defined as process of systematic recording of events, behaviour and artefacts, where the researcher plays the role of observer (Marchall and Rossman, 2011). The main purpose of that process is to gain knowledge about the research area through understanding of the research settings and participants' conduct (Bogdan and Biklen, 2006). Interview is another powerful tool to gain research data. Interview, in general, can be defined as conversation or dialogue between researcher and participant (Wilson, 1998). In qualitative interviews, scientists

explore human experience, trying to understand participants' points of view through freely expressed opinions and by presenting their life situations in close personal interactions between participants and researcher (Kvale, 2006) (see section 3.4 for more information about interviews).

3.1.1 The principles of constant comparison

Tesch (1990, quoted in Boeije, 2002, p. 392) views comparison as the "main intellectual activity that underlies all analysis in grounded theory". Within this method the researcher is able to develop a theory more or less inductively, categorising, coding, delineating categories and connecting them. One of the founders of Grounded Theory, Barney Glaser while emphasizing the importance of constant comparative method putting an emphasis on CCM, said that "the constant comparative method is designed to aid the analyst who possesses these abilities in generating a theory that is integrated, consistent, plausible, close to the data…" (Glaser, 2008, para. 2). Glaser (2008) outlines three main approaches in the qualitative data analysis:

- Coding data first and then assembling and analysing it.
- Merely inspecting data for new properties and writing memos for its properties.
- Joint coding and analysis comprising the constant comparative analysis method.

The third approach allows combining the coding procedure of the first approach with the theory development of the second one, as the constant comparative method is designed to help the researcher to generate integrated and consistent theory (Glaser, 2008).

Hennie Boeije in her "A Purposeful Approach to the Constant Comparative Method in the Analysis of Qualitative Interviews" (2002) lists five steps of comparisons. These steps outline Boejie's practical approach for CCM within the scope of empirical research, concerning couples, affected by multiple sclerosis, a chronic illness. Having patients and their partners individually and in couples as a source of information allowed her to view the research problem from the two different angles

and probably get hidden and subtle data, enriching the results. Those five steps are as follows:

1. Comparison within a single interview
2. Comparison between interviews within the same group
3. Comparison of interviews from different groups
4. Comparison in pairs at the level of the couple
5. Comparison of the couples.

Table 2 summarises how Boeiji's five steps were used in this research.

Table 2. Boeije's (2002) Five Steps of Comparisons and their usage in this research

Type of comparison	Method (Boeije)	Aim (Boeije)	Adjusted aim in this research
Comparison within a single interview.	Interview fragments are studied to find what exactly they mean and to label them with adequate code.	To formulate the core message of the interview and to understand the interview as a whole, including difficulties and inconsistencies.	To identify the main message of the interview and check for potential blind spots, problems, inconsistences.
Comparison between interviews within the same group.	Interviews are compared to obtain variety of research subjects and narrow further selection of participants.	To further develop conceptualisation; to discover the combination of codes.	To identify similarities and differences in opinions among users within the same group to foster the research scope.
Comparison of interviews from different groups.	Participants' and their spouses' interviews are compared.	To complete the picture already obtained and to enrich results by obtaining additional information from groups who are involved but not undergoing the experience themselves.	To understand better the differences and similarities between different groups, allowing for "projection" of the results of later groups onto previous ones.

Comparison in pairs at the level of the couple.	Comparison in pairs, both partners belonging to a couple.	To find information about issues concerning the couple from both perspectives.	Not applicable.
Comparison of the couples.	Comparison between couples, who share the same experience	Further conceptualisation the issues concerning the relationship.	Not applicable.

Not all these steps are applicable to this research due to the fact that there were no established couples among the participants. All participants took part in experiments individually. Thus, steps 4 and 5 (Comparison in pairs at the level of the couple and Comparison of the couples) are not applicable to this research and have not been applied.

Constant comparison is linked to and combined with theoretical sampling. That combination and co-application means that the researcher decides what data to collect next and defines also the source of the data according to preliminary theoretical ideas, answering the questions arising from the previous set of data. The cycle of comparison of old and new data can be repeated several times until so-called "saturation point" where collection of new data does not bring any new value (Boeije, 2002).

3.2 Action Research

Action research can be described as a form of self-reflective, collective research activity, undertaken for analysis and further improvement of the research techniques and for better understanding of the situations, where these research practices are applied (Kemmis and McTaggart, 1988).

Action research is used for improvements in education, e.g. professional development, systems planning, policy development, etc.

The essence of the action research, as the title implies, is the link between action and research which can be viewed as trying out new ideas in practice in seeking for further gain of knowledge about the phenomena under the research for further improvements of existing practices and techniques.

Action research as a concept was originated by Kurt Lewin (1946), who applied it to diverse and complex contexts, such as integrated housing, equalisation of employment opportunities or socialisation of street gangs in the post World War II US, proving the feasibility and robustness of the approach to resolve difficult and conflict-driven social situations.

Lewin's approach can be described as spiral steps, composed of planning, action and the evaluation of the result of action. The process starts with a general idea, that then changes and improvements are needed in the area under research. Then researchers break that general idea into smaller and more manageable steps. As data starts coming out, the process of data evaluation begins with the critical assessment of the results, which provides with the ground for planning new actions and new evaluations. The general plan is revised according to data analysis performed and the whole process starts again (see Figure 12).

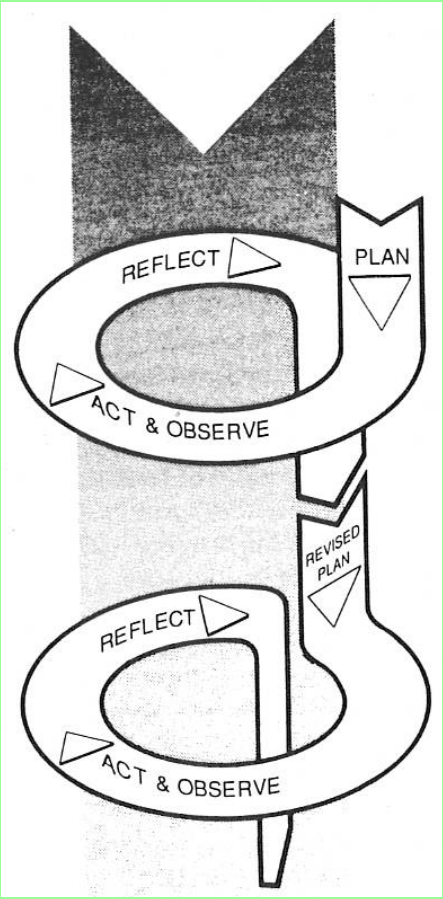


Figure 12. The action research spiral (Kemmis and McTaggart, 1988)

Lewin's approach requires flexibility of planning due to the complexity of most social situations in the areas under research. It is quite difficult to predict the sequence of necessary actions in the field and overlapping of action and observation processes is needed to allow changes as researchers learn from experience gained.

Before moving to implementation of action research activities in the field, researchers normally identify a so-called "thematic concern" – a broader area of concerns, shared by the group of researchers, forming the scope of further improvements. The identification of the thematic concern precedes the engagement of researchers into four fundamental aspects of the action research:

- To develop a plan for improvement of the current situation in the area under research
- To implement the plan
- To observe the effects of actions done in the context
- To reflect on these effects for further planning and subsequent actions in a cyclic way.

The action researcher performs those four activities in a collaborative way, involving participants in the action research process.

3.2.1 Action research approach in this research

Though this particular research is not seeking improvements of the research techniques in the research area and probably does not fully fall into a typical action research category, this research utilises the methodology of action research, combining four essential parts or activities: planning, acting, observing and analysing the results. Initially, each experiment is designed to explore one single potential factor of influence on the user's immersion experience. After obtaining the results of the experiment, the following analysis brings that factor or group of factors to the surface, narrowing the scope of further experimentation. This approach also complements Grounded Theory, used in this research (see section 3.5 for details). Planning for each experiment using action research methodology adopts a more flexible approach for the next steps in data gathering in order to accommodate the hidden and not always obvious nuances in participants' answers from the previous results and to take those nuances into consideration whilst

planning the next set of experimentation, which allows highlighting previously subtle and probably not fully expressed opinions, concerns and thoughts.

3.3 Survey

The term “survey” is used in different ways, but normally refers to the selection of a relatively large group of people and the collection of a relatively small amount of data from them (Kelly *et al.*, 2003). This is usually done through questionnaires or interviews. Surveys seek explanation and provide data for testing hypothesis. Survey has a certain number of advantages and disadvantages. For instance, surveys can produce a large amount of data in a short time period at relatively low cost, but the data collected are likely to lack details, being too shallow. Hence, it is advantageous to combine a survey for data collection as a quantitative approach with individual or group discussions as a qualitative method for gathering richer data and providing for better data validity.

The survey, administered to users in a form of questionnaire and suggesting the users to share their opinion through the Likert scale, is used in this research.

3.3.1 Likert scale

A “Likert scale” is actually the sum of responses to several Likert items. These items are usually displayed with a visual aid, such as a series of radio buttons or a horizontal bar representing a simple scale. A “Likert Item” is a statement that the respondent is asked to evaluate (Vanek, 2012). Likert scales (or more generally, summative scale) are developed by utilizing the item analysis approach wherein a particular item is evaluated on the basis of how well it discriminates between those persons whose total score is high and those whose score is low (Kothari, 2004). The scale consists of a number of statements, expressing either desirable or non-desirable relationship of the participant to the object under research. The respondent is asked to provide his or her opinion by marking an appropriate point on the 3, 5, 7 or even more levelled (or point) scale.

The traditional Likert scale (see Figure 13) has typical features such as a declarative statement (e.g. “I like Valentine’s Day”), an ordered continuum of response categories (e.g. from “Strongly disagree” to “Strongly agree”), a balanced number of positive and negative options and numeric value, assigned to a category.

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
I like Valentine's Day	1	2	3	4	5

Figure 13. Example of five-level Likert scale (Dawes, 2008)

A Likert-type scale as a variation of the traditional scale has similar features such as an ordered continuum of response categories or a balanced number of positive and negative options, but they do not use the traditional "Strongly disagree" – "Strongly agree" continuum, for instance, utilising other ordered continuums such as "Never" – "Always", "Mild" – "Severe" or "Not at all" – "A lot". A Likert-type scale also may or may not use a declarative statement (see Figure 14).

	Never				Always
I go out on Valentine's Day					

Figure 14. Example of Likert-type scale (Dawes, 2008)

Likert or Likert-type scales both may be constructed with or without midpoint (or middle value) such as "Neither disagree nor agree". Having the midpoint allows for more flexibility in responses due to the fact that participant may be willing to avoid expressing strong feelings, especially when a topic is sensitive or not well known. On the other hand, participants might be less discriminative, taking less time to weigh the merit of each response category.

Another point of consideration while constructing the scale is how many points it should have. Historically, 5- and 7-point scales are considered the most productive and accurate enough to produce reliable results. Simulation studies and empirical studies have generally concurred that reliability and validity are improved by using 5- to 7-point scales rather than coarser ones (those with fewer scale points). But

more finely graded scales do not improve reliability and validity further (Dawes, 2008).

The Likert scale has certain advantages, as the scale is relatively easy to construct and analyse data gathered, especially in user-centred research, allowing research participants an easy way to express their opinions. At the same time, a Likert scale does not distinguish how two "Agree" responses from two different participants differ in degree, or in other words, it does not recognise how one "Agree" response is greater or smaller than the other "Agree" response. Nevertheless, this method is considered to be reliable enough and quite favoured by researchers in different fields such as social studies, healthcare or human behaviour (Kothari, 2004).

Survey as a method of data collection with Likert scale analysis method was used in Experiment 1 and Experiment 4 of this research (see sections 4.1.7 and 6.4).

3.4 Interviews

Interviews, along with other data collection methods, are commonly used in qualitative research. There are three fundamental types of interviews: structured, semi-structured and unstructured. The structured version is the most rigid one, and essentially is a verbally administered questionnaire which allows no flexibility in follow-up questions and no variations in questions asked. By nature, structured interviews allow limited participant response and hence, limit the depth of data gathered.

Unstructured interview, as the counter version of the structured ones, does not reflect any preconceived ideas and is performed with little or no prior organisation. Such an interview might start with open-ended question, such as "What do you think of …" or similar, where the participant is encouraged to express his opinion without boundaries. The interview then will progress further, depending on what sort of responses were received from the participant. Unstructured interviews are very time consuming and can be difficult to manage since there are no predetermined interview questions and thus, very little guidance is provided on how to proceed and what to talk about. Participants often find this type of interview quite confusing and unhelpful. Therefore, unstructured interviews are mostly used when virtually nothing is known about the subject area.

Semi-structured interviews by definition take place in between structured and unstructured versions, consisting of several key questions to help to define the areas of research exploration, but at the same time allowing divergence in order to respond to a newly appearing idea or for further refining the topics of discussion. This format provides the participants with some guidance on what to talk about, which many of them find helpful. The flexibility of this approach, especially when compared to structured interview, allows for discovery of additional themes or elaboration of existing areas, which were not thought of by the research team (Gill *et al.*, 2008).

In this research the semi-structured interview method was used to collect data in Experiment 2 and Experiment 3 (see sections 4.2.6 and 4.3.5).

3.5 Grounded Theory

3.5.1 Overview

Grounded Theory (GT) is a general research method not owned by any school or discipline. It guides the researcher on how the data should be collected (quantitative data or qualitative data of any type, e.g. video, images, text, observations, spoken word etc.) and outlines the data analysis procedures (Scott, 2009).

Grounded Theory was developed by Barney Glaser and Anselm Strauss in 1967 and since then it is one of the most popular research methods, predominantly used in social science. In their book *The Discovery of Grounded Theory*, first published in 1967, the founders of this theory emphasised that the notion of generating new theory from data was opposed to testing existing theory: “We would all agree that in social research generating theory goes hand in hand with verifying it; but many sociologists have been diverted from this truism in their zeal to test either existing theories or a theory that they have barely started to generate” (as cited in Birks and Mills, 2011, p.2). Kathy Charmaz (2006, p. 2), as one of the well-known GT theorists and practitioners, outlines her vision on the theory as “methods which consist of systematic, yet flexible guidelines for collecting and analysing qualitative data to construct theories 'grounded' in the data themselves. The guidelines offer a set of general principles and heuristic devices rather than formulaic rules”. The grounded theorist begins with being open to “what is happening” in the studied area

in order “to hear, see and sense” while gathering data (see Figure 15). The data is constructed through observations, interactions and materials, concerning the research subject and then coded, which means attaching labels to segments of data, describing what each segment is about. The early data is constantly compared to the later gathered data while coding the latter. Through studying data and coding them, the analytical categories are derived, which later when the level of completeness or in terms of Grounded Theory, the level of saturation is reached, form the understanding of the studied phenomena, producing the theory, grounded in data (Charmaz, 2006).

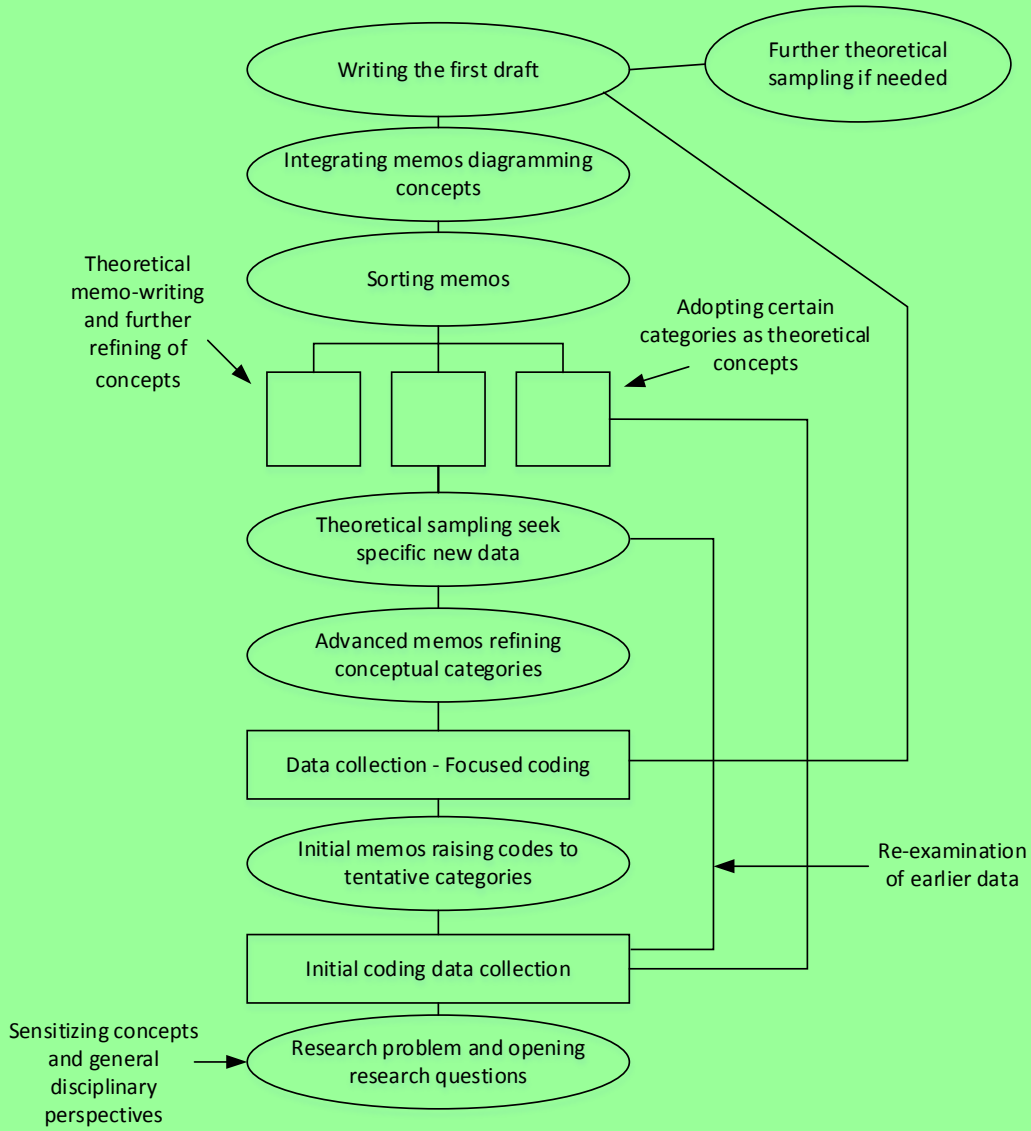


Figure 15. The grounded theory process (Charmaz, 2006)

Birks and Mills (2011) outline that there are several generations in grounded theory, sprining from the original version from Glaser and Strauss. The idea of generating a theory from the data gathered instead of testing existing theory became very popular as a research methodology since Glaser and Strauss's original 1997 text. They taught together in the University of California, San Francisco (UCSF) for 10 years where several cohorts of students grew up on this theory as solid followers, who would carry on the legacy of the theory originators. In the literature currently there is a trend to categorise Glaser and Strauss as the first generation of grounded theorists. At USCF they created a supportive and challenging teaching environment, which became a cradle for the second generation of grounded theorists, who later wrote their own interpretations of GT. Table 3 summarises seminal texts, suggested by Birks and Mills (2011) due to originality of the work and contribution to the theory (see Table 3).

Table 3. Seminal grounded theory texts (from Birks and Mills, 2011)

Year	Author	Title
1967	Glaser and Strauss	*The discovery of grounded theory*
1978	Glaser	*Theoretical sensitivity*
1987	Strauss	*Qualitative analysis for social scientists*
1990	Strauss and Corbin	*Basics of qualitative research. Grounded theory procedures and techniques*
1992	Glaser	*Basics of grounded theory analysis*
1994	Strauss and Corbin	"Grounded theory methodology: An overview" in *Handbook of qualitative research* (1st Edition)
1995	Charmaz	"Grounded theory" in *Rethinking methods in psychology*
1998	Strauss and Corbin	*Basics of qualitative research: Grounded theory procedures and techniques* (2nd Edition)
2000	Charmaz	"Grounded theory: Objectivist and constructivist methods" in *Handbook of qualitative research* (2nd Edition)
2005	Clarke	*Situational analysis: Grounded theory after the postmodern turn*
2006	Charmaz	*Constructing grounded theory: A practical guide through qualitative analysis*

Following the split of Glaser and Strauss in 1990, a debate about the relative merits of each scholar's work continues today. The reference to Glaser's and Strauss's different perspectives on grounded theory can be frequently seen in the literature. Often a researcher can demonstrate adherence to a traditional Glaserian or evolved

Straussian version of the theory, but few things are ever black and white, especially in such a highly interpretive research methodology as grounded theory (Birks and Mills, 2011). It is necessary to outline at this point that further refining or classification of grounded theory's different approaches lies beyond the scope of this research. Instead, the essential grounded theory steps are outlined here, those which are necessary to make in order that the research outcome could be considered as made within grounded theory's scope.

3.5.2 Data coding

Data coding is used to grasp what is actually in the interview data to identify what people think about the research phenomenon. Coding helps to move from the concrete statements to more abstract interpretations of data, contained in the interviews. However, the coding procedures were designed not to be followed dogmatically, but to be applied in an analytical and creative way. Strauss and Corbin (1998) see the purpose of coding procedures as follows:

- Build rather than test theory
- Provide researchers with analytical tools for handling masses of raw data
- Help analysis to consider alternative meaning of phenomena
- Be systematic and creative simultaneously
- Identify, develop and relate the concepts that are the building blocks of the theory.

Initial or open coding is the first step of data analysis, identifying important words in the interviews and labelling them accordingly. Usually those words and groups of words are direct quotations from participants. Categories are formed by groups of related codes. Categories are considered to be saturated when they are sufficiently explained in terms of their properties and when new data analysis return only codes that fit in existing categories (Charmaz, 2006).

3.5.3 Concurrent data collection and analysis

As Birks and Mills (2011) point out, referring to the original grounded theory text of Glaser and Strauss of 1967, concurrent data generation or collection and analysis is one of the fundamental principles of grounded theory. The researcher collects a

smaller amount of data at the beginning and starts analysing and coding it before more data is collected or generated. This approach differentiates grounded theory from other types of research design which initially require collecting the data and then coding it or to form an initial hypothesis, and then collecting the data to test that proposition.

3.5.4 Writing memos

Memos are written notes or records of a researcher's thinking during the process of study. It should be understandable that memos as such vary greatly in intensity, coherence, content, subject, etc. Many researchers critically assess their own ability to write memos. Nevertheless, memos play a very important role in the formation of a researcher's opinion and they are an ongoing activity for the grounded theorist (Birks and Mills, 2011). Charmaz (2006) calls the memo writing a "pivotal activity" which happens in between data gathering and writing a draft of the paper. Writing memos constitutes a crucial method in grounded theory; they help to think about "what's going on" and analysing one's data at early stages of the research.

3.5.5 Theoretical sampling

Theoretical sampling is used normally to provide with more data whilst in constant comparative analysis. It becomes apparent that more data is needed to saturate the categories which are under development. That often happens when the researcher needs to know more about categories, their properties, conditions they exist under or the dimensions of a category (Birks and Mills, 2011). Theoretical sampling means seeking data which develops the emerging theory. The main purpose of the process is to elaborate and refine the categories, forming the theory. The process continues until the saturation level is reached and no new properties emerge (Charmaz, 2006).

3.5.6 Constant comparative analysis

Constant comparative analysis is a part of the process of concurrent data collection and analysis. Normally it is performed on incident to incident, incident to codes, codes to codes, codes to categories and categories to categories bases. The process continues until a grounded theory is fully integrated (Birks and Mills, 2011). At the beginning, it is recommended to compare data to data to find similarities and

differences, for instance, within the same interview and similar statements in different interviews. If the researcher's code defines another point of view on the process, belief or action, it is necessary to note that and not to dismiss it. The researcher's ideas might be based on hidden meanings and actions which had not come to the surface yet. Such ideas form another set of ideas to check. The task of the grounded theorist is to make analytic sense of the material which might challenge taken for granted understandings (Charmaz, 2006). For more information about constant comparative methods, see section 3.1.

3.5.7 Theoretical sensitivity

Theoretical sensitivity is the ability of researcher to immerse themself into the topic of research through theorising, i.e. stopping, pondering and rethinking. To gain theoretical sensitivity the researcher needs to look at the studied phenomenon from a different angle, make comparisons and generate ideas. The end points might not be visible at this point, but it is more important here to see possibilities, establish connections and ask questions. Grounded theory gives methods to avoid mechanical application of knowledge packages and predetermined ideas (Charmaz, 2006). In Birks and Mills's (2011) text in terms of how theoretical sensitivity is reflected in researchers' backgrounds, researchers are called "a sum of what they experienced" (Birks and Mills, 2011, p.11). The researcher's level of theoretical sensitivity is very personal, reflecting the ability of insight into themselves and the area of study, their intellectual history.

3.5.8 Intermediate coding

The second major stage of data coding from the initial coding is intermediate coding. Moving from the initial to intermediate coding forms another step in applying grounded theory. The intermediate coding is used for developing fully individual categories by connecting sub-categories and linking categories together. Whereas initial coding is used to fracture data, intermediate coding serves to reconnect the data in ways that are more abstract than would be produced by thematic analysis (Birks and Mills, 2011).

3.5.9 Focused coding

Focused coding means using the most significant or frequent initial codes to go through large amounts of data. Focused coding seeks to determine which initial codes make the most analytical sense to categorise data. But it is not necessarily a linear process. At a certain point the researcher might need to go back to the initial data and examine it afresh. The actual research which is conducted through analysis of the data likely will differ from that planned before. Researchers learn throughout studying the data. Qualitative coding guides that process of learning. Through that process researchers begin to make sense of data. Careful attention should be paid to coding in order to understand acts and accounts, scenes and stories from the participants' points of view. Researchers need to know "what is happening" in participants' lives and in lines of recorded data and to understand participants' standpoints and situations. The logic of grounded theory coding differs from the logic of quantitative research, where preconceived categories or codes are applied to the data. In grounded theory, codes and categories are created by the researcher according to what they see in the data (Charmaz, 2006).

3.5.10 Generating theory

The final step in finalising of grounded theory studies is the generation of actual theory that explains the phenomenon under the research. The theory is generated by the researcher, using data collected earlier as a source. There are many ways to describe the process of theory generation, but the one, presented by Birks and Mills (2011), looks quite interesting. Figure 16 depicts essential grounded theory methods, used for theory generation, represented as three cogs, driving the whole process. The largest cog contains initial and straightforward methods, which are relatively easy to apply. It can be viewed as a powerhouse that drives the whole mechanism of research design, enabling data generation. The two smaller cogs include concepts that are equally important whilst taking the study beyond qualitative description to the next level of sophistication. Engaging those concepts provides for further refinement of the data and further generation of the grounded theory itself, should that be the case. Memos lubricate the whole process.

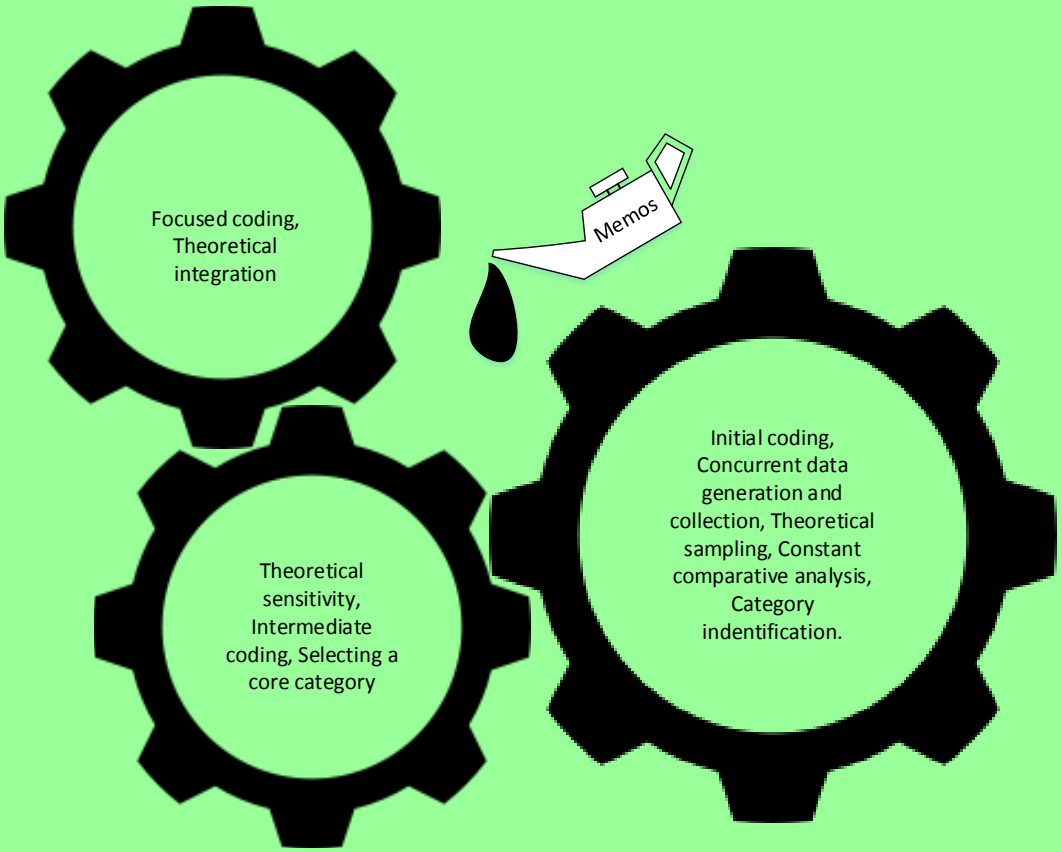


Figure 16. Essential grounded theory methods (adopted from Birks and Mills, 2011)

Grounded theory as a method for data analysis is used in experiments 2 and 3 of this research (see sections 4.2 and 4.3).

3.6 Focus Groups

Focus groups are a form of group interview that capitalises on communication between research participants in order to generate data (Kitzener, 1995). Though group interviews might also be used to collect data, the advantage of the focus group method is that the discussion is normally engaged between group members, which enriches the data and makes the whole process of interviewing more productive. This method allows not only to get people's opinions, but also to understand why they think that particular way. Group discussion is usually triggered by several open-ended questions from the researcher, encouraging group members to share their opinions and highlight the research questions or hypotheses in their own vocabulary, which often brings the research to a new and unexpected direction. The downside of the focus group method is that individual voices might be shut down

and not recognised within the group discussion. Group members might experience a certain level of awkwardness when the group is not homogeneous enough, if participants from different groups are mixed, for instance, or they have to express themselves in the presence of their manager or teacher. On the other hand, homogeneity should not eliminate diversity of group members, which may enrich the data gathered.

The optimal number of groups and participants per each group varies in the literature. Morgan (1997), for instance, suggests 3-5 groups with 6-10 participants in each group as an optimal number. Kitzinger (1995) sees up to 50 groups with 6-8 people in each, depending on the scale of the research. In the particular case of this research, several factors were taken into consideration, whilst evaluating the number of groups and the number of participants. Firstly, participants were meant to be recruited among students of the Department of Computer Science, who were taking the module “Social and Professional Project Management”, offering them a workshop on how to build a Virtual Showcase, required for that module. Thus, the number of focus groups were defined by the number of students, responsible for building that virtual showcase and willing to participate in one of the workshops. Secondly, the number of participants in each group was also defined by the number of students willing to participate in one particular workshop. And thirdly, combining students from different project groups into one focus group with optimal number of 6-8 people or in other words, making focus groups bigger, was not a desirable option due to privacy issues, since each project group has its own unique project ideas and might not feel comfortable participating in the workshop within one focus group. Hence, these constraints determined the number of focus groups at 8 and number of participants in each varying from 2 to 4, depending on how many students would like to take part in those voluntary workshops and the following discussion.

Focus groups discussion method is used in this research for Experiment 4.

4 Experimentation

In order to address the research question, namely, to evaluate factors potentially affecting user's immersion in a non-game, non-goal-oriented virtual world, four experiments were designed and conducted during this research, exploring different aspects of the virtual world's usage. This section explains the reasons why each experiment was designed and performed in that particular way.

4.1 Experiment 1

4.1.1 Background

Experiment 1 aimed to evaluate the findings against Conrad's (2011) theoretical predictions. Indeed, in 2011 the virtual world related activities for the unit, called Professional Project Management (PPM), taught at the University of Bedfordshire, were moved from a Second Life based virtual environment to an OpenSim based one (via ReactionGrid as the OpenSim service provider) for technical reasons. The customer support from the Second Life technical team during that particular period of time was far from being ideal and the PPM teaching team was receiving numerous complaints from the students about virtual world inaccessibility when it was most needed for the course assignments. Therefore, it was decided to change the virtual world's web hosting in order to address this issue. That unexpected situation provided an excellent opportunity to conduct this experiment and to figure out whether the new virtual environment affected the user's immersion experience due to the drop in number of users.

4.1.2 Research Question

A theoretical approach to evaluate virtual worlds in a systematic way – in particular focusing on alternatives to Second Life as the market leader – is taken in Conrad's work (2011), starting with the two antipodes extrinsic vs. intrinsic (which denotes a view from within the virtual world, i.e. the avatar's view versus the user view from 'outside' the world); and individual vs. world that identifies the perspective seen by the individual and contrasts this with the one taken by the world. The four dimensions immersion, cost, context and persistence are implied as shown in Table 4.

Table 4. Conrad's Four Dimensions for Virtual World Evaluation (Conrad, 2011)

	Intrinsic	**Extrinsic**
Individual	Immersion	Cost
World	Context	Persistence

The focus within this experiment was on immersion, the individual / intrinsic dimension, whilst further investigation on the other dimensions would have to be conducted elsewhere.

In his paper, Conrad (2011) uses this framework of four dimensions to evaluate five specific alternatives to Second Life – a dedicated provider (other than Second Life), a provider within the OSgrid, a virtual world hosted by the institution itself, a virtual world hosted by students themselves, or just continuing without any virtual world. Concerning immersion in particular, he argues, that the use of the virtual world of a dedicated provider, where the population of users is significantly lower than in Second Life, decreases the chances of users' immersion appearing within that virtual world, compared to similar experience in Second Life. Experiment 1 aimed to investigate this assumption further, based on primary data collected in the context of a student assignment.

4.1.2.1 Other than Second Life

The virtual worlds of the Second Life 'competitors' are based on similar technology with approximately the same degree of graphical realism and latency. Users can login from regular computers with regular 2D monitors which are "standard" for most home and office hardware specifications. Indeed, as has been observed in Conrad *et al*'s paper (2011) already, the only significant difference amongst currently existing online virtual worlds (e.g. Second life, ReactionGrid, OSGrid) is the number of concurrently logged-in users or in other words, the in-world population.

According to Carr and Oliver (2009), the number of concurrently logged in users in Second Life is around 62,500 per day (April 2012) and ReactionGrid's number of active users is not higher than 387 (March 2012) as per Second Life Grid Survey (2012). Any statistics on concurrently logged-in users in ReactionGrid was not found in published sources for direct comparison, however, this number of "active

users" is sufficiently indicative for our purpose. Though there is no precise definition of "active user" (and it seems like each online resource counts this number in different way (see Korolov, 2012; Oldenburg, 2010; O'Neil, 2011), it can be assumed that this is the number of users who perform some activities on the web resource within a given period of time, but not necessarily simultaneously. This number generally should be higher than the number of concurrently logged in users. Therefore, it is obvious that the overall active population in ReactionGrid is significantly lower than the population engaged in Second Life.

4.1.3 Context

The experiment has been conducted with students using ReactionGrid, which has all the features of a dedicated provider: similar to Second Life, virtual islands can be rented to provide land on which students can pursue their activities. The technical handling of the virtual world provided by ReactionGrid is indeed similar to the one in Second Life. Structures can be built using prims, scripting, texturing etc. and communication is possible on local chat as well as by instant messages. However, and in strong contrast to Linden Labs and Second Life, there is almost no casual or recreational traffic of residents within ReactionGrid.

The experiment took place during a final year undergraduate course called Social and Professional Project Management. Students were required to build an educational showcase within ReactionGrid and to develop an artifact of their own choice (unrelated to virtual worlds) as part of a PRINCE2® managed project. Also students were encouraged to look for example showcases within Second Life while building on the ReactionGrid island.

4.1.4 Participants

Participants were recruited from the undergraduate level students of the University of Bedfordshire. Nineteen participants took part in this experiment, 16 males and 3 females, aged from 18 to 44 years. All students were studying computer science or engineering related courses at the university.

4.1.5 Venue

The regular university computer lab was used as a venue, equipped with desktop computers with sufficient technical specifications to provide real-time support for 3D online-based virtual environment rendering.

4.1.6 Task

Participants were asked to spend at least 30 minutes in the virtual world performing (or not) activities, related to their assignment, such as using prims to build structures or scripts to add animations, importing other elements (e.g. pictures, furniture, trees, other decorations) from the internet, etc. or communicating with group mates through the local chat. It is important to emphasise that participants were informed that all these activities could be performed in any sequence preferred, skipped partly or not performed at all as it was left entirely to their discretion. Such a freedom of choice for the activities sequence, given within the suggested set of tasks was necessary to achieve a non-goal-oriented environment, necessary for this experiment. The data was gathered through the questionnaire, administered to participants in a form of online survey.

4.1.7 The Questionnaire

The questionnaire used in this experiment was a modified version of that used by Jennett *et al.* (2008) for their experimentation on user immersion. The modifications to the questionnaire were necessary since Jennett *et al.*'s questionnaire was tailored towards use in a game environment and therefore contained specific, game-oriented questions. In particular, two questions "How much did you want to "win" the game?" or "When interrupted, were you disappointed that the game was over?" from Jennett *et al.*'s questionnaire were considered to be not applicable to the context of the experiment and were excluded from the questionnaire.

Answers were presented to participants on a Likert scale, rating from 1 (the lowest) to 5 (the highest) scores. An open question asking for any other comments was added at the end of the questionnaire. All 29 questions were mandatory. The questionnaire was made available online and the link was provided to the students during their practical sessions. The Google Docs service from Google was used to

make the questionnaire available online and to collect the results in a systematic way. Questions used in the experiment are presented in Table 5.

Table 5. Questions asked in Experiment 1
Note: Respondents were asked to choose a value from 1 to 5 where 1 and 5 were labelled as indicated in the last two columns. The scale options 2, 3 and 4 were not labelled (Kanamgotov *et al.*, 2012)

	Question	1	5
1	To what extent did the task hold your attention?	Not at all	A lot
2	To what extent did you feel you were focused on the task?	Not at all	A lot
3	How much effort did you put into playing the task?	Very little	A lot
4	Did you feel that you were trying you best?	Very little	Very much so
5	To what extent did you lose track of time?	Not at all	A lot
6	To what extent did you feel consciously aware of being in the real world whilst doing the task?	Not at all	Very much so
7	To what extent did you forget about your everyday concerns?	Not at all	A lot
8	To what extent were you aware of yourself in your surroundings?	Not at all	Very aware
9	To what extent did you notice events taking place around you?	Not at all	A lot
10	Did you feel the urge at any point to stop doing the task and see what was happening around you?	Not at all	Very much so
11	To what extent did you feel that you were interacting with the Virtual World environment?	Not at all	Very much so
12	To what extent did you feel as though you were separated from your real-world environment?	Not at all	Very much so
13	To what extent did you feel that the task was something you were experiencing, rather than something you were just doing?	Not at all	Very much so
14	To what extent was your sense of being in Virtual World environment stronger than your sense of being in the real world?	Not at all	Very much so
15	At any point did you find yourself become so involved that you were unaware you were even using controls?	Not at all	Very much so

16	To what extent did you feel as though you were moving through the task according to you own will?	Not at all	Very much so
17	To what extent did you find the task challenging?	Not at all	Very difficult
18	Were there any times during the task doing in which you just wanted to give up?	Not at all	A lot
19	To what extent did you feel motivated while accomplishing the task?	Not at all	A lot
20	To what extent did you find the task easy?	Not at all	Very much so
21	To what extent did you feel like you were making progress towards the end of the task?	Not at all	A lot
22	How well do you think you performed in the task accomplishing?	Very poor	Very well
23	To what extent did you feel emotionally attached to the task?	Not at all	Very much so
24	To what extent were you interested in seeing how the task's events would progress?	Not at all	A lot
25	How much did you want to accomplish the task?	Not at all	Very much so
26	Were you in suspense about whether or not you would successfully accomplish the task?	Not at all	Very much so
27	To what extent did you enjoy the graphics and the imagery?	Not at all	A lot
28	How much would you say you enjoyed being in the Virtual World environment?	Not at all	A lot
29	Would you like to do this task again?	Definitely not	Definitely yes

4.1.8 Results

Nineteen responses from participants were received in total. 19 of the 29 questions did not indicate any trend towards either end of the Likert scale, i.e. neither more than 50% scored 4 or 5, nor more than 50% scored 1 or 2. Therefore, focus should be placed first on the 10 other questions where a certain trend is visible (see Table 6 and Table 7).

Table 6. The seven questions where more than 50% of the respondents choose a value of 4 or 5 on the Likert scale

Question number	1–2 (%)	3 (%)	4–5 (%)
3	15.8	31.6	52.6
4	26.3	15.8	57.9
8	21.1	26.3	52.6
11	5.3	26.3	68.4
21	10.5	21.1	68.4
22	15.8	15.8	68.4
25	5.3	31.6	63.2

The seven questions where more than half of the respondents scored 4 or 5 could be considered as unrelated to the immersion experience itself. Q3 and Q4 (see Table 6), for instance, refer more to the effort put by the participants into the task rather than their feelings of "being there", Q21, Q22 and Q25 predominantly indicate the progress participants made and their desire to accomplish the task successfully, rather the sense of immersion. Q8 can be interpreted as an indication of self-awareness while doing the task as opposite to a "loss of the sense of reality". The only exception might be Q11, showing that participants were feeling interacting with environment. However, such an interaction, which was a part of their assignment, does not prove that a state of immersion was achieved. Indeed, the process of building something itself can be viewed as a necessary, but not sufficient factor to feel immersed in the environment. On the other hand, the three questions (Q7, Q12, Q15) where the majority of respondents scored 1 or 2, seem to indicate that not much immersion took place while doing the task – participants were well aware of themselves and were not driven away from their daily routines (see Table 7).

Table 7. The three questions where more than 50% of the respondents chose a value of 1 or 2 on the Likert scale

Question number	1–2 (%)	3 (%)	4–5 (%)
7	57.9	36.8	5.3
12	52.6	36.8	10.5
15	52.6	36.8	10.5

Table 8. Questions with balanced answers – neither a 50% majority towards 1–2 or towards 4–5

Question number	1–2 (%)	3 (%)	4–5 (%)
1	26.3	26.3	47.4
2	15.8	36.8	47.4
5	47.4	31.6	21.1
6	15.8	36.8	47.4
9	15.8	36.8	47.4
10	21.1	36.8	42.1
13	26.3	47.4	26.3
14	42.1	36.8	21.1
16	21.1	47.4	31.6
17	15.8	52.6	31.6
18	42.1	15.8	42.1
19	26.3	31.6	42.1
20	31.6	42.1	26.3
23	42.1	31.6	26.3
24	10.5	42.1	47.4
26	36.8	21.1	42.1
27	31.6	31.6	36.8
28	10.5	42.1	47.4
29	31.6	26.3	42.1

Interestingly the results for some questions, which scored between 40% and 50% (see Table 8) might be viewed as a certain support of the trend discussed above. Q1 and Q2, for instance, indicate that participants were focused on the task; but were they really immersed? On the other hand, Q6 and Q9 might be interpreted as a proof that not much immersion was experienced by the participants. Q10 might be interpreted in both ways – either a participant is deeply immersed and feels anxiety that calls him or her back to reality, or the participant is not immersed at all and feels like "looking around" instead of concentrating on the task. Q19, Q24 and Q26 were about feelings concerning tasks, accomplishing success and progress which broadly fall into the same category as the questions in Table 6.

Comments within the open question did not relate to immersion directly but rather provided feedback on the technicalities (such as unavailability of the server) or relevance to the assessment for the students' course therefore emphasizing the extrinsic view on the virtual world and avoiding any intrinsic perspective.

4.1.9 Statistical analysis of the results

The chi-square test is normally used as a test for statistical significance. Statistical significance means that there is a good chance that the researcher is right in an assumption that the relationship between two variables exists. But statistical significance is not the same as practical significance. The researcher might find statistically significant results, but they might not have any practical application. For instance, is there is statistically significant relationship between a citizens' age and satisfaction with city recreation facilities. The findings might indicate that 5% of citizens older than a certain age are not satisfied with that kind of service, but 5% might not be a large enough number to view this issue as seriously affecting citizens. Thus, the researcher must always take into consideration both statistical and practical significance of the results. The steps for conducting the statistical significance test are:

1) State the research hypothesis
2) State the null hypothesis
3) Select a probability of error level (alpha level)
4) Compute the test for statistical significance
5) Interpret the results (Saint-Germain, 1997).

Here it is important to outline, that the term "research hypothesis" which is used by Saint-Germain (1997) and the term "alternative hypothesis" which is used by Black (1992) are defining the same type of hypothesis – the hypothesis, which is the opposite of the null hypothesis. The term "alternative hypothesis" is used throughout this thesis. Also, in Black's (1992) interpretation, the null hypothesis is chosen first and the alternative one is chosen second. Though that slight variation does not bring any significant difference, that sequence is used in this research.

Thus, following those steps for conducting the significance test, first, the null and alternative hypothesizes must be defined (Black, 1992).

4.1.9.1 Steps 1 and 2. Choosing null and alternative hypotheses

A null hypothesis normally states that there is no relationship between variables under research (e.g. no relationship between the length of the job training programme and the rate of the job placement; no relationship between graduate pay

and gender of the graduates, etc.) The null hypothesis works for the researcher as a "straw man", since it is easier to disprove the null hypothesis than to prove the research hypothesis (Saint-Germain, 1997). The alternative hypothesis states the expected relationship between two variables (e.g. the rate of the job placement is related to the length of job training programme; graduate assistant's job pay is influenced by gender, etc.) (Saint-Germain, 1997; Kvanli *et al.*, 2003).

As Black (1992) discusses in his *Business Statistics. And Introductory Course* text book, choosing null and alternative hypotheses might be a difficult and frustrating process. Usually, the alternative hypothesis is the one which the researcher wants to prove to be true, "upon which the burden of proof falls" (Black, 1992, p.368). The null hypothesis is viewed as a statement, proving that the alternative hypothesis is false. If, for instance, a researcher is interested in testing whether a new drug is more effective than the old one, the hypotheses might be:

Null: the new drug is no better than the old one

Alternative: the new drug is better than the old one

To test these two hypotheses, data should be gathered and analysis should be performed. If the data show that the null hypothesis is false, the alternative hypothesis is accepted by default – the new drug has been shown to be more effective (Black, 1992).

Since all the answers of Experiment 1 participants are distributed among the range of scores, such as 1–2, 3 and 4–5, defined by the position on the Likert scale, it is logical to conclude that the range of scores will form 3 categories of answers, falling into each slot. That is, Category 1 is formed by the answers scored 1 or 2 on the Likert scale, Category 2 is formed by the answers scored 3 and Category 3 is formed by the answers scored 4 or 5 on the Likert scale (see Table 9).

Table 9. Formation of categories for the chi-square test of Experiment 1

Score on Likert Scale	1–2	3	4–5
Categories	Category 1	Category 2	Category 3

Forming both the null and alternative hypotheses for Experiment 1 results, participants' answers are grouped according to the scores given by participants on the Likert scale to each question (see section 3.3.1). As can be seen from Table 6, Table 7 and Table 8, each question has been answered by a certain number of participants, giving certain Likert scale scores (i.e. 1–2, 3 or 4–5) to each question. Question 1, for instance (see Table 8), has been given 1–2 scores by 26.3% of participants, the score 3 has been given by 26.3% and the scores 4–5 by 47.4% of participants. Thus, it would be logical to suggest to use those three groups of scores as categories whilst analyzing the results for significance, trying to understand how participants' answers are spread among those three categories.

Therefore, the null hypothesis assumes that each of those categories is equally chosen by participants, spreading all the answers evenly. The alternative hypothesis states the main research idea. It is the hypothesis which the researcher is interested to prove, as stated by Saint-Germain (1997). Thus, the alternative hypothesis, as a main research hypothesis and opposite of the null hypothesis will state that each of those categories Therefore, the null and alternative hypotheses for Experiment 1 Chi-Square test should appear as follows:

Null: each category is equally chosen by participants

Alternative: each category is differently chosen by participants

4.1.9.2 Step 3. Selecting the probability of error level (alpha level)

There are two types of error which potentially might occur in the research project:

Type I error – when the researcher assumes that the relationship between two variables exists, but in fact, it does not. Type I error is committed when a true null hypothesis is rejected where it should not be rejected. The probability of committing a Type I error is called alpha (Black, 1992; Saint-Germain, 1997).

Type II error – when the researcher assumes that the relationship does not exist, but in fact, it does. Type II error is committed when a false null hypothesis is not rejected where it should be rejected. The probability of committing a Type II error is called beta (Black, 1992; Saint-Germain, 1997).

Researchers generally specify the probability of committing a Type I error that they are willing to accept, i.e. the value of alpha. In social sciences most researchers select an alpha level equal to .05 (Black, 1992; Saint-Germain, 1997). Since Experiment 1 is very close in nature to social science subjects, exploring the users' behavior under certain constraints, the value of .05 is accepted as the level of alpha for analysis of Experiment 1 results.

4.1.9.3 Step 4. Computing the chi-square

The Chi-Square test is computed on a question-by-question basis in order to analyse and evaluate the significance of each answer. All the questions are combined into three groups according to the percentage of answers on each score level. Group 1 contains the questions scored 4 or 5 by more than 50% of users' answers on the Likert scale (see Table 6). Similarly, Group 2 consists of the questions scored 1 or 2 on the Likert scale by more than 50% of users' answers (see Table 7). And finally, Group 3 contains questions with so-called "balanced" answers, where the majority of users did not lean towards either end of the Likert scale, scoring 3 for these questions (see Table 8). The results of calculations of chi-square values for Group 1 questions are presented in Table 10. In Table 10, Table 12 and Table 14 the column "Observed %" indicates the number of users, given as a percentage and the values in this column were not used in chi-square calculations.

Table 10. Chi-square calculations for Group 1 questions

Question 3				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	3.002	15.8	1.752281
3	6.333333	6.004	31.6	0.017125
4-5	6.333333	9.994	52.6	2.115865
Total:3				**∑=3.885272**
Question 4				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	4.997	26.3	0.281966
3	6.333333	3.002	15.8	1.752281
4-5	6.333333	11.001	57.9	3.44007
Total:3				**∑=5.474318**

Question 8				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	4.009	21.1	0.85303
3	6.333333	4.997	26.3	0.281966
4-5	6.333333	9.994	52.6	2.115865
Total:3				**∑=3.250862**
Question 11				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	1.007	5.3	4.479446
3	6.333333	4.997	26.3	0.281966
4-5	6.333333	12.996	68.4	7.009125
Total:3				**∑=11.77054**
Question 21				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	1.995	10.5	2.971758
3	6.333333	4.009	21.1	0.85303
4-5	6.333333	12.996	68.4	7.009125
Total:3				**∑=10.83391**
Question 22				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	3.002	15.8	1.752281
3	6.333333	3.002	15.8	1.752281
4-5	6.333333	12.996	68.4	7.009125
Total:3				**∑=10.51369**
Question 25				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	1.007	5.3	4.479446
3	6.333333	6.004	31.6	0.017125
4-5	6.333333	12.008	63.2	5.084501
Total:3				**∑=9.581073**

As can be seen from Table 10, the value of chi-square for each category is calculated using the formula $(E-O)^2 / E$, where E is expected frequency of appearance and O is observed frequency of appearance. The chi-square for each question is the sum of chi-squares of each category within that question.

The observed frequency of appearance of the category is literally how many users have chosen that category whilst answering that particular question (see Table 10).

The expected frequency of appearance of the category is how many users theoretically would choose that category if all 19 participants were distributed evenly among those categories whilst answering that particular question. Unlike the observed number, the expected number must be calculated. To calculate expected

frequency of appearance of each category, the total number of participants is divided by the total number of categories: Expected = Participants Total / Categories Total (Deviant, 2010) or 19 / 3 = 6.333 (see Table 10).

Then all chi-square values of categories are summarized, forming the total chi-square values for each question (see Table 10).

4.1.9.4 Step 5. Interpreting the results

The next step, as outlined by Saint-Germain (1997), is to compare the calculated chi-square value to the value from the distribution table at the given alpha level (see section 4.1.9.2) and degree of freedom.

The degree of freedom (df) is a difficult concept, as researchers agree (Black, 1992; Eizenhauer, 2008; Walker, 1940). Helen Walker (1940), for instance, called the concept "almost mystical, with no practical meaning for the person, who is not mathematician and unfamiliar with N-dimensional geometry and who knows the contribution to modern sampling theory only from second hand sources, such as textbooks" (Walker, 1940, p.253). Ken Black (1992) in his *Business Statistics. An Introductory Course* text book for university-level statistical courses, states that "the concept of the degree of freedom is difficult and lies beyond the scope of this text" (Black, 1992, p.425). Similarly, the full description of df is beyond the scope of this research; it seems reasonable to limit its description by the practical meaning or how it could be applied to the chi-square test. Stephanie Deviant (2010) defines the degree of freedom as "the number of independent pieces of information that went into calculating the estimate", outlining the formula for df calculation as *n-1*, where *n* is the number of categories (Deviant, 2010). The same definition can be found in Walker (1940), Black (1992) and Eisenhauer (2008). Thus, for the purpose of this research, the formula df = n-1 is accepted. Therefore, the degree of freedom for Experiment 1 is equal to 3 minus 1, where 3 is the number of categories, i.e. df = 3-1 = 2.

The alpha level is defined in Step 3 and is equal to .05 (see section 4.1.9.2).

As can be seen in Table 10, the chi-square values are different for each question, varying from 3.885 to 11.771. The corresponding value of chi-square (at df = 2 and

alpha = .05) from the statistical table is 5.991 (see Appendix C). To interpret the results of the chi-square test, the calculated chi-square value should be compared to the chi-square value from the table. If the calculated value is less than the given one, the null hypothesis should be accepted and the alternative hypothesis should be rejected. If the calculated chi-square value is greater than the given one, the null hypothesis should be rejected and the alternative hypothesis accepted (Saint-Germain, 1997; Black, 1992; Deviant, 2010).

Comparing computed and table given values of chi-square it can be observed that for Question 3, for instance, chi-square-calculated is 3.886 and it is less than chi-square-given, which is 5.991 (i.e. 3.886 < 5.991) (see Table 11). That gives a ground to accept the null hypothesis, which states that each category is equally chosen and to reject the alternative hypothesis which states that each category is differently chosen.

Using the same pattern, other questions can be analysed, summarizing the results in Table 11.

Table 11. Results of the chi-square test for Group 1 questions

	Chi-Square value		Hypothesis	
Question	Calculated	Table (df=2; α=.05)	Null	Alternative
Q3	3.885272	5.991	Accepted	Rejected
Q4	5.474318	5.991	Accepted	Rejected
Q8	3.250862	5.991	Accepted	Rejected
Q11	11.770538	5.991	Rejected	**Accepted**
Q21	10.833914	5.991	Rejected	**Accepted**
Q22	10.513688	5.991	Rejected	**Accepted**
Q25	9.581073	5.991	Rejected	**Accepted**

As can be seen from the Table 11, for questions 3, 4 and 8 the calculated value of chi-square is lower than the table value. Thus, the null hypothesis (each category is equally chosen by participants) is accepted and the alternative hypothesis (each category is differently chosen by participants) is rejected for these questions. The acceptance of the null hypothesis indicates that there is no relationship between two variables (user's answers and categories) (Saint-Germain, 1997). Answers are not related to categories and have been chosen randomly, not really expressing users' opinions. In contrast, for questions 11, 21, 22 and 25 the calculated chi-square value

is greater than the given value and in this case the null hypothesis is rejected and the alternative one is accepted. The rejection of the null hypothesis and acceptance of the alternative one indicates that there is a relationship between those two variables and answers are related to categories and have been chosen not randomly, but differently, expressing users' opinions.

The chi-square values for Group 2 (see Table 12) are calculated using the same method applied to Group 1. Group 2 consists of the questions marked 1 or 2 on the Likert scale by more than 50% of participants (see section 4.1.9.3).

Table 12. Chi-square calculations for Group 2 questions

Question 7				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333333	11.001	57.9	3.440070333
3	6.333333333	6.992	36.8	0.068501333
4-5	6.333333333	1.007	5.3	4.479446333
Total:3				**∑=7.988018**
Question 12				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333333	9.994	52.6	2.115865333
3	6.333333333	6.992	36.8	0.068501333
4-5	6.333333333	1.995	10.5	2.971758333
Total:3				**∑=5.156125**
Question 15				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333333	9.994	52.6	2.115865333
3	6.333333333	6.992	36.8	0.068501333
4-5	6.333333333	1.995	10.5	2.971758333
Total:3				**∑=5.156125**

As can be seen from the summarized results in Table 13, the chi-square value for question 7 is greater than the given chi-square value from the statistical table; therefore the null hypothesis should be rejected and the alternative hypothesis accepted, indicating that there is a relationship between categories and answers. That suggests that the answer for question 3 expresses users' opinions.

Table 13. Results of the chi-square test for Group 2 questions

	Chi-Square value		Hypothesis	
Question	Calculated	Table (df=2; α=.05)	Null	Alternative
Q7	7.988018	5.991	Rejected	**Accepted**
Q12	5.156125	5.991	Accepted	Rejected
Q15	5.156125	5.991	Accepted	Rejected

For questions 12 and 15 the calculated chi-square value is less than the table value and the null hypothesis should be accepted and the alternative hypothesis rejected, which is an indication that there is no relationship between variables and answers for those questions were chosen randomly without expressing opinions.

The chi-square calculations for Group 3 questions (see Table 14) are performed according to the methods utilized for Group 1 and Group 2 calculations. Group 3 consists of so-called "balanced questions", marked neither 1, 2 nor 4, 5 on the Likert scale by more than 50% of participants. Replies for these questions were gathered in the middle of the Likert scale (see section 4.1.9.3).

Table 14. Chi-square calculations for Group 3 questions

Question 1				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	4.997	26.3	0.281966
3	6.333333	4.997	26.3	0.281966
4-5	6.333333	9.006	47.4	1.127865
Total:3				**∑=1.691798**
Question 2				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	3.002	15.8	1.752281
3	6.333333	6.992	36.8	0.068501
4-5	6.333333	9.006	47.4	1.127865
Total:3				**∑=2.948648**
Question 5				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	9.006	47.4	1.127865
3	6.333333	6.004	31.6	0.017125
4-5	6.333333	4.009	21.1	0.85303
Total:3				**∑=1.998021**
Question 6				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	3.002	15.80	1.752281
3	6.333333	6.992	36.80	0.068501
4-5	6.333333	9.006	47.40	1.127865
Total:3				**∑=2.948648**
Question 9				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	3.002	15.80	1.752281
3	6.333333	6.992	36.80	0.068501
4-5	6.333333	9.006	47.40	1.127865
Total:3				**∑=2.948648**

Question 10				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	4.009	21.10	0.85303
3	6.333333	6.992	36.80	0.068501
4-5	6.333333	7.999	42.10	0.43807
Total:3				**∑=1.359602**
Question 13				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	4.997	26.30	0.281966
3	6.333333	9.006	47.40	1.127865
4-5	6.333333	4.997	26.30	0.281966
Total:3				**∑=1.691798**
Question 14				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	7.999	42.10	0.43807
3	6.333333	6.992	36.80	0.068501
4-5	6.333333	4.009	21.10	0.85303
Total:3				**∑=1.359602**
Question 16				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	4.009	21.10	0.85303
3	6.333333	9.006	47.40	1.127865
4-5	6.333333	6.004	31.60	0.017125
Total:3				**∑=1.998021**
Question 17				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	3.002	15.80	1.752281
3	6.333333	9.994	52.60	2.115865
4-5	6.333333	6.004	31.60	0.017125
Total:3				**∑=3.885272**
Question 18				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	7.999	42.10	0.43807
3	6.333333	3.002	15.80	1.752281
4-5	6.333333	7.999	42.10	0.43807
Total:3				**∑=2.628422**
Question 19				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	4.997	26.30	0.281966
3	6.333333	6.004	31.60	0.017125
4-5	6.333333	7.999	42.10	0.43807
Total:3				**∑=0.737162**
Question 20				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	6.004	31.60	0.017125
3	6.333333	7.999	42.10	0.43807
4-5	6.333333	4.997	26.30	0.281966
Total:3				**∑=0.737162**

Question 23				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	7.999	42.10	0.43807
3	6.333333	6.004	31.60	0.017125
4-5	6.333333	4.997	26.30	0.281966
Total:3				**∑=0.737162**
Question 24				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	1.995	10.50	2.971758
3	6.333333	7.999	42.10	0.43807
4-5	6.333333	9.006	47.40	1.127865
Total:3				**∑=4.537694**
Question 26				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	6.992	36.80	0.068501
3	6.333333	4.009	21.10	0.85303
4-5	6.333333	7.999	42.10	0.43807
Total:3				**∑=1.359602**
Question 27				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	6.004	31.60	0.017125
3	6.333333	6.004	31.60	0.017125
4-5	6.333333	6.992	36.80	0.068501
Total:3				**∑=0.102752**
Question 28				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	1.995	10.50	2.971758
3	6.333333	7.999	42.10	0.43807
4-5	6.333333	9.006	47.40	1.127865
Total:3				**∑=4.537694**
Question 29				
Category	Expected	Observed	Observed %	$(E-O)^2/E$
1-2	6.333333	6.004	31.60	0.017125
3	6.333333	4.997	26.30	0.281966
4-5	6.333333	7.999	42.10	0.43807
Total:3				**∑=0.737162**

The results are summarised in Table 15. Unlike for Groups 1 and 2, results for Group 3 indicate that all chi-square values calculated for each question in this group, are less than the reference chi-square values from the table (see Appendix C). Thus, that the null hypothesis should be accepted and the alternative hypothesis should be rejected which is an indication that there is no relationship between variables (Saint-Germain, 1997). Subsequently, it means that participants were answering these questions randomly, not putting their opinion behind each answer.

Indeed, these questions gathered participants' marks in the middle of the Likert scale, unlike Group 1 and Group 2 questions (see section 4.1.9.3) not expressing too much of participants' feelings.

Table 15. Results of the chi-square test for Group 3 questions

	Chi-Square value		Hypothesis	
Question	Calculated	Table (df=2; α=.05)	Null	Alternative
Q1	1.691798	5.991	Accepted	Rejected
Q2	2.948648	5.991	Accepted	Rejected
Q5	1.998021	5.991	Accepted	Rejected
Q6	2.948648	5.991	Accepted	Rejected
Q9	2.948648	5.991	Accepted	Rejected
Q10	1.359602	5.991	Accepted	Rejected
Q13	1.691798	5.991	Accepted	Rejected
Q14	1.359602	5.991	Accepted	Rejected
Q16	1.998021	5.991	Accepted	Rejected
Q17	3.885272	5.991	Accepted	Rejected
Q18	2.628422	5.991	Accepted	Rejected
Q19	0.737162	5.991	Accepted	Rejected
Q20	0.737162	5.991	Accepted	Rejected
Q23	0.737162	5.991	Accepted	Rejected
Q24	4.537694	5.991	Accepted	Rejected
Q26	1.359602	5.991	Accepted	Rejected
Q27	0.102752	5.991	Accepted	Rejected
Q28	4.537694	5.991	Accepted	Rejected
Q29	0.737162	5.991	Accepted	Rejected

4.1.10 Discussion

As researchers argue, there are several technical factors that affect immersion experience: vividness of the graphic, wide field of view, surround sound, haptic feedback, etc. (Slater *et al*., 2009). But one of the most important factors that lead to immersion is the possibility to communicate with other people while being in the virtual world (Warburton, 2009) and see their appropriate reaction. "I could feel the "real class" when I saw bunch of you gathering at the outside of the ground floor. I felt that finally I would meet all my classmates (even though it was not real)" – this is how one of participants commented his feelings after an experiment described by Carr *et al.* (2009). Another important aspect which might affect immersion is the presence of correlation between a user's activity and feedback from other users. For instance, when somebody gives a talk, the visible reaction of the audience, e.g. nodding, turning heads or making gestures, brings to the speaker the feeling of true

interaction with the listeners. Slater *et al.* (2009) describe that phenomenon as "correlational presence". Indeed, while in real life these little symbols of interaction are hardly noticeable, in virtual worlds they might play a greater role (Slater *et al.*, 2009). Common sense suggests that this correlational presence depends greatly on how many people can be potentially involved in this kind of interaction.

These two factors – communication and correlational presence – probably play a vital role in achieving immersion experience.

The data collected during the course of this experiment suggests that the level of immersion that can be achieved in Second Life is significantly higher than the one of the in-world of a dedicated provider, such as ReactionGrid. This is further evidenced, for example, by a study by Conrad *et al.* (2010) that seems to suggest that immersion indeed took place when a similar assignment as discussed in this experiment was conducted in 2008–2009 within Second Life, although it should be noted that the focus of that study was more on the specific relationship between the user and their avatar and therefore, the findings of that study and studies within Experiment 1 with a dedicated provider as a virtual world platform do not compare directly.

Also, as has been noted from many aspects, a result that highlights Second Life as the only 'immersive' environment has to be considered highly unsatisfactory – both from an academic or a business driven point of view. Further research needed to be conducted into identifying strategies to address this lack of immersion in other environments and mechanisms in a constructive way.

Immersion, as a phenomenon, as something that happens to a human being and can be described as "sense of being there", does not occur only due to advanced technology that creates a convincing in-world. There are also other factors, in particular the co-presence of the users which leads to the possibility to communicate with each other while being in the virtual world.

Statistical analysis performed for this experiment using the chi-square test, indicated that participants' opinions were expressed mostly for questions gaining 1,2 or 4,5 scores on the Likert scale, consisting of Group 1 and Group 2 questions

(see section 4.1.9). That confirms the initial idea to analyse all the answers, grouping them according to distribution of scores on the Likert scale. Indeed, both ends of the Likert scale normally indicate stronger expressed opinion than the middle portion of the scale (see section 3.3.1). Thus, Group 3 questions, which gathered the majority of scores in the middle of the scale, are rather not indicative, illustrating that participants were not too sure whether the context described in those questions is affecting participants significantly enough to express an opinion strongly. In contrast, Group 1 and Group 2 gathered more solid responses, indicating more opinions expressed by participants.

It is interesting to point out that within Group 1 and Group 2, questions which gained significantly more than 50% of answers, indicating stronger opinion expressed, also passed the chi-square test. For instance, questions 11, 21, 22 and 25 from Group 1 gained 4 or 5 on the Likert scale from 68.4% to 63.2% of users who answered these questions. These questions also passed the chi-square test since the calculated value is greater than the reference value from the table. However, questions 3, 4 and 8 did not pass the chi-square test, though they gained the same 4 or 5 score from more than 50% of respondents with the range from 52.6% to 57.9%. Question 4 with its 57.9% of users just marginally did not pass, having chi-square calculated value of 5.474, less than reference value of 5.991. In Group 2 only question 7 (57.9% scored 1 or 2) passed the chi-square test, whereas questions 12 and 15 did not pass with 52.6% of users scoring 1 or 2 on the Likert scale (see section 4.1.9).

4.2 Experiment 2

4.2.1 Background

The second experiment took place from November 2012 to January 2013. Since this experiment was considered as a continuation of Experiment 1, it has been decided to explore another aspect potentially influencing immersion, namely, how real-world environmental disturbance (e.g. noise, music, people around, non-work-oriented venue, etc.) would affect users' immersion experience in a virtual world. In Experiment 1, the influence of the in-world's population decrease has been researched and results indicated that the drop of population indeed affects users'

immersion experience. Thinking of what else might affect immersion, Witmer and Signer (1998) outline four main groups of factors, namely control, sensory, distraction and realism factors. The isolation from physical environment provided, for instance, by a head mounted display is considered by these authors as one of the important ones, working towards achieving an immersion experience for the user. If users perceive that they are outside of the virtual environment when viewing the virtual environment through the conventional display, the immersive aspect is lost (Witmer and Signer, 1998). But what happens if the user is being distracted from his activities in the virtual world by something that happens around the user in his real-world surroundings? What impact could some distractive factors, such as random noise or presence of other people around, have on the user? As an attempt to address these questions, Experiment 2 was designed and conducted. Context

Experiment 1 (see section 4.1.1) was conducted in the controlled environment of a regular university classroom with the research question of how lack of communication in a virtual world might affect the immersion experience of the users. In Experiment 2, it was decided to explore real-life environmental noise as another factor which possibly might have an impact on users while they are in a VW. The virtual environment of Carleton University (Ottawa, Canada) was used as a platform for this experiment (see section 2.2.9). The general handling, navigation and avatar customisation options of Carleton Virtual are similar to those of ReactionGrid, used in Experiment 1.

Two real-world venues were identified for this experiment – quiet office environment vs noisy student bar (see section 4.2.4). The Virtual Campus of Carleton University (see Figure 9) was chosen among other platforms since it provides access to the virtual world using a regular web browser. It also features ease of access and operation by the user. The campus was not populated by the users at the time of the experiment, which made possible to put aside the communication aspect and concentrate on the environmental disturbance of the users, as this was the initial idea of Experiment 2.

4.2.2 Participants

Participants were recruited among students of the University of Bedfordshire, staff members and author's friends. Twelve people in total took part in the experiment, females and males, aged from 20 to 50 with different backgrounds, ranging from computer graphics professionals to specialists in linguistics and management. Participants were asked to spend an unspecified amount of time (as much as they wanted) in the virtual campus and to answer the questions administered to them in the form of semi-structured one-to-one interviews.

4.2.3 Test Venues

The test venues were chosen according to expected noise level: one of the Department of Computer Science and Technology offices as the "quiet" venue and the Student Union bar in the Campus Centre of the University of Bedfordshire as a "noisy" counterpart. The level of noise in both places was not measured but it was assumed that in the bar it is normally significantly higher than in the office, which was informally confirmed during a test. Both venues were used during regular working hours and evenings, depending on participants' availability.

4.2.4 Activities in the Virtual World

Participants were asked to login to the virtual world, modify their avatars as they wish, find the building with classrooms among other buildings in a campus, watch video tutorials dedicated to structure building techniques in Second Life, walk around the campus and familiarise themselves with the environment and finally find the aboriginal village and watch the villagers' native dances. To facilitate the whole process for participants, prior to each session each participant received a printed copy of the brief guidelines. Participants were not asked to follow the test plan strictly; they were informed that they could skip any part of the test or simply abandon the whole experiment at any time for any reason.

4.2.5 Interview Process

The semi-structured interview format was chosen for this experiment (see section 3.4). Questions were originally developed for this experiment (see Appendix A) with effort applied to avoid so-called leading questions in order not to bias participants. All the questions were intended to be as neutral and friendly as

possible, asking mostly about participants' feeling and emotions, associated with their activities in virtual campus. Some questions had refining sub-questions which have been asked for clarification or further elaboration of the main answer. The sequence of questions was approximate, depending on how detailed the participant was in his answers. Sometimes it was necessary to skip a few questions and return to them later if the participant was willing to talk about an adjacent topic or bring some examples from his previous experience, etc. Every possible effort was made not to interrupt participants and let them speak freely in the most natural flow of discussion they preferred, as per the methodology outlined in Harrell and Bradley (2009).

During the test, the facilitator tried to position himself slightly behind the participant to minimise his own presence and not to interfere in participant activities unless it was absolutely necessary (e.g. the system crashed or the participant was asking for help or willing to communicate with the facilitator). This technique follows the methodology suggested by Pernice and Nielsen (2009). During the interview, the interviewer tried to maintain a friendly atmosphere, avoiding, however, excessive familiarity. The test process and interviews were recorded using audio and video recording equipment. Participants' activities in the virtual world were recorded by screen capture software.

4.2.6 Results and Discussion

Though at the planning stage the main research question had been borne in mind, it was decided not to limit users in responses during the interview and let them speak freely even if their responses went beyond the scope of the main research question, as is normally suggested by grounded theory methodology (Strauss and Corbin, 1998). That strategy brought new factors, which became apparent during the test while participants were sharing their experience answering interview questions.

Analysis of users' answers indicated that factors affecting users' experience in VR differ by level of importance (see Figure 17). Factors were ranked according to the number of times they were mentioned by users, forming three groups – Red (11–12 times), Amber (7–8 times) and Green (2–3 times).

Factors	Complaints		Factors merged	Complaints
People	11		People	11
Mission	2			
Purpose	2			
Story	3		Purpose	12
Activities	3			
Feeling lost	2			
Graphics	7		Graphics	8
Decoration	1			
Navigation	7		Navigation	7
Avatar customisation	2		Avatar customisation	2
Control (latency)	3		Control(latency)	3

Figure 17. Factors affecting users' experience in the virtual world

4.2.6.1 Red Group

As can be seen from Figure 17, the majority of participants complained about the lack of people in the virtual world to communicate with. Thus, a number of users tried to communicate even with bots in different ways – verbally or somewhat tactile, trying to click on a bot or the surroundings to get some kind of response. Users also mentioned that they would like to see the environment more interactive, complaining, for instance, that the fire place in the Indian Village is not responsive or notice boards in a campus centre were static, not allowing scrolling or a slide show as a form of information retrieval. All this corresponds to the results of the first experiment (Kanamgotov *et al*. 2012), where the need for different forms of communication was outlined by the majority of users as a dominant factor, needed to achieve an immersion experience.

A number of factors (e.g. "Mission", "Story", "Purpose", "Activities", and "Feeling Lost") initially were in the Green group since they individually did not receive enough complaints to fall into the Red group. However, since the individual meanings of each of these factors are very close, they can be combined, allowing merging into a larger single group "Purpose", collecting 12 complaints in total. The lack of purpose of "being there" was also indicated by the majority of users as an affecting factor. Participants complained that they do not know why they are in VW, what was the purpose of their presence in the virtual campus, contrasting to a

game environment, where the purpose is clearly outlined and the user does not need to find the tasks to keep himself occupied and hence, potentially interested in the environment.

4.2.6.2 Amber Group

The Amber group consists of factors scored 7–8 negative responses from users, concerning graphics and navigation issues. By "graphics" users mean resolution of the picture, architecture style, elements of decoration, etc. These factors, when combined together, form the phenomena of realism, which might trigger the beginning of immersion experience through better resolution and visual appeal of the picture. It is interesting to point out that one user noted that too much resolution can make the whole picture "boring". Another user put more emphasis on the decorative aspect rather than the resolution itself, arguing that the presence of shops, restaurants, cafes, etc., might bring more realism to the site than the simple increase of number of pixels per inch.

Navigation is another factor which might affect a user's experience in VW, according to the answers received. Most complaints received referred to the "general emptiness" of the place, where the guest does not know where to go and what to do since the existing navigational signs are not very informative and nobody is around on the site to provide help.

4.2.6.3 Green Group

The Green group formed participants who indicated the lack of avatar customisation options and latency of the system as two factors, affecting their experience in VW. The avatar customisation engine at Carleton Virtual is quite similar to that in Second Life, though it allows fewer options to choose and modify the avatar. Answers provided indicate that users modify their avatars at a level (depth) which satisfies their needs at the degree of the user-avatar association established. Users do not see the reason why they need to spend more time and effort to bring their virtual representation closer to their real image, if they do not associate themselves with their avatars at a certain level. However, results indicate that there is no direct link between the depth of avatar customisation and the level of user-avatar association. Two users noted that they would customise their avatars if their

experience in VW is longer. Thus, the main limitation here is not a deliberate decision not to associate themselves with their avatars, but rather regret that under these particular circumstances that association cannot be achieved.

The majority of participants did not complain about avatar control or system latency. However, some participants pointed out that those factors were annoying them, causing delays in avatar movements which participants wanted to see smoother than they were. Rendering objects, especially distant ones, was another concern, when users, as they reported, did not understand where to move the avatar since they do not see the landscape with fully rendered buildings and other objects.

As Experiment 2 results indicated, the majority of participants were concerned about absence of other people in the virtual world and the lack of clearly outlined purpose of "being there". Those two factor gained 23 complaints – the highest number of user complaints.

The absence of people around the virtual campus ("People") caused a '*feeling of being lost and abandoned*', being '*like on the moon and I am the only person there*', gaining 11 complaints. *'Where are all those shops, restaurants or other places with people? It feels very uncomfortable and unwelcome when you are all alone here'*- as reported by one participant. Participants also pointed out that they would like to see more people around to *'make the whole area more lively and populated'* and not only to be able to ask advice when needed, but '*just to know that you are not the only person here'*. Some of the participants were even trying to talk to avatar bots, which have been placed randomly throughout the campus area probably for decoration purposes since they were not able to respond to users' requests sent using local chat. That indicates the real need for such communication between avatars, which closely relates to the communication aspect identified in Experiment 1.

"Purpose" (12 complaints) was another concern, expressed by a number of participants: *'I don't see any purpose of my being there, what's the purpose of the whole idea?'* Or as another participant pointed out: *'There is no mission here, at least I can't really see it. Why am I here? I remember, I was playing Sims, it's quite similar to this, but there you know what to do since the system gives you advice…'* Activities were found meaningless by some participants, who did not really

understand why they should be sitting and watching '*those videos without any practical use'*. "Walking around campus" as an activity was found more interesting since participants felt they were familiarising themselves with new surroundings, wandering through buildings and campus area.

"Graphics" (7 complaints) along with "Decoration" (1 complaints) gained in total 8 complaints. Participants suggested that '*the graphics could be better, more realistic and have more decorative elements'*, noting that buildings were constructed '*in plain and boring way'*, and campus area is empty and '*have no even some flowers'*. Again, The Sims were in active comparison, participants pointed out that *'there the graphics were 10 times better and avatars looked more realistic than here'*. It is interesting to point out that at the same time some participants noted that *'too much of graphics might drive the user out of the main point'* and the graphics level of Carlton Virtual was sufficient to the purpose.

"Navigation" (7 complaints) relates closely to "Graphics" but more concerns the usability of the site rather than its vividness or resolution. Upon arrival at the campus, some participants did not feel not too comfortable, not exactly knowing what to do and where to go: *'I did not know where I am, no signs, no directions, just buildings, buildings…'* as reported by one participant. In fact, campus was equipped by sign boards, but participants reported that they '*were not well placed and hardly readable from distant'*.

"Control" or in fact, latency of the system (3 complaints) was reported as a factor not of a high importance according to the number of responses, but something which requires improvement. *'It's not very nice when you are trying to move your avatar and instead of walking to where you want, it starts jumping, jerking or turning'*, as was reported by one participant. In fact, mostly it was caused by a relatively slow internet connection rather than hardware or virtual platform limitations. This fact as potentially causing user distraction was taken into consideration while planning Experiment 3 (see section 4.3).

4.2.7 Statistical Analysis of the Results

Considering the discussion in section 4.1.9 it would be logical to conclude that the chi-square test should be applied for the results of Experiment 2 in similar way as

it was applied to Experiment 1. Thus, following the steps outlined in section 4.1.9, the null and alternative hypotheses should be evaluated first.

4.2.7.1 Step 1 and 2. Choosing null and alternative hypotheses

Using the same pattern applied to Experiment 1 in hypothesis evaluation, the null and alternative hypotheses for this experiment can be formed on the bases of understanding how participants were choosing each factor. Factors form categories against which participants express their opinions and depending on "how much of the opinion" they put into each category, the significance of the answers can be judged. That "amount" of opinion can be reflected in how much effort users put in the evaluation of factors and how close they try to approach the phenomenon in their approximations. In other words, if participants spend time and effort on each answer, which can be judged by the different frequency for each category, then there is a hope that the decision is made consciously. In contrast, if participants are just replying randomly, without thorough understanding of the subject, which can be judged by equal frequency of answers, then there is a chance that decisions are made randomly. Therefore, for Experiment 2, the null and alternative hypotheses should appear as follows:

Null: categories (factors) are noted by users with equal frequency

Alternative: categories (factors) are noted by users with different frequency

4.2.7.2 Step 3. Selecting the probability of error level (alpha level)

The probability of error remains the same .05 as for Experiment 1 chi-square calculations (see section 4.1.9.2).

4.2.7.3 Step 4. Computing the test

The results of running chi-square tests are presented in Table 16.

Table 16. Chi-square test of Experiment 2 results

Factors	How frequently mentioned by users		$(E-O)^2/E$
	Expected	Observed	
People	7.167	11	2.049935677
Purpose	7.167	12	3.25908874
Graphics	7.167	8	0.096817218
Navigation	7.167	7	0.003891307
Avatar customisation	7.167	2	3.725113576
Control (latency)	7.167	3	2.422755546
Total: 6	Expected= 43 / 6 = 7.167	Total: 43	∑=11.55760207

In Table 16, factors are grouped according to the similarities of their meanings (see sections 4.2.7.1 to 4.2.7.3 and Figure 17) and sorted according to the frequency of appearance in users' answers. The total number of factors is 6. The total observed frequency of appearance is 43. To calculate expected frequency of appearance of each factor, the total observed frequency of appearance is divided by the total number of factors as follows: Expected = Observed Total / Factors Total (Deviant, 2010) or 43 / 6 = 7.167. The value of chi-square for each factor is calculated using the formula $(E-O)^2 / E$, where E is expected frequency of appearance, O is observed frequency of appearance. Then all chi-square values are summarized, coming to 11.558 in total (see Table 16).

4.2.7.4 Step 5. Interpreting the results

Participants in Experiment 2 identified 6 factors in total (see section 4.2.8.1), thus the degree of freedom (df) for this distribution is df = 5, as the number of factors (categories) minus 1 (see section 4.1.9.4).

The reference value of chi-square from the statistical table is 11.07 (see Appendix C). Since the calculated value of chi-square is greater than the value from the statistical table (11.558 > 11.07), the null hypothesis (categories (factors) are noted with equal frequency) should be rejected and the alternative hypothesis (categories (factors) are noted with different frequency) accepted (Saint-Germain, 1997; Black, 1992; Deviant, 2010). The acceptance of the alternative hypothesis supports the research idea and proves the significance of the data, indicating that participants were making opinion-based decisions whilst evaluating those categories (factors).

This is quite important to note, that the whole of Experiment 2 was conducted under the guidance of Grounded Theory and initially there was no presumed number of factors, the importance of which should be tested by this experiment. New factors emerged from the participants' answers during interviews and data analysis, as suggested by the Grounded Theory approach (see section 3.5). The initial research question of how real-life environmental disturbance might affect users in a virtual world did not cause any concerns from users, whereas new factors, such as "People", "Purpose", "Graphics", etc., appeared to be more important for them. Since these factors were considered by users as limiting their experience in virtual world activities, it was logical to identify and explore more potential limitations and constraints that users might experience in a virtual world as further steps of the research. Thus, the ideas for a new experiment started to take shape.

4.3 Experiment 3

4.3.1 Background

The third experiment took place in June 2013, aiming to explore the influence of the factor of mobility on the user's immersion experience. That research question became apparent gradually whilst analysing the results of the previous two experiments. Experiment 1 explored the factor of population of a virtual world and its influence on user immersion (see section 4.1.2). Experiment 2 utilised the Grounded Theory approach and brought to surface new unexpected factors, such as "People", "Purpose", "Graphics", etc. (see section 4.2.2). Thus, it would be logical to suggest that a number of other unknown factors might be discovered by further experimentation with the same approach as used in Experiment 2 – giving the participants freedom of thinking and evaluating the factors by them rather than testing predetermined hypothesis. Indeed, as the second experiment's results analysis indicated, the factor, which was the main research idea to be tested, of real-life environmental noise did not prove any significance in participants' eyes. In contrast, new factors which had not even been considered at the planning stage, were identified by participants (see section 4.2.7). That proves that the right approach and right methodology have been chosen for this phase of experimentation. However, not to expand the research area too broadly and keep it in controlled and defined scope, the general research idea normally should be

outlined prior to setting up the whole experiment. For Experiment 3, the factor of mobility was taken as a main research area, or in other words, will users' immersion be affected by the technical and environmental limitations when the mobile device is the only meaning of communication. The reason for such a choice is the significant advance of mobile devices during recent years and the growing influence of that advance on further development of the internet. Thus, such a choice for the next experiment as a continuation of the previous two experiments seemed to be reasonable.

It is necessary at this stage to define technical constraints of mobile devices which could be regarded as potential contributors to immersion limitations. The key technical constraints are: CPU capabilities, memory capacity, memory bandwidth, power consumption, physical size (ARM Information Centre, 2011). Thus, these limitations can be considered as factors, potentially affecting the users' performance and hence, their immersion experience (Csikszentmihalyi, 1990).

At the initial stage of the experiment planning, it could be logical to try to understand at least preliminarily, what other factors, along with the technical constraints, might play significant roles in limiting a user's experience. At the same time, as learnt from Experiment 2, users might have their own opinions about "rights and wrongs" and those opinions should not be overlooked, as suggested by Grounded Theory methodology (see section 3.5)

Those preliminary factors could be classified as extrinsic (environmental limitations) or intrinsic (user's ability to use a virtual world, user's mood, willingness to perform activities, etc.).

By "environmental limitations" is meant how the user's interest to do online activities will be affected or not, if his technically limited phone or tablet PC is the one and only media linking him or her to the virtual world.

By "user's willingness, etc." is meant the participant's wish to perform activities in the virtual world and his own intrinsic limitations to do so and be involved in those activities.

4.3.2 Platform

Since the experiment was conducted in a small provincial town in the south of the Russian Federation, the lack of broadband internet in public places was expected. Thus, it was decided to perform an experiment in a locally (not online) running virtual environment, using a 7-inch Android tablet with sufficient CPU power. As an alternative to internet-based virtual worlds, the mobile version of the popular Sims 2 game was chosen for use.

The choice of that particular game was suggested for the following reasons: it is very close in idea, design and control to 3D virtual worlds, utilised in the previous experiments; it does not require high speed internet; it is a 3D virtual environment scenario-based game; it features better graphics as per users' responses (see section 4.2.7) than, for instance, Carlton Virtual, used in the previous experiment, in terms of resolution and design, decoration, navigation, avatar control and latency of the system. And finally, it is a game which many of the participants from the previous experiment referred to. This game is very close to non-game 3D virtual worlds with the difference that the purpose or story line – the factor which scored 2nd place by significance among our users' complaints – is already incorporated into the scenario, which allows users simply to follow it from level to level without being disappointed by "I have nothing to do here, so I got bored". The main limitation was probably the expected lack of population of real users, which could have an impact on the experiment's results. Nevertheless, under those particular circumstances the experiment was conducted in, that limitation could be seen as not significantly contributing to the overall results, since the factor of population was already explored in Experiment 1. Moreover, according to New Media Trend Watch report (2013), 33% of smart phone and tablet PC users utilise their devices for games, which lies within the scope of general mobile device usage. Thus, the Sims 2 virtual environment was a considered suitable, but limited substitution for the online-based virtual worlds used in previous experiments.

4.3.3 Participants and Activities

Participants were randomly recruited from people of different age (18–48 years old), gender and professional background. Twenty-six participants in total took part

in this experiment. They were asked to start Sims 2 and follow instructions, provided by the system, spending within the virtual world as much time as they wished. The virtual world of Sims 2 consists of a small town to be developed by the user. The system offers the user to choose an avatar, modify it using tools and a number of choices for gender, type of personality, clothes, skin, etc. and follow the guidance, provided by the system, allowing the user's avatar to build his house, to buy furniture for it and perform some activities in the household, e.g. watching TV or growing paprika. As the user advances in those activities, at some level the system will advise him or her to choose another avatar and make both avatars meet and have some kind of relationship. This is a very brief description of the main plot or scenario, predetermined by the system. The user can not alter it, add steps or skip undesired steps. The only option the user has is to choose the form of activity within the given scope, dancing with another avatar or making him laugh, for instance, or choosing the subject of activity, growing carrots instead of paprika or choosing a particular type of furniture within the budget available. As can be seen, the scenario or sequence of activities is quite rigid, not allowing much variation, guiding users from the beginning throughout the lifespan of the avatars. It contrasts with the main line of activities performed by the participants in Experiment 2, where they were asked just to spend some time in Carlton Virtual, which caused many complaints during interviews, resulting in evaluation of one the main factors affecting user's interest: the story line or purpose of being in the virtual world. Thus, it has been decided to eliminate the factor of "Missing Purpose" by providing the users with the definite scenario-based and guided environment, where other emerging factors, if ever, could be identified and evaluated.

Participants were also notified that their participation was voluntary and they could stop and abandon the experiment at any time for any reason. The same set of questions, utilised in Experiment 2, was administered to them in the form of semi-structured interview.

4.3.4 Venue

Experiment 3 took place in the author's home town in the southern part of the Russian Federation. The reason for this lies beyond the research requirements or

research ideas since that was an explicit administrative decision of the University. Since the relocation abroad became inevitable it was decided to use this opportunity to foster the research outcome and obtain more data from a different group of users.

Two types of venue (street café as an indoor one and bench in the park as an outdoor one) were chosen as regular places where normally people use their mobile devices, such as smart phones and tablet PCs, while being out of the home or office. Both venues were used during day time and evenings, depending on participants' availability and weather conditions. It might be interesting to point out that according to the Adobe Consumer Survey (2013), about 80% of tablet users use their devices at home. That might be interpreted as suggestive enough to conduct this experiment at the user's home instead of in a café of open air space, but at home the tablet might not be the only means of communication which plays, as believed, an important role in evaluation of immersion affecting factors.

4.3.5 Questions and Interview Process

Questions were originally developed for this experiment (see Appendix B). Interview technique, utilised in Experiment 2 (see section 4.2.6) and Grounded Theory methodology (see section 3.5) were also used in this experiment.

5 The Framework

During analysis of Experiment 3's results, the new factors potentially affecting immersion, emerged and formed the structure of the framework.

In principle, the main areas of the framework can be defined as potential contributors or "affecters" of a user's immersion: the virtual world itself, the device used, the environment surrounding the user and the user's intrinsic characteristics. Those areas can be subdivided into smaller sub-areas, which are the factors influencing the immersion.

5.1 Virtual World

Analysis of participants' answers formed the initial shape of this sub-area (see Table 17).

Table 17. Factors of the "Virtual World" section of the framework

Impact	Virtual World
1	Clear goal outlined
1	Commercial aspect
1	Preview
1	More focused
1	Time limit
1	Scale
2	More emotions
2	Clearer instructions
3	Less linear
3	Faster
4	Real people
5	RL simulator
5	Hints from system
6	More real life
7	Graphics
8	Plot
8	Tasks
8	No RL or Wrong Type

"Impact" means the number of responses from participants indicating the significance of each factor. For instance, the factor "Real people" that scored 4 responses is more significant than the factor "Choice", which scored 3. These

factors are placed in "lower impact – higher position" order, representing increasing significance of factors while going down in the table.

5.1.1 Impact factor 1

"Clear goal outlined" – This was the response from the participant who wants to see why he is *'doing all this in this virtual world'*. He needs more motivation in terms of foreseeing the final aim, the purpose of his "being there". Without that vision from the beginning of his presence in the Sims 2 environment, he lost his motivation to continue his activities.

"Commercial aspect" – this participant suggested that the virtual world should have provided the option to make money: *'To present my stuff I could sell or advertise in some sort of showroom.*

"Preview" – the need to foresee *'if not the final result, but at least where we are going in this Sims and what should I expect later'* was expressed by this participant. It relates to "Clear goal outlined" but not with the emphasis on the final goal, but rather on the intermediate results preview between each level.

"More focused (e.g. on kids' education)" – participant sees Sims 2 more as an educational environment rather than entertainment: *'Very good thing to teach kids let's say health and safety, simulating those situations here without danger to traumatise children. Also good for persons with disability'*.

"Time limit" – the need to limit the play time since *'kids might get addicted'*. Interesting to note that this input was made by the user who had had problems with game addiction in the past, as became clear later.

"Scale" was mentioned by one user as a limitation, which prevents her from feeling more involved in her interaction with the virtual world. *'This town is quite limited in size, I need more space here, more houses, places, more people'*.

These factors are not the main contributors towards or against the user's immersion according to the lowest response rate. However, as can be seen from these answers, participants would like to see these conditions met in order to be more involved in their activities.

5.1.2 Impact factor 2

"More emotions" – these two participants found the whole idea *'too cold and not exciting'*. They need *'more reasons to be there. Just following those stupid instructions are not enough, I would do something else instead in real life, rather than spending time there'. 'I need more emotions, to meet somebody at least, if they cannot provide me with some sci-fi environment, more exciting that just buying something for my house. Things I do in my real life are not really exciting when I repeat them in virtually'.*

"Clearer instructions" – two participants were not quite happy with instructions, provided by the system, *'I don't know how to do this when it tells me to buy stereo or enlarge the house'; 'It was quite confusing at the beginning, not clear instructions provided and if you don't have previous experience, you might get adverted from this Sims.'*

5.1.3 Impact factor 3

"Less linear" – these participants need more options and variety, choices which the system offers, the possibility to skip some tasks and go for another one without waiting while this particular task will be accomplished. *'Why I need to wait while this house is building or that carrots are growing? I would like to have a choice not only within the given task but also an option to choose different types of task. The system is too rigid.' 'These instructions are not leaving any freedom for you, they are too definite…' 'If I could change something here, I would add more freedom in my actions while I am making changes to the space around me…'* Summarising, these participants need not only more choices in their activities, but also to be able to switch from task to task at their own decision or to choose a different type of activity at that point, which probably could be interpreted as a "decision point" in a system.

"Faster" – Three participants wanted to have faster paced events. They expressed concerns about how activities are broken up by time intervals in between tasks. For instance, if the participant started constructing a house for another avatar, he has to wait until the whole construction is over in order to continue with other tasks since the system is blocking the screen, not allowing anything else other than just sitting

and watching the moving time line. *'Things here are too slow. Why we have all these breaks in between? They are distracting'*. Those breaks between tasks were reported as one of the elements preventing participants from feeling more involved in their activities, more immersed into the virtual world.

5.1.4 Impact factor 4

"Real people" behind avatars, as opposed to the system-generated characters, would be preferred by four participants. They pointed, that *'the whole thing with real people behind avatars would be much better'. 'I could talk to them'* as one participant said. It does not necessarily mean similarity with real-life environment or tasks. As one participant pointed out, if he plays the game, he would prefer an environment where he could keep communicating with real people, involved in the game, naming "The World of Tanks" as an example. Another participant explained her interest in this type of communication for the possibility to learn something new (e.g. technique) while communicating or in her case, interacting with the remotely logged in user, naming "Street Fighter" as an example of such an interaction. *'From every player you can learn new style and it is always different since a lot of players involved, which cannot be reproduced by any computer'.*

This corresponds to the results from Experiment 1, where communication was evaluated as a major contributor to user immersion, though the virtual environment in that case was completely different to that referred to by these users. However, the trend to have an option to talk or interact in other ways to real people remains the same.

5.1.5 Impact factor 5

"Real-life simulator" is the expression used by one of the participants to describe his view on Sims 2. *'One can use this to try things, to practise in something like in real life'. 'I always wanted them short (hair) but I am hesitating whether it fits me. And then it will take too much time to grow them back if you find out it doesn't. So, here I can try it safely'*. Another participant liked the option of house construction, trying different layouts, enlarging or, in contrast, squeezing rooms or applying exotic colours to the walls: things which are not probably achievable in real life, but could be safely and quickly applied within this virtual world. There was also

advice from one of the participants to use this kind of virtual world for educational purposes, *'to try show kids what to do and what not. In real life that might be difficult but here it is safe and kids or people with disabilities could safely learn some skills, depending on the topic of specialisation'*. Also, the suggestion to use Sims 2-like virtual worlds with enhanced capabilities for city council employees training was expressed. *'You can provide them with real town life simulator, allowing some budget and assigning training tasks to plan the city layout and to run different institutions, like schools, companies and so on'*. In fact, participants did not see this factor as a negative, they just suggested one of the possible ways to use this world if its capabilities are enhanced.

"Hints from the system". A number of participants complained that they did not get help from the system when they needed, got confused or did not know what to do next. *'If I know that I could choose the avatar, I would definitely do so'*, as reported by one participant, describing her avatar choice. The major route to follow offered by the system did not cause problems, whereas more clear hints at some steps could certainly help some participants to improve their experience. For instance, while constructing a house, it was not too clear how to move a wall or place a piece of furniture properly oriented, which caused some problems later, while manipulating with the avatars. *'Why can't my avatar go to toilet? What's wrong?'* Or *'How is this dog supposed to find a treasure? Actually, where is it, can't see it…'* Some participants found the system's instructions not clear enough, giving a brief explanation of what to do at this step, but not explaining how. *'How can I make them (avatars) meet and communicate? Quite confusing…'* Sometimes the lack of help from the system affected more vital elements of user-system interaction. For instance, one participant did not modify his avatar and left it as was. When he was asked about the reason during an interview, he said that he did not know about such an option. Later on during the interview he expressed the wish to be associated with his avatar, but did not know how to bring its appearance closer to himself. Unlike minor obstacles, like choosing a place for one's TV or rotating sofa, the avatar modification might affect the participant's wish to be more involved in the virtual world's activities through his association with his avatar.

5.1.6 Impact factor 6

"More real life" – these responses indicate that participants need the virtual world to resemble real life more than they see it in Sims 2. *'Only the dog was real there, the rest was too unnatural and lifeless.'* Interestingly, another participant, along with complaints that *"it is too much or real life there. I do my household in my real house and I don't need it repeated there"* pointed out that *'This Sims should be closer to real life. We don't have this top view from above, if they want to represent how it is in reality, they need to change that. Avatars also are moving awkwardly, the whole thing is just I don't know, too much'.* Another participant was satisfied by the nature of tasks, emphasising that the real-life-like tasks involve her more than fictions: *'The nature of tasks is fine- to shop, to have shower, etc., it's like a real town life. I would like to have tasks like in RL, don't like fictions. It's more involving me, though I can't say I am fully absorbed. It entertains me, you can spend some time on it'.* Real-life-likeness is not only limited by the tasks or surrounding scenery, but also, as some participants indicated in their answers, by the need to see relationship there, resembling a real-life one: *'I need my avatars acting independently, I don't like controlling them. I would like to see them making the relationship themselves, more like we do in real life, not just following script'.*

5.1.7 Impact factor 7

"Graphics" was reported by seven participants as it required improvements in terms of vividness, naturalism and resolution, concerning the way general scenery (e.g. houses, grass, trees, etc.) and avatars were drawn. *'The only natural thing here is the dog. I liked it the most'. 'These trees are so unnatural, I mean… not only, but everything here is lifeless, we need more colours, more resolution and vividness here'. 'I would certainly improve the graphics here, it affects my interest. Compare, let's say, to GTA, there it is much better, every detail is in place. But here… all these things are too "squarerish", including the avatar and everything around'. 'The resolution is too low here, I don't know, maybe it is just the tablet's monitor, but when I play at home, I am using a proper big screen and my impressions are different, more real than here. Maybe it's the screen size, I don't know, but so far I was quite comfortable with the screen…'* As can be seen, users refer to other virtual worlds, mostly in game environments, which they have used or are using on home

computers currently. Participants do understand the difference in idea and realisation between the mobile version of Sims 2 and their favourite shooter, played on a powerful desktop or even Playstation. But still, the urge is obvious to have better graphics in all, meaning that, as participants think, they would improve their experience with the Sims 2 virtual world.

5.1.8 Impact factor 8

Complexity of Sims 2 was one of the major concerns of the participants. This factor can be subdivided by two sub factors: "Plot" or the main scenario of events within Sims 2, and "Tasks" – how the individual tasks might impact the users' experience.

"Plot" or scenario was found by two users to be too simple. *'We need more interesting plot here, more places, more options, like career development, more neighbourhood. I feel limited here, need more like in real life'*. Another participant also needed more interesting plot, but in contrast, he is not looking for anything resembling real life: *'I need something more interesting and exciting, not all these things I do in my life anyway, something that could keep me involved, chasing or doing some strategy, I don't know, but not these (activities).'* In both cases as can be seen from the answers, users are not satisfied by the scenario the system offers, but in different way: one needs more real-life-like activities; another one is looking for something opposite, something that he cannot probably experience in reality, but needs to do from time to time.

"Tasks". *'Tasks need to be improved'* – that was the major message from the participants about how they feel when performing those activities. Mostly they were not happy with the complexity and nature of the tasks. *'It is too simple and primitive. Why I should buy a toilet for my avatar? I feel like an idiot. I need something more interesting and exciting'*. Some of the participants were fine with the task nature, but within the task scope given by the system they would like to see more choices, e.g. in avatar customisation or more choices in growing something like paprika. One participant reported that tasks *'are too manipulative from above'* meaning that user has too much control over "life" in the virtual world and *'they (avatars) need more freedom there'*, which corresponds more to the avatar handling improvement, but also might be considered from the task performing point of view.

Repeating tasks were also causing problems with some participants: *'I lost my interest when tasks started repeating'*, meaning that similar tasks should be performed with all avatars which is not what he wanted to see. Other users would prefer to get just directions from the system and within those directions to choose, or even better, to create tasks, requiring more freedom of action within the environment. In contrast, some users needed to get the predetermined tasks, they feel happy with doing what system told them to do instead of going through the complexity of creating something new. Participants also reported that their association with the avatar, for instance, depends on task complexity: the more difficult and challenging task they have, the more interest they feel in the whole experience. Some participants needed real-life-like tasks, e.g. house construction which they found the most interesting part of Sims 2. *'I like this, I can move everything here all around and furnish my house in some weird way'*. *'I cannot build up the real house in my real life for now, so I can practice here'*. These two responses might be viewed as a need to do something not achievable in real life, which corresponds to the need of "Educational environment" with the difference, however, that in this case ("*weird choice*") participants would like to try something they would not do in real life due to the fact that those things just might not be acceptable (e.g. strange costumes of avatars or options to save somebody), whereas in "Educational" they need predictable and useful options.

"No Real Life" or "Wrong type" was also a quite popular response from participants, who wanted to see a more exciting and adventurous environment: *'I don't like all these routines, buying, constructing, going to toilet. I need something more exciting, unusual and adventurous…like, say, Temple Run'*. Another participant also did not like the general idea of the Sims 2 scenario, but the response was a bit unusual: *'I would prefer something like Angry Birds. Simple, stupid and nothing in common with real life. I can play for time killing purpose and forget about it'*. Some of the participants referred to their personal experience, something with they have been preoccupied recently for a significant amount of time and certainly do not wanted to repeat again in a virtual world. *'I prefer to do my house building in my real life, rather than here. It is too artificial, sort of ersatz world and actions. As a construction simulator it is not developed enough, as a game or*

whatever virtual world is it is too predictable and boring. I need, well, to experience risks and something unusual, not sitting on the couch and watching TV as these avatars.' Concerns were also raised about tasks, which reminded some participants of their daily life too much. *'I have a garden since I live in a village and actually grow all that stuff anyway, plus taking care of my cows, chickens and so on, not really exciting to do it here again. I would like to… I don't know… save somebody, to do something unusual and even crazy'.* Another participant pointed out that the controlling aspect of Sims might be dangerous since it gives us a wrong model to follow: *'We should not control anyone in our life and this is all about control. I don't like it. It is dangerous, it teaches us wrong things. We should accept things in life as they are and not to try to go against and be rewarded for real things only, like help for other people. Here we are rewarded for nothing. This looks like a bad example of real life and might distract people from a good way'.* Too "real life" environment and script was noted by many participants in different ways. Most concerns were caused by the non-adventurous character of Sims 2, the lack of real actions, mystery, sci-fi or at least fairy-tale-like scenario, which could take away someone's mind and keep the user involved. *'The empty game zone'*, *'Lifeless'"*, *'Mechanical'*, *'Too schematic'*, *'Too real-life–like'* – those were the definitions participants gave to Sims 2.

5.1.9 Statistical analysis

For statistical analysis of each part of the framework the chi-square test was used the same way it was used in experiments 1 and 2 (see sections 4.1.9 and 4.2.8).

5.1.9.1 Step 1 and 2. Choosing null and alternative hypotheses.

The null and alternative hypotheses were chosen using the same method applied in Experiment 2 due to similarity of the experiments' nature and results (see section 4.2.8.1).

Null: categories (factors) are noted by users with equal frequency

Alternative: categories (factors) are noted by users with different frequency

5.1.9.2 Step 3. Selecting the probability of error level (alpha level)

The probability of error remains the same at .05 as for the chi-square calculations for experiments 1 and 2 (see sections 4.1.9.2 and 4.2.8.2).

5.1.9.3 Step 4. Computing the test

The results of running the chi square test for the Virtual World section of the framework are presented in Table 18.

Table 18. Results of the chi-square test for the "Virtual World" section of the framework

Virtual World Factors	How frequently mentioned by users		$(E-O)^2/E$
	Expected	Observed	
Clear goal outlined	3.722	1	1.990878939
Commercial aspect	3.722	1	1.990878939
Preview	3.722	1	1.990878939
More focused	3.722	1	1.990878939
Time limit	3.722	1	1.990878939
Scale	3.722	1	1.990878939
More emotions	3.722	2	0.796849088
Clearer instructions	3.722	2	0.796849088
Less linear	3.722	3	0.140132670
Faster	3.722	3	0.140132670
Real people	3.722	4	0.020729685
RL simulator	3.722	5	0.438640133
Hints from system	3.722	5	0.438640133
More real life	3.722	6	1.393864013
Graphics	3.722	7	2.886401327
Plot	3.722	8	4.916252073
Tasks	3.722	8	4.916252073
No RL or Wrong Type	3.722	8	4.916252073
Total categories: 18	Expected = 67/18 = 3.722	Total observed: 67	$\sum$=33.74626866

5.1.9.4 Step 5. Interpreting the results

Participants identified 18 factors in total for this section of the framework (see Table 18), thus the degree of freedom (df) for this distribution is df = 17, as the number of factors (categories) minus 1 (see section 4.1.9.4).

The reference value of chi-square from the statistical table is 27.587 (see Appendix C). Since the calculated value of chi-square is greater than the value from the statistical table (33.746 > 27.587), the null hypothesis (categories (factors) are noted with equal frequency) should be rejected and the alternative hypothesis (categories

(factors) are noted with different frequency) accepted (Saint-Germain, 1997; Black, 1992; Deviant, 2010). The acceptance of the alternative hypothesis supports the research idea and proves the significance of the data, indicating that participants were making opinion-based decisions whilst evaluating those categories (factors).

5.2 Avatar

Avatar is another contributor to the user – virtual world interaction. The majority of user communications performed in the virtual world are made through the user's virtual representation and the main access media to that world: the user's avatar. Thus, the avatar plays an important role in user-world interaction and possible immersion (see Table 19).

Table 19. Factors of the "Avatar" section of the framework

Impact	Avatar
1	Closer to Real Life
1	Realism
1	Adjustable
1	More avatars
1	Less control over avatar
1	Communication
7	Not enough choices
13	Need association

5.2.1 Impact factor 1

"Closer to Real Life" was one of the concerns, expressed by one participant: '*My avatar is too masculine, I chose a girl and she looks like an athlete and no option to bring her closer to what I need. I tried all options.'* This user was looking for association with her avatar but could not achieve that association due to the reason that the options of avatar modification were limited in her opinion and she could not adjust her avatar appearance according to her feelings of how the avatar should look: *'Avatars should be as close as possible to humans'* is another statement from this user. It is interesting to point out that at the same time this participant expressed quite an antipathy to the Sims 2 environment in general: '*…not my type, it should be non-real-life like. What's the purpose of the game that reminds me of my own life? I need something different, like Angry Birds, where I can do something completely different.'* It seems like the avatar aspect is the one this participant found

worth paying attention to, especially the avatar modification part: '*I like the changes I've made, but I need more options to choose from and my avatar should be drawn better.'*

"Realism" is quite similar to the "Closer to Real Life" definition, given by another user. She was trying to modify her avatar in the closest possible way to match her own personality, but realized that there are no flexibility in the avatar modification due to lack of choices. The way the avatar was drawn did not convince this participant in terms of realism: '*They are too square, not natural looking. And they need more dress options. I can't find what I am looking for to adjust her to what I have in mind.'* This participant had a strong wish to associate herself with her avatars, not even the first one, but with the second one as well, though the second avatar was a male, whereas the participant was a female: *'The first avatar was a female, I wanted her to be like me, but could not achieve that, can't dress her properly as I wish. Not exactly like me, idealized me, like me in a dream world… to be something I can't be in my life maybe. The second one was a male, but I also see myself in him, I mean, my male part, since we all have both female and male parts of our personalities, right? So, it's not like my partner, more like my male side…'* The urge for "realism" lies, as it can be seen from the answers, in that wish of association.

The "Adjustable" (need to be more) factor is based on one participant's complaint that she cannot adjust or modify her avatar in the way she likes. It relates closely to the number of choices allowed for different aspects of avatar appearance (e.g. costume, skin, character, etc.) modification. It does not mean that this user needs an "adjust" option as an avatar modifier, she would be satisfied by a greater number of choices offered by the system, if they finally lead to her goal to customise her virtual representation in the best possible way.

"More avatars" refers to the number of avatars involved in participant's activities during her/his interaction with the virtual world: '*I need more avatars here. One is not enough. You can't really build too much with even two or three avatars. I realise they should appear at later stages, but when I am going to reach that? Till then I feel I need more people around.'* It appears that there are two aspects involved in

this factor: the scale of events is limited due to insufficient number of avatars and places they visit and operate within, and the lack of communication between avatars, associated with that limitation. The participant, however, realises that she is at the entry stages of Sims 2 and later on the number of avatars probably will be increased. But at this particular level this factor plays a negative role in her immersion experience.

"Less control over avatar" was pointed out as something undesirable and preventing this participant from establishing better communication with her avatars. By "communication" it should be understood not the verbal exchange by messages or dialogues with the avatars but rather her involvement in activities performed by avatars and her control over those activities: '*I need them to be free from my control, otherwise I cannot associate myself with such weak characters. I need real ones.'* Her first avatar was a female, and the second one was a male: '*I was associating myself with her at the beginning, but later lost that probably because I got bored. Then I thought maybe some guy will appear and he appeared* [smiles]. *So I was choosing his clothes carefully since he supposed to be a sort of partner. But I did not like that control over him, I need him making real decisions.'* It appears that she values the existence of her potential partner and possibility to grow some kind of relationship between them, but at the same time she dislikes such an option in virtual worlds due to the fact that it is not natural: '*When they started dating I just stopped, it's too much. I need real relationship with real people. The real thing is just our life, real conversations, spending time together, etc. So my brain is not linked to this since I see it as too artificial.'* It might be viewed as an example of high expectations from of virtual world experience but only to a certain extent, while it does not concern too sensitive personal aspects.

"Communication" between avatars was referred by one participant as one of the factors which might ignite her interest for the whole Sims 2 experience: '*I lost the sense of time when they were meeting (after construction was finished), but not for a long time. It was interesting to see how they will communicate. I don't know what was holding me, maybe expectations to see something better, waiting for a moment to do something for a house or having neighbours.'* At the same time this participant pointed out that she lost her interest after her avatars started dating: '*I am not*

interested in dating. That was too much…' It possibly indicates that the user is quite sensitive to this topic and she does not like the idea to include it in this kind of environment, which in her opinion, is not suitable for such an activity. The latter statement was indirectly found having some ground by analysing her answers about social networks, where she was very active (*"it's my life"*) and further more narrowing down to her particular interest in communication with the opposite gender. Again, it looks like the environment did not match her expectations.

5.2.2 Impact factor 7

"Not enough choices" summarises all concerns about the variety of choices in avatar customisation offered by the system. Participants outlined that they need more options in every aspect of avatar modification such as appearance, clothes, character or behaviour. Modifications made to an avatar are not the self-goal of participants, according to their answers. Modifications are needed for bringing the avatar's appearance as close to the imagined one as possible in order to get the desirable level of association with her or his avatar. That appearance does not necessarily represent the participant's way of looking in real life, it is rather how the participant would perceive her or himself in that imaginary world, where "things are possible": *'I can't get here an exact match to what I would call myself, though I liked that dress. It is mine. But the rest, the face, hair, moving style are not really "me" and I can't adjust it properly.' 'My avatar is too…not like me. I was trying to choose her as close as possible to me, but could not find the proper character.' 'I am not romantic in my life, so I thought why not, why not try, I mean, something new and see what happens. But I don't see too much of being romantic in my avatar, neither can I choose clothes or actions. We need more choices here.'* Sometimes participants chose a female avatar since she had more choices: *'I don't know, I don't think I am associating myself with her, but she had more choices in clothes, so I chose her. Good to play around, choosing costumes but they could have more options. Like those dresses are not really impressive…'*

5.2.3 Impact factor 13

"Need association". Choices in avatar behaviour were also criticized by participants, reflecting that this limitation prevents them from feeling associated

with their avatars: '*Those primitive options we have there, like buying something or shaking hands with your partner don't bring me closer to my avatar. How can I associate myself with somebody who just goes to the toilet, plants something and argues with his partner to get scores? I feel like an idiot.'* Answers concerning user-avatar association indicated that more than half of the users needed to feel associated with their avatars. Users pointed to different reasons, explaining why that association is desired, but generally they concluded that they don't feel "there" if they don't see their avatars as their representation in the virtual world. That representation might appear in different forms, ranging from mere similarity or resemblance of the user to an opposite visual appearance. Since non-human avatars were not an option in Sims 2, participants were limited in that kind of choice, not being able to choose fantasy characters, though neither of the participants expressed their wish to use such a character. Thus, by "opposite" it is meant different gender, clothes, character or rather the mode of behaviour (e.g. "Romantic", "Creative person" or "Tycoon"). It is interesting to point out that when choosing the opposite gender, for instance, the user is not necessarily seeking the representation which is opposite to his or her real one. As one participant reported, she was looking for her male part in her avatar choice: '*My choice was a male. We all have male and female sides of our characters, so I wanted to see myself in him* (avatar) *as a guy.'*

Another user pointed out that he chose the opposite to his character intentionally, seeking to try something new, something he thought he was missing in his personality: '*I am not romantic at all, just not, which is ok with me, but I wanted to try it out just to see what it is like to be romantic. So, I have chosen my first avatar as a romantic, male by the way. The second one was supposed to be a partner, or sort of partner for him, I thought well, maybe there will be something growing…'* Concerning his associations with both avatars, this participant concluded: '*With my first avatar my association depended on the task which he was performing. As I said, I am not romantic, so I can't associate myself with him in that sense, but to try… With tasks, if they are not so stupid, it would be better and more chances I would find something common in both of us. But with all these nonsense jobs, no, not really. And with the second one, well I am not a girl, it is his partner.'*

Such association also can depend on the topic, the general idea of the virtual world the participant is dealing with: *'If this…Sims 2 is better tailored with more interesting idea behind, I would probably feel more interested in this. Normally, when I play games, I am quite within, though I play them very rarely. It's quite engaging, as I see my previous experience, but that was a shooter. I was so in there that at the end I had some kind of health problems, head was spinning, not very comfortable. But here, in Sims, not too much. This topic is not really mine…'*

There was also a response from one participant, who was associating herself with all three avatars she created, but in different ways: "*The first avatar was a girl since I am playing this game and associate myself with it. The second avatar was a boy for a difference and the third one I was trying to match the first two.'* The first avatar was an idealised model of herself to a certain extent, which depended mostly on the range of choices in avatar modification. The second one could be viewed as her alter ego, the other side of her personality, which probably cannot be unveiled in her normal life, but can be explored safely in this virtual world, a sort of a test platform, where the unachievable could be achieved or at least imagined. And the third avatar was aimed to be company for the first two, forming, perhaps, a small community of town dwellers, with shared neighbourhood and common interests.

This participant was trying to use the available options and bring her own virtual representation to her real self as closely as possible: '*But mostly associated with the first one since at the beginning you don't know what's next, how the avatar will behave since you are not fully integrated into the game. I have chosen similar hair colour to mine or clothes which I like, but later on while playing I realised that it is not my character, behaviour, personality etc. It has something on her own. You put part of yourself into each avatar but I still did not get full match.'* As can be seen from her response, this user was quite interested in finding the way to associate herself and her avatar, but was disappointed by the system's limitations, not offering her enough choices since the avatar templates limited her too much and she would prefer to create the character, rather than to try to find the matching one from the existing: *'I did not choose the avatar's character since you have to choose it from templates. Generally, when you play you choose somebody as yourself but exaggerated and ideal.'* As can be concluded from these answers, this participant

initially had a strong wish to be associated with her avatars, trying to find similarities with herself in each of them, but soon realised that the system did not provide her with either enough choices nor allowed her to create avatars in the most associative way.

Sometimes participants were not so eager to find associations with their avatars and as a result, they were choosing default ones: *'Both avatars were females, I don't know why. Default was a girl and I left it as is, I don't know why. Don't remember the character type. Dressed in dress. Does not look like me, I did not think about associations with myself, just chose her. Don't know why the second one was a female. The third might be an animal :). Ok, it will be a male.'* But at the same time, as this user reported, she found the dog avatar the most attractive and the real personage among the rest, though he was not adjustable at all and she sought associations between the dog avatar and her own dog, giving the dog avatar the same name as her real dog has: '*I liked the dog, he was like real in terms of graphics, plus was making money. Changed the dog's name, it was too complicated, I gave it my dog's name.'* The dog in this scenario played a role of some kind of attractant, the point where the user finds a point of interest in a generally not so involving environment.

As can be concluded from these responses, the avatar plays a vital role in the user–virtual world interaction as a media or tool, which is used by the user to access the virtual world. The avatar might have a positive or negative effect on the user's immersion experience. Some users normally have an initial intention to achieve association with their avatars, which might be affected by avatar characteristics, such as adjustability of appearance, character and behaviour in the virtual world.

5.2.4 Statistical analysis of the results

Step 1, Step 2 and Step 3 of the chi-square test remain the same as in the "Virtual World" F (see sections 5.1.9.1 and 5.1.9.2).

5.2.4.1 Step 4. Computing the test

The results of the chi-square test for the "Avatar" section of the framework are presented in Table 20.

Table 20. Results of the chi-square test for the "Avatar" section of the framework

Avatar Factors	How frequently mentioned by users		$(E-O)^2/E$
	Expected	Observed	
Closer to Real Life	3.25	1	1.557692308
Realism	3.25	1	1.557692308
Adjustable	3.25	1	1.557692308
More avatars	3.25	1	1.557692308
Less control over avatar	3.25	1	1.557692308
Communication	3.25	1	1.557692308
Not enough choices	3.25	7	4.326923077
Need association	3.25	13	29.25
Total categories: 8	Expected = 26/8 = 3.25	Total observed: 26	∑=42.92307692

5.2.4.2 Step 5. Interpreting the results

For the "Avatar" section, participants evaluated 8 categories (factors) in total. Thus, the degree of freedom is df = 7 (see section 4.1.9.4).

The reference value of chi-square for df = 7 at alpha level of .05 from the statistical table is 14.067 (see Appendix C). Since the calculated value of chi-square is greater than the value from the statistical table (42.923 > 14.067), the null hypothesis (categories (factors) are noted with equal frequency) should be rejected and the alternative hypothesis (categories (factors) are noted with different frequency) accepted (Saint-Germain, 1997; Black, 1992; Deviant, 2010). Thus, the rejection of the null hypothesis and the acceptance of the alternative hypothesis proves the significance of the data, indicating that participants were making opinion-based decisions whilst evaluating those categories (factors).

5.3 Environment

"Environment" comprises the real-world environment, the actual place, where the experiment was set up. Environmental conditions, such as noise, presence of other people at the venue or weather might potentially affect or not the test results. Since the experiment was conducted within certain limitations, both venues were chosen according to several factors, such as weather conditions or the participant's availability. Effort was applied, however, to split the number of both types of venues as close to equal as possible, ending up with 11 indoor and 12 outdoor venues. Table 21 summarises the number of impact factors identified.

Table 21. Factors of the "Environment" section of the framework

Impact	Environment
1	Weather
1	Being watched
2	Phone calls
2	Outdoors
16	No disturbance

5.3.1 Impact factor 1

"Weather". The factor of weather affected only one participant in the outdoor venue (bench in the park) when it became too cold. The participant stopped using the tablet and asked to wrap up the experiment. This particular case might be considered as an exception due being a single case. In all other cases, participants did not complain about the weather conditions either for the reason of good weather or the fact that the participants did not care too much. Overall, the impact of the weather is quite a subjective matter which depends on the outdoor conditions and the participant's level of tolerance.

"Being watched" as a factor of disturbance was outlined by one participant, who felt ashamed that somebody could see him "playing games". Other environmental factors of disturbance did not play significant role. For instance, he received a phone call during the experiment, but according to his answer, it did not disturb or distract him too much: '*The only concern I had was that I might look silly sitting on the bench and staring on the tablet screen…'* At the same time, he felt comfortable if being watched at home while playing computer games: '*Well, they know me* [family members] *and they know that I am not normally wasting my time. But here in the park, strangers might think that I am completely stupid or childish.'* As can be seen, this participant was quite concerned about how he looks in a public place and how possible observers might interpret his behaviour while being busy with something which he considers not appropriate for himself. It is the fact of observation that plays this role of physiological barrier, preventing him from feeling comfortable using a tablet in a public place, rather than the occupation itself. At the same time, he would feel comfortable reading books, for instance, viewing the whole situation, however, with the certain sense of humour: *'But if you, let's say, read a book here, would you feel the same? – No, with a book it's completely different. Everyone*

should be reading books, privately or publicly, no matter. Doing that I would give young people a good example and people around would probably say oh, he is a smart guy' [smiles].

5.3.2 Impact factor 2

"Phone calls" were mentioned by two participants as something they would like to avoid while being occupied with Sims 2. In both cases, phone calls were regarded as disturbing not as a randomly received calls, but expected and awaited in one case and received from an undesirable caller in another case. *'Sitting and awaiting my phone call is not really something which brings concentration in what I'm doing here. I know they will call me at some point, but don't know when and that keeps me nervous…',* as this participant reported. Another participant received an unexpected and undesirable phone call during a test: *'I just know who is calling and that person is really annoying sometimes. Other than that, phone calls don't disturb me, now or in general. I am always with my phone and people call me very often.'* Other participants were also receiving and answering their phone calls but they did not report any disturbance associated with those calls. These two particular cases might be viewed as special circumstances, associated either with a particular time of expecting a phone call or a particular person whose call is not expected nor desirable.

"Outdoors" as a factor was reported by two participants as they pointed out that they are not very much used to using a computing device, such as a tablet, in an outdoor environment. The first participant owned a tablet and had experience of using it in her daily life. However, she did not feel very comfortable using the tablet during the experiment due to the particular reason of being outdoors: *'I don't normally use my tablet when I am not at home. People might watch me and see what I am doing there. Plus it is not really safe to take my iPad outdoors. Normally, I am using it at home or at uni.'* At the same time this participant was comfortable with using her smartphone outdoors: '*With my phone it's different. It's smaller and I can always hide it in my pocket and people don't see my screen when I am chatting or something…*' Another participant was disturbed by outdoor noise generated by passing cars on a quite busy street: '*I am more used to my home, quiet environment.*

This noise disturbs me, but not too much.' In both cases the "outdoors" factor itself is not playing that significant a role in preventing users from continuing their activities. They were rather concerned by other factors, such as noise, privacy or personal safety issues, than by the fact that they are not indoors.

5.3.3 Impact factor 16

"No disturbance". The majority of participants (16 in total) reported that the environment does not disturb them, no matter indoors or outdoors because they are interested in their activities or, in contrast, not having such. '*Normally, the environment doesn't disturb me when I am interested in what I am doing. I don't even hear what other people say at those moments, which causes little problems in my family. So I am not really disturbed now.' 'No, I can't say I am disturbed now since I don't care really, no interest in this. Though I prefer quiet places to work. When they get too noisy in my office, it bothers me.' 'I feel absolutely fine when I am in social networks, I can do that in a bus, on the street or at home, it doesn't matter since I am quite interested in what I am doing, like talking to my friends, so I don't really notice people around or something else. But here (in Sims) I just don't like it and people who are passing by bother me. I'm not really comfortable.'* As can be seen from these answers, the interest in the activities plays a vital role with these participants: if they are interested in those activities, they don't consider the environmental disturbance as too significant a factor, which might affect their interest and hence, decrease their involvement. Subsequently, a participant might feel disturbed if she loses the initial interest for various reasons. As was reported by one participant, she is interested while she wins: '*I normally fell interested when playing games at home. My sister is an expert in those, so she tried to involve me. At the beginning I was ok, I was winning, so I liked it. But later on I was facing some problems, so I lost my interest and stopped. Here it's the same, at the beginning it was interesting, but after I got bored, so since I am not involved too much, I am sort of bothered by these people around…'* Another participant pointed out that he was fine with the noise in the café and people around until he heard particular music he liked, clarifying, however, that it did not bother him too much: '*I like that song, that's why I reacted like that, but that did not distract me too much since I am not really "in" this, I mean, in what I am doing. Not really absorbing*

me, so I don't care.' The nature of work was also brought up by one participant as a factor of disturbance, outlining the fact that more relaxed this user is, the less he feels disturbed: '*It depends. If my work is not very important, let's say, somebody's life doesn't depend on it, then I feel more comfortable and even people around talking do not bother me. If I make a mistake, it would not affect anyone, so I am not afraid to make it because somebody has just started talking to me. So, now I am not really involved in this, plus it is not so important, so I am ok with noise and everything.'* It is interesting to point out that one participant mentioned the outdoor noise as something that does not distract, but in contrary, could inspire him: '*Noise here* [in a park with random people passing by and talking] *doesn't bother me at all, I am used to it. Moreover, it can even work out for my imagination, bringing some kind of new atmosphere to what I am doing.'*

5.3.4 Statistical analysis of the results

Step 1, Step 2 and Step 3 of the chi-square test remain the same as in the "Virtual World" section of the framework (see sections 5.1.9.1 and 5.1.9.2).

5.3.4.1 Step 4. Computing the test

The results of the chi-square test for the "Environment" section of the framework are presented in Table 22.

Table 22. Results of the chi-square test for the "Environment" section of the framework

Environment Factors	How frequently mentioned by users		$(E-O)^2/E$
	Expected	Observed	
Weather	4.4	1	2.627272727
Being watched	4.4	1	2.627272727
Phone calls	4.4	2	1.309090909
Outdoors	4.4	2	1.309090909
No disturb	4.4	16	30.58181818
Total categories: 5	Expected = 22/5 = 4.4	Total observed: 22	∑=38.45454545

5.3.4.2 Step 5. Interpreting the results

Participants evaluated 5 categories (factors) for the "Environment" section of the framework. Thus, the degree of freedom is 4 (df = 4) (see section 4.1.9.4).

The reference value of chi-square for df = 4 at alpha level of .05 from the statistical table is 9.488 (see Appendix C). Since the calculated value of chi-square is greater

than the value from the statistical table (38.454 > 9.488), the null hypothesis (categories (factors) are noted with equal frequency) should be rejected and the alternative hypothesis (categories (factors) are noted with different frequency) accepted (Saint-Germain, 1997; Black, 1992; Deviant, 2010). Thus, the rejection of the null hypothesis and the acceptance of the alternative hypothesis proves the significance of the data, indicating that participants were making opinion-based decisions whilst evaluating those categories (factors).

5.4 Device

The Android-based 7-inch tablet was used for this experiment. The basic technical characteristics of that tablet (e.g. CPU power or memory size) were found sufficient; participants' responses did not indicate that technicalities were viewed by the users as obstacles which could prevent them from their activities in the virtual world. However, participants outlined a number of features which potentially could impact their virtual experience (see Table 23).

Table 23. Factors of the "Device" section of the framework

Device					
Impact	**Negative**	**Impact**	**Neutral**	**Impact**	**Positive**
1	Touch Screen	9	Screen Size	4	Mobility
5	Screen Size			3	Screen Size
				2	Privacy

The tablet PC, as viewed by participants, might have certain advantages and disadvantages. The 7-inch screen size, for instance, was considered as a positive impact factor by some participants (3 users) whereas 5 users found that size insufficient and hence, gave to that option a negative response. One participant reported that he was not used to a touchscreen and would prefer the regular control tools such as mouse and keyboard. A certain number of participants (9 in total) considered that the screen size is not so important a factor, providing neutral responses. On the positive side of characterising the tablet PC were the mobility of the device, or in other words, the possibility to move freely around the venue, if needed, while performing activities in the VW; the screen size was considered by 3 users as a good option, *'not too large and not too small, just right size'*; 2 participants outlined, that with the tablet PC they feel more secure than with the

stationary desktop since they can *'hide in quiet corner and nobody can see what they are doing there'* and they feel *'more private'* with a mobile device while doing something with Sims or online in general.

As can be seen from these responses, the technical peculiarities of the mobile device used for this experiment, might play both positive and negative roles as the user views that, for example, screen size was considered in positive, neutral and negative ways, whereas mobility was viewed as a certain advantage. Thus, the usage of the mobile device of this screen size (7 inch) will not fall into strictly defined positive or negative categories, but rather stay in the middle neutral position.

5.4.1 Statistical analysis of the results

The "Device" section of the framework is divided into 3 subsections (positive, negative and neutral) according to participants' responses.

Step 1, Step 2 and Step 3 of the chi-square test remain the same as in the "Virtual World" section of the framework (see sections 5.1.9.1 and 5.1.9.2).

5.4.1.1 Step 4. Computing the test for negative responses

The results of the chi-square test for the "Device" section of the framework are presented in Table 24.

Table 24. Results of the chi-square test for negative responses in the "Device" section of the framework

Device Factors (Negative responses)	How frequently mentioned by users		$(E-O)^2/E$
	Expected	Observed	
Touch Screen	3	1	1.333333333
Screen Size	3	5	1.333333333
Total categories: 2	Expected = 6/2 = 3	Total observed: 6	$\sum$=2.666666667

5.4.1.2 Step 5. Interpreting the results

Participants evaluated 2 categories (factors) for "Device" section of the framework. Thus, the degree of freedom is 1 (df = 1) (see section 4.1.9.4).

The reference value of chi-square for df = 1 at alpha level of .05 from the statistical table is 3.841 (see Appendix C). Since the calculated value of chi-square is smaller than the value from the statistical table (2.666 < 3.841), the null hypothesis (categories (factors) are noted with equal frequency) should be accepted and the

alternative hypothesis (categories (factors) are noted with different frequency) rejected (Saint-Germain, 1997; Black, 1992; Deviant, 2010). Thus, the rejection of the alternative hypothesis and the acceptance of the null hypothesis proves that participants' answers do not indicate that participants were concerned too much about the factors they evaluated. The observed frequencies are not significantly higher than the expected ones or in other words, participants were not taking these factors as significantly affecting them since they did not mention these factors often enough to gain the difference between "observed" and "expected" which would allow for a higher chi-square sum.

5.4.1.3 Step 4. Computing the test for neutral responses

The results of the chi-square test for the "Device" section of the framework are presented in Table 25.

Table 25. Results of the chi-square test for negative responses in the "Device" section of the framework

Device Factors (neutral responses)	How frequently mentioned by users		$(E-O)^2/E$
	Expected	Observed	
Screen Size	9	9	N/A
Total categories: 1	Expected = 9/1 = 9	Total observed: 9	N/A

5.4.1.4 Step 5. Interpreting the results

Nine participants identified the screen size in a neutral way, indicating that this factor (category) does not affect them while performing their tasks in VW. In this particular case, the observed frequency is equal to the number of expected ones. That makes the use of the formula $(E-O)^2/ E$ impossible due to fact that in ordinary arithmetic division by zero is undefined. Thus, the chi-square test is not applicable to this part of the framework.

5.4.1.5 Step 4. Computing the test for positive responses

Table 26. Results of the chi-square test for positive responses in the "Device" section of the framework

Device Factors (positive responses)	How frequently mentioned by users		$(E-O)^2/E$
	Expected	Observed	
Mobility	4.5	4	0.055555556
Screen Size	4.5	3	0.5
Privacy	4.5	2	1.388888889
Total categories: 3	Expected = 9/3 = 3	Total observed: 9	$\sum$=1.944444444

5.4.1.6 Step 5. Interpreting the results

The reference value of chi-square for df = 2 at alpha level of .05 from the statistical table is 5.991 (see Appendix C). Since the calculated value of chi-square is smaller than the value from the statistical table (1.944 < 5.991), the null hypothesis (categories (factors) are noted with equal frequency) should be accepted and the alternative hypothesis (categories (factors) are noted with different frequency) rejected (Saint-Germain, 1997; Black, 1992; Deviant, 2010). Thus, the rejection of the alternative hypothesis and the acceptance of the null hypothesis proves that participants' answers do not indicate that participants were concerned too much about factors of mobility and privacy which they evaluated, considering that these two factors were not affecting them significantly.

5.5 User

User's personal characteristics and background also may have their impact on his experience in VW (see Table 27).

Table 27. Factors of the "User" section of the framework

Impact	User
1	Fear to be ashamed of playing game
1	Motivation
1	Felt like an idiot - tasks
1	Feedback from the system
1	Skills level match
1	Negative experience with Sims
1	Circumstances
2	Not a gamer
2	Fear to waste time
3	Learning (novelty)
3	Amount of efforts
4	Fear to get addicted

5.5.1 Impact factor 1

"Fear to be ashamed of playing game" was reported by one user. This factor was described in Environment section, but certainly it is also an intrinsic feature of this particular user, his psychological barrier, which might affect his experience in VW.

"Motivation" was mentioned by one user as he did not see another reason for spending time with Sims 2 apart from participating in the test: *'I don't know why I am doing this... This is not interesting and not catching me. I am just helping you with your "experiment", otherwise I would not really play this Sims.'*

"Felt like an idiot" was what one participant said about how she was feeling. The complaint was raised due to the "task's primitivism": *'Sending the avatar to the toilet and making him wash hands afterwards is not really something I would like to see. This is too simple and stupid. Angry Birds are also simple and stupid but that's a different kind of game, you know that when you start. Here I just don't see it attractive anyhow, plus at the end I feel like an idiot…'* This factor also relates to the VW options themselves, as given the complication of the tasks defined in this case by the virtual environment, the user just follows the predetermined scenario. However, not all the users share the same feelings about task primitivism; it is the user's individual views which make such a difference.

"Feedback from the system" was reported by one of the users as an option which is missing in this VW: *'I remember one time I played car racing, using that wheel and pedals, you know, kind of car dashboard, you feel like you are in the car! And pedals are vibrating and the wheel too, like in real car. Here I need the same'* [smiles]. The participant obviously understands that within this VW that request is hardly achievable, but this is a certain message which indicates that more feedback from the system is required to enhance the user's experience.

"Skills level match" was the factor mentioned by one user as affecting his experience in this VW since his skills level, as he evaluated it, were lower than required by Sims 2. The "skills – VW's requirements" mismatch created obstacles, small but often barriers in User – VW interaction, which decreased the participant's interest in his activities: *'I was feeling confused at the beginning, when I was trying to figure out what to do and how. I don't probably have sufficient skills to play this kind of game, I don't know… When every time I need to do something, that causes a big problem and I lose my interest. This could be simpler or explained better or I don't know…'* The other side of this factor is that some participants found their skills level exceeding the level of Sims 2, emphasizing the primitivism of the virtual

world, that the tasks they were busy with were too simple and hence, not '*catching my attention*' as one participant said. More details about this phenomenon can be found in the "Virtual World" section as described from the VW's characteristics perspective.

"Negative experience with Sims". One participant reported that her previous experience with an earlier version of Sims was rather negative: '*I knew already what was it, I played this Sims before and I did not like it. My previous experience with Sims was two years ago for 15-20 min. Not interesting at all. Just tried. Maybe because I am biased against it since I like a different type of game, quiz like, where you need to think.*' Nevertheless, she pointed out that some of the options were quite interesting and engaging: '*The most interesting part is house building. I liked to be a constructor, choosing floor and wall paintings. But the interior is more interesting, like your own house and you are choosing. It was the most interesting part.*' This input indicates that the user was aware of the VW nature and type of activities she would need to perform. That biased the user to a certain extent, but as can be seen from her response, she was still feeling some interest in certain types of activities, finding them involving to a certain extent.

"Circumstances" were reported by one participant as a factor which can affect the user's experience: *'Under other circumstances, I promise, I would get immersed more…'* By "circumstances" this participant meant her personal ones, which she experienced just before joining the experiment: '*Considering that I did not sleep well at night, did not have proper lunch… feeling kind of nervous, so did not get immersed.'* On the other hand, the current conditions under which this user was performing her VW activities were also considered as "circumstances": *'I can tell about circumstances under which I would be interested in playing, but I need to think… in a queue, bored and have a lot of battery power…or if I get paid.'* The latter remark might be considered also as a lack of motivation since this participant did not see any other reasons to deal with Sims 2 other than to help with the experiment.

5.5.2 Impact factor 2

"Not a gamer". This is interesting point, reported by two participants, absolutely ruling out any interest in computer-based games or VW activities due to their "general incompatibility with this sort of activities". As one of these users reported: '*No computer game can attract me. I use my computer for work, emails, etc. but not playing any games. I just don't like them at all.'* At the same time this user pointed out that some parts or her activities in this VW was interesting enough: '*The most interesting part of the whole this is when you dress your avatar, trying this costume or that one. Avatar – well, I felt like creator maybe, choosing character, clothes, kind of amusing. Male, crazy, casual, don't know why male, don't like females. I don't think I am associating myself with him, choose what I like in people maybe, clothes as well, I like casual. John, recalled Terminator, boy John, first thing came to my mind.'* As can be seen, with the whole negativism in general to computer games and to Sims – 2 in particular, the user still finds some attractive and even to a certain extent engaging points in this VW.

Another user in this category was in principle playing games, but table ones, seeing them as a sort of activity you spend with your friends rather than alone: '*My leisure time is very limited, but when I have it I play Nardy* [backgammon]*, like two days per month I can dedicate to it. But Nardy is not just a game, I would call it a form of communication. We are talking while playing, having tea or something.'* The communication aspect for this user is the most important one; he spends time with his game partner, which might be a different person every time, for the purpose of talking and discussing the latest news probably. The goal to win the game is not so important in this case, the table game is regarded rather as a medium, connecting players. The same sort of approach this user has to computer-based games or more broadly, virtual environments. If they do not serve the purpose of communication with other people, they will be most likely ignored or paid little attention to. At the same time, this participant was quite neutral to social networks which are meant to be communicative environments, not even remembering in which particular social network he has an account: '*Social networks are also not very attractive, just one account thanks to you in VKontakte* [popular social network in Russia]*, once per week to see your pics. Oh, it's Facebook, sorry, I forgot.'*

"Fear to waste time". Two participants reported their concern of spending time in vain: *'I think I played 5-10 min… what? 50 min? So I threw 50 min of my life away…'* This regret should be viewed with regard to the fact that this user found Sims 2 very attractive and absorbed her fully, expressing even a fear to get addicted. However, as can be seen from her response, she did not like the idea of spending that much time with that kind of activity instead of doing something useful: '*This game is drowning you in, we cut ourselves from RL. We stop taking part in RL and taking part in the game. In fact, we spend too much time playing. If I played 50 min then I did not do anything useful during that time. Everything we do must be useful and have a good impact and develop us. I was not developing but getting in fact digested information.'* If this user could "develop" herself in her own understanding during her presence in a VW, she might not be so concerned about the amount of the time, spent in a virtual world.

Another user reported the same concern: '*From one side I had fun, on the other hand I realized that I was wasting my time. I thought, ok, just two secs more, then a new task is coming, just couple of secs more, oh, what might the next one be … I stopped when the game demanded internet connection or some routing which was boring, so I decided to stop.'* This participant was also driven by his activities in the virtual world, but at the same time he was not comfortable with the idea of inappropriate time spending since playing games in his understanding was a pure waste of time. Moreover, as he noted, gambling was a part of his character he was not very pleased with: '*I have to say that I am quite a gambler, so probably I feel engaged more than the others. I do realise that this occupation is useless, but I was quite interested in what I was doing.'*

5.5.3 Impact factor 3

"Learning" (novelty) was reported by three participants as an option which was keeping them interested in their activities within the VW: *'It was interesting at the beginning when it was new and I could learn something which I had never experienced before, I have never tried this kind of game or activity, not attracted really. But was quite keen in learning of how to do this and that. But later on it became boring, when you have to repeat what you do again and again.'* Another

participant stated: *'I am normally quite an active person so I like everything new, something which I haven't tried before and this was fine when I started. Like learning, when I play "Street Fighter" I always learn new techniques. Here it was the same, but unfortunately as you advance here, tasks are repeating and nothing new.'* The third participant had an experience with strategy games and was missing the variety and novelty in Sims 2 at the stage, when he learnt the basics: *'Was too predictable. I was missing the complexity, something new on each stage. Maybe I just did not reach those stages when more avatars would be involved and they might be doing different things, but so far they are repeating again and again. Gets boring at some point…'* As can be seen, all three responses are quite similar with the slight variation that the first participant had no previous experience with such an environment and his urge for novelty was based probably just on his curiosity and need for a challenge: *'I like when I don't know something and making those efforts to get that, challenges drive me normally*.' The latter two were more experienced with 3D strategies and they expected to have similar feelings with Sims 2 as well. But due to the fact that the system was quite limiting them at that stage they reached, they were feeling quite disappointed, providing answers similar to *'I would probably never try this again, too boring and doesn't hold me'*.

"Amount of efforts" was reported by three users as affecting them due to insufficiency of their efforts applied to interact to VW: *'I need normally to apply significant efforts when I am doing something in order to get interest to my occupation. If it's too easy or too difficult then I feel like it is not for me, I mean, my work responsibilities. I feel quite absorbed and enjoying if I see the progress in what I am doing. Same here, too simple, why should I feel anything here? Hope was it will be at the beginning, but later on it turned out that it is not actually. I am not occupied here at all.'* Another user was contrasting this: *'Well, I normally feel interest until I face problems, to be honest, when I play something like this'* [smiles]. *I have some experience with games as well, I remember I started playing one... don't remember the name though… so, at the beginning it was fine, enjoyable, but as it went to more advanced levels, I started losing and I did not like it* [smiles] *, so I just dropped it. It's my nature probably. Here with Sims it is the same – interesting at the beginning, but then got too complicated and I did not like it anymore… too*

much effort…' And the third participant was more leaning to the first response, emphasising, however, the novelty aspect of the activities along with the efforts applied: *'When it is not challenging it does not excite me, I need some tasks when I could learn something, which I probably never knew before. Plus it requires, you know, that you need to think, analyse and so on. So, if that part is missing, it is not interesting for me.'* As it can be seen from these responses, all three participants indicate in their answers that in order to feel involved in their activities they need to spend a certain amount of effort while interacting with the VW. But that amount should be sufficient, not exceeding a certain limit beyond which the user might lose his or her interest and at the same time the level of those efforts should not be too low in order that the user feels rewarded.

5.5.4 Impact factor 4

"Fear to get addicted" was outlined by five participants as impacting them. Not all those users evaluated this factor as one of the major ones. For instance, as one participant reported, it was interesting at the beginning and she was afraid to get involved too much since, as she already knew, the Sims in general was quite popular: *'At the beginning it was interesting since it was for the first time and I was even afraid to get addicted since many people play this game. It was interesting to create and see how it looks like, but then it was just tasks which were not very interesting.'* As can be seen, that was the nature of tasks that stopped her from further involvement in the Sims, not just the natural feeling that she *'might get into it too much'* with the hard way back.

Another user indicated that the VWs of this type and the Sims in particular must be limited somehow either by play time limit or parental control since he was positioning the Sims as an educational environment with further improvements and refinement: *'This might serve as an educational tool for children, for example, they could try safely things they can't try safely in reality. But games, even educational, might be dangerous for them, even for adults, so it should be restricted and accessed only with the guidance of parents.'* Thus, this user is more concerned about third party experience, considering that the children-users might be affected by their interaction with this VW. At the same time, he does not think that he personally

will experience the negative influence of the Sims, in spite of the fact that he had a negative experience with computer games in general: *'I am not involved really, it is not interesting to me, not engaging. I used to play a shooter and that was enough, got sort of immunity after getting health problems. But this type of whatever it is – game or I don't know… is not really my type.'*

Another participant was concerned about this problem, explaining that he is quite an addictive person and he does not really want to get addicted to the Sims, though he did not find this environment particularly attractive or so involving: *'I am actually quite a gambler, I can get addicted to this, but I don't want to. It is not that interesting, but still might involve you and it is difficult to get back.'* This concern was raised due to his particular personality regardless of the absorbing capability of the Sims. Similar feelings were expressed by another participant, who admitted that she might fall into some kind of dependence on that environment, also pointing out that in general she does not find it so attractive, but capable to involve her at an undesirable level. She had a negative experience with a similar virtual environment: '*Previously I played Farming, it is similar to this but you are not crating avatars, you buy a farm. It absorbs you as well and influences you the same way. I was playing 4 months, 5.5–6 hours per day. It is online. I realized that I have many things to do left over, they were piling up and later it became a big problem. So I was not only leaving behind all my problems but creating problems for other people. So I don't want to repeat it again.'*

5.5.5 Statistical analysis of the results

Step 1, Step 2 and Step 3 of the chi-square test remain the same as in the "Virtual World" section of the framework (see sections 5.1.9.1 and 5.1.9.2).

5.5.5.1 Step 4. Computing the test

The results of the chi-square test for the "User" section of the framework are presented in Table 28.

Table 28. Results of the chi-square test for the "User" section of the framework

User Factors	How frequently mentioned by users		$(E-O)^2/E$
	Expected	Observed	
Fear to be ashamed of playing game	1.75	1	0.321428571
Motivation	1.75	1	0.321428571
Felt like an idiot - tasks	1.75	1	0.321428571
Feedback from the system	1.75	1	0.321428571
Skills level match	1.75	1	0.321428571
Negative experience with Sims	1.75	1	0.321428571
Circumstances	1.75	1	0.321428571
Not a gamer	1.75	2	0.035714286
Fear to waste time	1.75	2	0.035714286
Learning (novelty)	1.75	3	0.892857143
Amount of efforts	1.75	3	0.892857143
Fear to get addicted	1.75	4	2.892857143
Total categories: 12	Expected = 21/12 = 1.75	Total observed: 21	$\sum$=4.75

5.5.5.2 Step 5. Interpreting the results

Participants evaluated 12 categories (factors) for the "Environment" section of the framework. Thus, the degree of freedom is 4 (df = 11) (see section 4.1.9.4).

The reference value of chi-square for df = 11 at alpha level of .05 from the statistical table is 19.675 (see Appendix C). Since the calculated value of chi-square is smaller than the value from the statistical table (4.75 < 19.675), the null hypothesis (categories (factors) are noted with equal frequency) should be accepted and the alternative hypothesis (categories (factors) are noted with different frequency) rejected (Saint-Germain, 1997; Black, 1992; Deviant, 2010). Thus, the rejection of the alternative hypothesis and the acceptance of the null hypothesis proves that participants' answers do not indicate that participants were concerned too much about the factors they evaluated. The observed frequencies are not significantly higher than the expected ones or in other words, participants were not taking these factors as significantly affecting them since they did not mention these factors often enough to gain the difference between "observed" and "expected" which would allow for a higher chi-square sum.

5.6 Framework finalized

All the factors finally formed the framework, which is represented in Table 29. As can be seen from this table, the factors form five groups: Virtual World group, Avatar group, Environment group, Device group and User group. Within each group, factors are ranked according to the number of responses they received from the users or in other words, how many times the users mentioned the factor. The "Clear Goal Outlined" factor in the Virtual World group, for instance, has been mentioned one time, whereas the "No real life or Wrong type" factor has been mentioned eight times by the users. That indicates the different level of importance or "weight category" of each factor, in this example they are categories one and eight.

Table 29. The framework of factors affecting immersion

Impact	***Section of the framework and its factors***	***Explanation***
	Virtual World	**The in-world, as opposite to real world**
1	Clear goal outlined	The goal of scenario is not clear
	Commercial aspect	Options to make money is needed
	Preview	Preview of next step is needed
	More focused	More objective plot is needed
	Time limit	Time limit is needed to avoid excessive use by kids
	Scale	The scale is too limited
2	More emotions	The plot needs to involve more emotions
	Clearer instructions	Instructions from the system are not clear
3	Less linear	The events flow is too predictable
	Faster	The events flow is too slow
4	Real people	Real people behind avatars are needed
5	RL simulator	VW is viewed as life simulator
	Hints from system	More hints from the system are needed
6	More real life	VW is needed to be closer to realities
7	Graphics	Graphics require improvements
8	Plot	Plot to be more engaging

	Tasks	Tasks in VW should be more interesting
	No RL or Wrong Type	The Sims is a wrong type of VW for these users
Impact	**Avatar**	**Graphical representation of user**
1	Closer to Real Life	Avatar is too unreal and awkward
	Realism	More realistic image is needed
	Adjustable	More flexibility in avatar customisation
	More avatars	Larger avatar population in VW
	Less control over avatar	More freedom for avatar in actions
	Communication	Ability to communicate to avatar
7	Not enough choices	More avatar choices
13	Need association	Users need association with their avatars
Impact	**Environment**	**The real-world environment**
1	Weather	Weather elements, such as rain, sunshine, etc.
	Being watched	Fear of being observed by other people in the real world while participating in the experiment
2	Phone calls	Incoming phone calls to the participant's phone
	Outdoors	Being out of building, on open space such as park, street while using tablet PC for experiment
16	No disturbance	The real-world environment does not disturb users in any aspect
Impact	**Device**	**Tablet PC**
1	Touch screen	This user does not like touch screens
2	Privacy	Users found privacy more achievable on tablet PC than on a desktop
4	Mobility	Users found mobility of tablet PC as a convenient option
3	Screen size (Positive)	A small 7" screen size is considered as a plus
5	Screen size (Negative)	A small 7" screen size is considered as a minus

9	Screen size (Neutral)	A small 7” screen size is considered as neither plus nor minus
Impact	**User**	**A person, participating in experiment**
1	Fear to be ashamed of playing game	User considered playing “games” shameful
	Motivation	More motivation is needed to do activities in VW
	Felt like an idiot - tasks	Tasks are too simple
	Feedback from the system	More feedback is needed from the system
	Skills level match	User’s skills level should be matching the complexity of the tasks in VW
	Negative experience with Sims	Previous negative experience with Sims
	Circumstances	Personal circumstances, preventing the user from being involved in what the user is doing
2	Not a gamer	User is not a gamer and does not like computer games
	Fear to waste time	Playing computer games considered to be a waste of time
3	Learning (novelty)	Need novelty in activities and learning opportunities
	Amount of efforts	Amount of user’s efforts should be sufficient to feel satisfaction
4	Fear to get addicted	Due to previous experience and / or nature of these users they expressed some fear that they might get addicted to what they were doing in experiment

The diagrammatic representation of the framework is shown on Figure 18. The numbers in brackets indicate the impact of each factor, as presented in the table form of the framework.

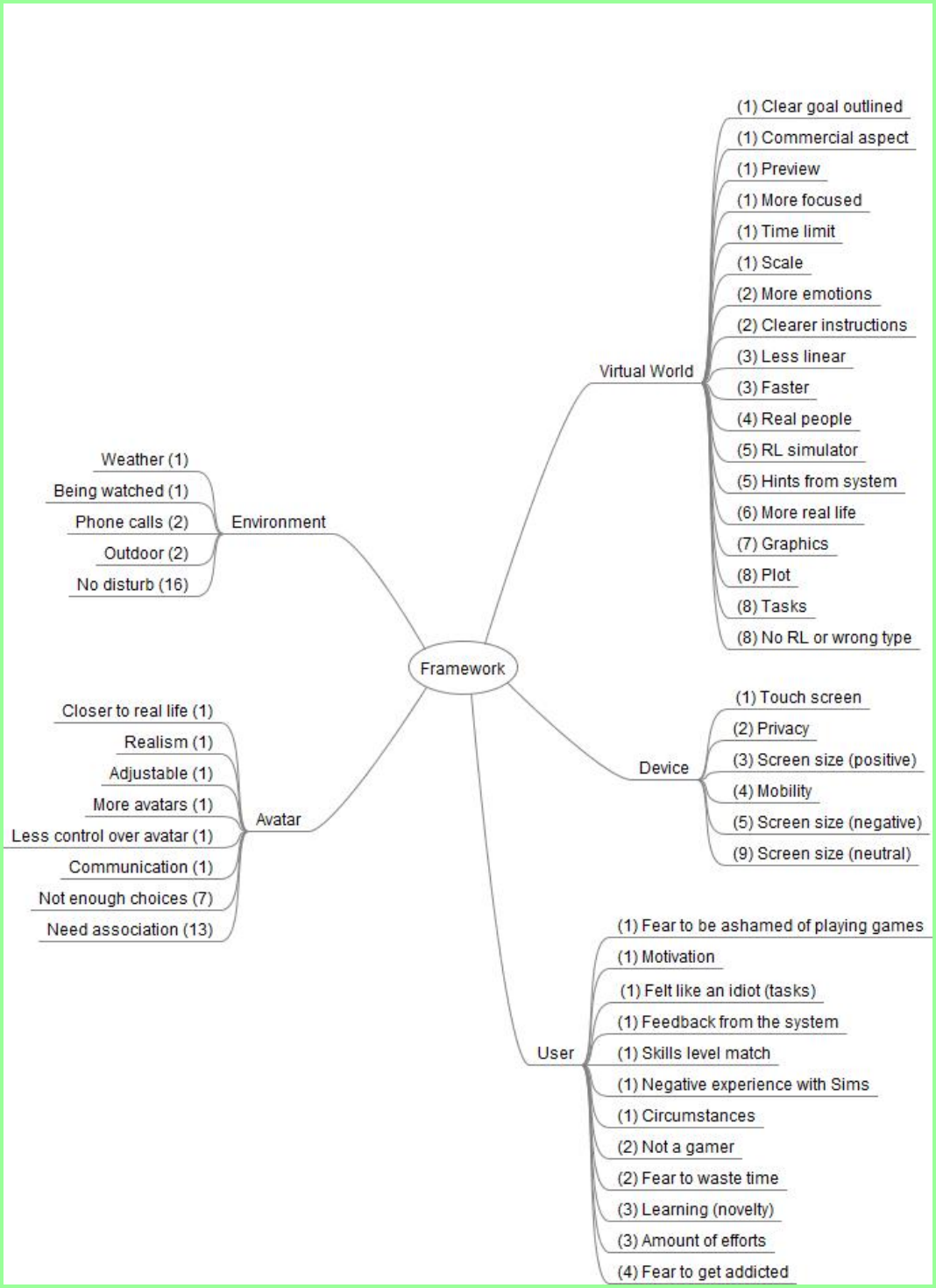


Figure 18. The diagrammatic representation of the framework

These factors forming the framework have been evaluated as potentially affecting users' immersion experience in a virtual world. However, they have been evaluated under certain test conditions. Users' opinions under those conditions were shaped

by different extrinsic and intrinsic constraints and the question of how reliable, valid and applicable these factors are under different conditions, still remained open. Thus, the necessity of the next experiment, where users could try the framework in real conditions of building a virtual world, appeared to be the next logical step.

6 Experiment 4

Experiment 4 was initiated to test the framework factors with a different set of participants in order to understand how those factors would be viewed by people who are actually involved in a virtual world building process.

Factors comprising the framework were identified by a group of participants during Experiment 3. The initial purpose of this framework is to provide a useful and reliable tool for VW designers. Such designer groups or individuals might be located and work in different technical and cultural environments.

To check the framework for robustness and applicability in different environments, it is necessary to choose conditions different to the earlier experiments, including venue, platform, task and users. To meet this requirement, another group of different users was recruited for Experiment 4. In order to achieve better validity of data, certain changes to test conditions were made, recruiting a different number of users with different backgrounds, utilising a different test environment and a different virtual world. The only test parameter which was left intact was the framework, which basically was “migrating” from one test condition to the others.

The number of people in the Experiment 3 and Experiment 4 groups was different since generally speaking, the number of virtual world builders can vary in real situations. Twenty-three participants were recruited for Experiment 3 and thirty-one participants were recruited for Experiment 4.

Both groups of participants consisted of people with different professional backgrounds, varying from students of linguistics and IT professionals to students of computer science.

Both groups have different cultural backgrounds since Experiment 3 and Experiment 4 took place in different cultural environments of the Russian Federation and the UK. Premises used for both experiments also vary: a combination of leisure outdoors and indoors for Experiment 3 and university classroom indoor environment in Experiment 4.

Different computer systems were used for virtual world access, hardware and software: 7-inch Android tablet for Experiment 3 and Windows-based desktop PC for Experiment 4.

Virtual worlds used for both experiments are also different: the Sims 2 environment in Experiment 3 and an OpenSim based environment, created for educational purpose, in Experiment 4.

Thus, the necessary variety in all aspects of the test conditions were achieved for better validity of the results, simulating as close as possible real virtual world building conditions.

6.1 Participants

A group of students of the University of Bedfordshire was recruited to take part in Experiment 4. Participants were males and females, studying different subjects of computer science, including the Social and Professional Project Management module. Within the requirements of that module, students needed to build a virtual showcase in a virtual world, based on the OpenSim platform.

Thirty-one participants in total took part in this experiment, divided into eight focus groups with typically 2-4 people per group, depending on how many group members were responsible for the showcase building task.

6.2 Platform and Task

OpenSim was used as the platform installed on the department's dedicated server. The virtual world was accessible through Imprudence Viewer, while operating by the default avatar. An avatar's appearance is changeable with certain limits. The task for participants was outlined as creating a virtual showcase in the virtual world, where project teams would be presenting their final products or services, developed by the team while working on the projects. The showcase normally takes the form of a building, enabled by interactive screens, informative posters, and points with external links to other web resources. Each team has its own building spot of limited size. The architectural style, forms, quality and quantity of decorations were left to the discretion of the project team. The only limitation is the building size, which should not exceed predefined dimensions. The whole construction is built using

prims (primitive building objects, such as cubes, cones or rings). The use of scripts is encouraged but not mandatory.

6.3 Focus groups method

One of the methods used for data gathering was a focus group interviews method. The goal of this part of Experiment 4 was to present factors evaluated in Experiment 3 to participants of Experiment 4 and get opinions through the discussions in the focus groups. Eight focus groups were formed in total; the factors were presented to each group separately in the form of the whole framework. Discussions were conducted to encourage participants to share their opinions in the form of free conversations. Participants discussed each factor individually, moving from one factor to another one through the framework presented. Each group performed differently and conversation flow was not necessarily the same for each group. The emphasis was, however, to allow as free a conversation as possible, minimising the influence of the test facilitator as is suggested by focus group discussion guidelines. All discussions were audio recorded. For more about focus group method see section 3.6.

6.3.1 Group One

Group One emphasized that the use of the OpenSim-based VW is quite difficult since the group members did not have previous experience with that and they lack the creativity required for building nice and presentable structures in the virtual world: *'It's quite tough, I have to say, it will take a lot of time from us. We are in the computer networking, not building architecture, so I personally don't think that I have that sort of creativity to do this. Plus we never used this before.*' Members of this group mentioned that probably the efforts of the whole project group will be required to accomplish the task in a reasonable time. They did not modify their avatars, explaining that for the building structures purpose '*the fancy avatar is not really required since there is no other people around to impress'*. Group members also reported that they did not have previous experience with Second Life – type virtual worlds, but they used to play first person shooter (FPS) games. "Environments", both real life and VR, were reported as critical to achieve quality of task due to possible disturbance from people in both cases: *'I would work here*

in uni since at home I cannot really concentrate – TV, siblings, phone calls disturb me. Here we have work environment, at least we know why we are here. In virtual world also, if too many people around and they are just chatting, it will affect me. If they are working there – then it's not.'

"Time limit" along with "Clear Instructions" were also reported as limitations and affecting factors: *'Time is definitely limiting us and that makes us nervous. If we have more time for this we would explore the options better and get good results. Also instructions from the system are not very obvious, definitely need them more understandable.'*

"Weather" as a factor was misinterpreted by participants since the venue was indoors and the real-life weather outside of the classroom could not affect the users: *'It is good that we can change the weather there* [in VW], *brings more realism.'* Originally as a factor, the weather was outlined by participants in Experiment 3 as a potentially affecting factor since the venue for approximately half the users was outdoors.

"Clear goal" also was outlined as a desirable option of the whole scenario: *'That would certainly help if we know what and how to do, instead of just getting there with no idea how it should look like* [the structure]*.'*

"Privacy" in both virtual and real worlds was reported as an issue: *'We need more privacy there. Other people can see our work and plagiarise. Or at least take out ideas… And the same here* [in a lab], *people are around us, so they can see what we are doing.'*

"Fear to waste time" as a factor was not outlined as an important one: *'Not sure about this, we are not wasting time here, we are working, so why fear?'*

"Fear to be ashamed" received quite a strong response from one of the participants of this group: *'I don't understand this totally. Who cares and why should I? If I am even wasting my time, which is not true in this case, it is my time, not somebody's and I can spend it as I want, including playing games! I am playing games, so what?'* It is interesting to point out that this factor was reported by some participants of Experiment 3 as affecting oneself since they did not wanted to be observed by

other people in the venue as playing games, as they understood manipulating the Sims 2 environment. The difference between these two reactions lies probably not only in the fact that the tasks, which have been assigned to users in both cases, were perceived as different (playing games versus building a structure for learning purposes), but also a cultural difference between students and young people in Russia and Britain. The latter assumption needs, however, further exploration with the emphasis on that aspect.

6.3.2 Group Two

"Clunky control and manipulation" was reported by this group as one of the critical factors which prevents them from successfully building the structure: *'Very inconvenient. Clunky. Placing objects is a problem, it is not liquid and convenient. I would change it* [placing option] *if I could. Difficult to move around your structure and key combinations are not "standard", arrow keys are not very good for this, WSD is much better, but that activates the chat, which we don't really need here.'* Limited colour options was also reported as an issue, as '*more colours required for trees, grass and there is no snow as an option'*. Participants suggested two modes for the virtual world-builder mode and user mode. Within the first one they would like to see all the menus and options on the same screen, without '*jumping between pop ups'*, whereas the latter mode could be a regular, default mode, which they were using in this experiment. Participants also suggested the option to import '*real objects from outside world'* and use them in the VW. When it was pointed to them that this option actually exists in the system, they outlined, that '*it was not too obvious how to use that feature'*.

"Wrong type as system to use" was indicated by this group: *'I don't understand why we are forced to use this system. If I need 3D objects I would use dedicated software like 3D-Max, for example, where everything is done just better. And if I need to present my work to my boss, I would go to Kickstarter. Or, let's say, to use something from Adobe family.'*

"As a concept" was another concern of the users of this group: *'It is good probably, but it just proves the concept, that's all. It is not absorbing you or creating that special environment, like Oculus Rift does. It is just the beginning for them, but that*

kind of things will be more useful, I think, since it is fully cutting you from the outside world.'

"Scale" was another factor, as reported, limiting the performance of this group: *'It is not enough space. You know Minecraft? So there you have much more land than here. – But what would you build if you have more space? – Bigger buildings, even city maybe.'*

"Minecraft" was repeatedly reported as a good and proper example of building environment: *'In Minecraft, building is much easier, they are using blocks so you just stack those and they are linking nicely, so they whole process take much less time. Though it looks quite ugly, but much better to manipulate. In Rust it's even better, they have a good library of elements which is missing here. Well, there is a library, but number of elements is not enough.'*

"Avatar modification" was reported as having lack of modification options and as something which is not really important for this kind of activity: *'Avatar – I did not modify it. Why? No one is around and for building purposes I don't really care how my avatar looks like. – But I did. I changed it from female to male and nothing really changed, just shoulders became broader… '* Another used added that the avatar is good to have customised if you have a group of users with common goals to communicate with.

"Privacy" was also reported by this group as a missing point in both cases, with VW and in real life for the same reason, which was outlined by the first group: '*other people can see our work and copy it'*. One of the users suggested, that privacy in general is more complex issue in such systems, which as a statement was not fully supported by his colleagues: *'People don't think about it, but in Second Life, for example, all you do is monitored and recorded, all your activities are tracked and your profile is built… - I think, you're taking it too far'*[smiles].

"Purpose" or "Focus" was also reported as an influencing factor: *'I would say more specific – better. If the task is more focused we would get better results, like first to build then to present. Here we are not sure what we do, how it should look like at the end and how we should present there our product.'*

6.3.3 Group Three

Group Three repeated some of the concerns previously outlined by other groups: "Clunky controls", "Minecraft", "Avatar modification", "Scale". With the latter one, participants suggested to have the building space expandable *'as large as you want'* to build the *'fancy world'*, not only a number of buildings. The avatar also drew some attention with the response '*can I actually kill the avatar?*' One participant figured out that the WSD keys, the importance of which was outlined by other groups, can be activated if the chat option is minimised. With the controls, gravity was suggested as an additional option *'for better linking objects while building'*. The ability to *'generate lights'* was expressed by one of the participants to add them to the scenery. Concerning control options, participants of this group complained that '*it is too detailed and many barriers*', comparing to those in Minecraft, where everything could be done by stacking building blocks on each other. The library of elements for building (so-called prims) was also outlined as insufficient, compare to the Minecraft's counterpart. The concluding opinion, however, was rather positive, indicating that '*once you start messing around* [figuring out what to do and getting familiarised with the system] *you will be ok*'.

6.3.4 Group Four

Group Four decided to go straight to the survey and clarify those questions while discussing them. Mainly the same set of concerns outlined by previous groups (e.g. privacy, tasks, people behind, etc.), was expressed by this group, adding, however, some additional comments.

"Clunky control" was also mentioned by this group, followed by the remark: *'I don't think that there was no enough choices here, still huge choices, you just need to start exploring it.'*

"Not a gamer" was agreed by the participant with the emphasis on the goal: *'Agree, I am not a gamer, no goal – not a game.'*

6.3.5 Group Five

Group Five decided not to take part in the discussion and only to complete the survey. No further explanations were provided. Since it had been explained to the

participants at the beginning that this experiment is voluntary, no further attempts to engage the discussion were made.

6.3.6 Group Six

Group Six responses were also concentrated on the survey completion, rather than on keeping discussion alive. However, one participant provided this response: *'It's very different. It's easier than I expected, I thought it would be programming…'*

6.3.7 Group Seven

'*Difficult at the beginning, but 10 min later it was okay*', '[we need] *bigger* [building] *blocks and bigger scale*', '*avatar is not for this project*', '*controls are tweaky* [awkward]', '*system is fast enough*', '*games experience helped*' were the responses of this group.

6.3.8 Group Eight

"Need grid" as a response appeared in this group for the first time during the whole experiment: *'If we have a visible grid* [on the building spot], *it would help to build.'*

"More natural". *'If it is a simulator, controls should be easier. Oculus* [Oculus Rift] *is almost there, but you still need to use your mouse and keyboard'*.

The WSD key combination was mentioned again as a desirable option: '*WSD is needed and generally, key bindings should be changeable.'*

"Proper editor". *'I would use actual 3D editor like Mayo* [Adobe Mayo] *instead of this.'*

"No social needs" required as reported by the user: *'The system should be more geared towards these particular needs: building structures, the project goal. There is no needs for socialisation* [in VW]*.'*

"System is too chaotic" – *'This system seems to be not very polished. It is not too difficult if you know bits and pieces, but efforts… It takes too much efforts, it's too chaotic. Why don't we use Minecraft?'* Yet again, the participant mentioned Minecraft as a good example of building capability. As can be seen, this newly appeared factor, or more precisely, the reference to something desirable as a phenomenon persists in almost every group's answers.

6.3.9 New factors identified

As a result of the focus group discussions, participants evaluated an additional set of factors which affect participants of Experiment 4 in their activities while in the virtual world (see Table 30).

Table 30. Factors identified in the focus groups of Experiment 4

Factors identified	Framework area	Explanation
Work environment	Environment	The real physical world work environment
Time limit	Environment	Prefer to extend time allowed to build VW
Weather change	Virtual World	As an option to bring more realism to VW
Clear goal	Virtual World	The task goal should be more clear
Privacy	Virtual World	Needed more privacy in virtual world to protect copyright
Fear to waste time	User	No such fear
Fear to be ashamed	User	Strong negative response
Clunky control and manipulation	Virtual World	Building process is affected by this
Wrong type as system to use	Virtual World	Better systems than this for building purpose
Good as a concept	Virtual World	As a concept, but not practical too much
Scale	Virtual World	Bigger scale is needed
Minecraft	Virtual World	As a good example of how such system should be
Avatar modification	Avatar	More options for avatar modification
Purpose	Virtual World	The same a goal
WSD keys	Virtual World	Control concern, this keyboard keys combination known from games were suggested as necessary option
Gravity in the virtual space	Virtual World	Gravity is helping to build, when upper layer is “finding” its way to the lower one
Ability to generate lights	Virtual World	To make lights on the scene to enrich the scenery
Too complex control	Virtual World	Control of building process is too detailed and many barriers (need Minecraft-like stacking)
Bigger (building) blocks and bigger scale needed	Virtual World	Building blocks are too small and difficult to handle

Avatar is not for this project"	Avatar	Avatar option is not necessary for building purpose
Need grid	Virtual World	Coordinate grid is required to help building
Proper editor	Virtual World	Better editor with more options is needed
System is too chaotic	Virtual World	System should be more logical

As can be seen from Table 30, participants mostly were concerned about factors in the area of Virtual World. The reason for this probably lies in the nature of the task presented to participants, the creation of virtual structures for the purposes of participants' course assignment. The Avatar section caused significantly fewer concerns, getting only 2 opposite responses, where one was implying that there were not enough avatar modification options in the system and another one pointing out that an avatar is not needed at all for this kind of system (see section 6.3.7).

Two factors are related to the Environment area of the framework – "Work environment", which did not get any complaints from users; and "Time limit", where users expressed the wish to have a longer time frame for their activities. This factor was misinterpreted by participants since originally by Experiment 3 it was identified as a wish to have a time limit for being in VW to avoid kids from getting addicted to Sims 2 (see section 5.1.1).

Two factors from the User area of the framework ("Fear to waste time" and "Fear to be ashamed of playing games") received quite a criticism from Experiment 4 participants, outlining that they feel neither of these (see sections 6.3.1 and 6.4.6).

All these new factors can be added to the framework as a supplementary section to be taken into consideration since these factors do not bear an impact weight as other factors of the framework do. These factors appeared on the stage unexpectedly, as a result of the grounded theory approach to the focus group result analysis since the initial idea of Experiment 4 was not factor evaluation, but confirmation of existing factors, evaluated in Experiment 3. Thus, they cannot be prioritised and fitted into framework at this stage.

6.4 Survey method

The goal of this portion of Experiment 4 was to present factors from Experiment 3 to participants of Experiment 4 and get participants' opinions about each factor individually through the online-based survey.

A five-point traditional Likert-scale with neutral mid-point and additional comment box for each factor was chosen as it offers the most flexible approach for participants to express their ideas.

Participants were asked to read the main declarative statement "This factor affected me while I was building my Showcase", and provide their opinion using the scale of five response categories: "Strongly disagree", "Disagree", "Neither agree nor disagree", "Agree", "Strongly agree", filling the "Other" field with comments if they wished to provide such. Factors were presented in the same sequence they appear in a framework.

While analysing the survey results, attention is paid first to answers indicating stronger trend, either positive ("Agree", "Strongly agree") or negative ("Disagree", "Strongly disagree"), utilising the same technique used in Experiment 1 results analysis (see section 4.1.8). Neutral ("Neither disagree nor agree") answers do not provide any visible trend, but should be taken into consideration at further stages of analysis as a supplementary data source. If participants agree more than disagree (the sum of "Strongly agree and "Agree" scores is greater than the sum of "Strongly disagree" and "Disagree" scores), then the factor is considered as affecting Experiment 4 participants. If participants disagree more than agree (the sum of "Strongly Disagree" and "Disagree" scores is greater than the sum of "Strongly agree" and "Agree" scores), then the factor is considered as not affecting, which can be illustrated by the example from Table 29: the "Clear goal outlined" factor is considered as an affecting factor since the sum of "Agree" (17) and "Strongly agree" (1) scores is greater than the sum of "Strongly disagree" (0) and "Disagree" (4), i.e. (A+SA) > (SD+D) or (17+1) > (0+4). Hence, the factor is an affecting one for participants. In contrast, "Commercial aspect factor" is not thought of as an affecting one due to the fact that (A+SA) < (SD+D) or (7+6) < (8+6).

6.4.1 "Virtual World" related factors

As can be seen from the Table 31, eighteen factors in total, concerning the Virtual World aspect were identified during Experiment 3, scoring from one to eight. Hence, participants of Experiment 3 prioritised those factors according to the score earned, lower score – lower priority or lower importance for the participants. "Clear goal outlined", for instance, scored one point, which means that one participant considered that factor as affecting him. "No Real Life or Wrong Type" scored eight points which means that eight participants from Experiment 3 considered this factor as affecting them.

Among those 18 factors, presented to Experiment 4 participants, 13 factors were considered as affecting and making impact on participants. Three factors ("Commercial aspect", "More emotions" and "Real life simulator") were not considered as affecting by Experiment 4 participants (see Table 31).

Table 31. "Virtual World" section factors as seen by Experiment 3 and Experiment 4 participants

Experiment 3		Experiment 4		
Impact	This factor affects me	Disagree	Agree	Affects more than 50% of users
	Virtual World			
1	Clear goal outlined	4	18	Yes
1	Commercial aspect	14	13	No
1	Preview	1	15	Yes
1	More focused	6	18	Yes
1	Time limit	11	14	Yes
1	Scale	3	20	Yes
2	More emotions	9	9	No
2	Clearer instructions	7	18	Yes
3	Less linear	9	8	No
3	Faster	5	17	Yes
4	Real people behind	2	19	Yes
5	Real Life simulator	10	6	No
5	Hints from system	4	24	Yes
6	More real life	5	12	Yes
7	Graphics	5	20	Yes

8	Plot	12	18	Yes
8	Tasks	6	17	Yes
8	No Real Life or Wrong type	6	6	No

The highest score (24 points), for instance, from Experiment 4 participants was earned by the "Hints from system" factor, which indicates that 24 participants from the Experiment 4 group indicated this factor as affecting them during their activities in the VW. The lowest score is gained by "No Real Life or Wrong type" and "Real Life simulator" factors (both gained 6 responses). Participants neither see the virtual world as a real-life simulator nor seek for closer representation of real life in the VW. The type of VW also did not disturb them, hence, those factors got a minimum from the users. It is interesting to point out that "No Real Life or Wrong type" gained equally on the approving and disapproving sides, hence, this factor falls into category "No" and cannot be considered as a valuable factor for participants. The "More emotions" factor also falls into the same category.

Some factors are marginally "winning" or "loosing". The "Commercial aspect" factor, for instance, was disapproved of by participants and thus, is considered marginally as not an affecting factor – fourteen participants considered this factor as not affecting them vs thirteen participants who found this factor as affecting them. The "Less linear" factor is in the same category, the number of participants on both sides is almost equal and "disapproving" opinion is not significantly prevailing.

The absolute score gained by the factor is not so important in this case since it just confirms that the right system was built (Hahn, 2013). The fact that Experiment 4 participants applied those principles (factors) evaluated in Experiment 3 proves that the system built meets the desired requirements regardless of how high or low Experiment 4 participants evaluate or rank each of those factors.

6.4.2 "Avatar" related factors

Eight factors in total have been evaluated by participants during Experiment 3 (see Table 32). The absolute majority of Experiment 3 participants (13 in total) would like to see association with their avatars, seven participants complained about not

having enough choices for avatar modification. Six other factors earned one score each, e.g. participants were not eager to see the virtual world closer to real life or expressed the need for realism, for instance. All these factors were discussed in details in section 5.2.

The Experiment 4 group prioritised the "Communication" factor as the highest with total approving score 19 (see Table 32). Participants stated that *'communication is needed if group of people with common goal is doing something in virtual world'*. Participants also felt that the system is not adjustable enough and they need more flexibility and options, which reflected by eighteen points, gained by the "Adjustable" factor. "More avatars" was another major concern (16 points) along with "Not enough choices" (15 points), indicating that avatar customisation options did not satisfy users' needs.

Table 32. "Avatar" section factors as seen by Experiment 3 and Experiment 4 participants

Experiment 3		Experiment 4		
Impact	This factor affects me	Disagree	Agree	Affects me
	Avatar			
1	Closer to Real Life	12	11	No
1	Realism	12	11	No
1	Adjustable	5	18	Yes
1	More avatars	4	16	Yes
1	Less control over avatar	12	8	No
1	Communication	2	19	Yes
7	Not enough choices	11	15	Yes
13	Need association with my avatar	5	12	Yes

On the disapproving side, the "Closer to Real life" factor scored twelve points along with "Realism". Participants did not see that the virtual world they were using needs to be "more real" than it was since the level of "realism" was sufficient for the needs of the showcase construction. However, both of those factors prevailed only marginally (twelve vs eleven points). "Less control over avatar" (twelve points) also was not regarded by the participants as a factor significantly affecting them, due to the fact that less control was not really required as it was not contributing

towards successful completion of the task. “Not enough choices” for avatar customisation gained eleven points since the participants viewed this factor as not vital for the particular needs within the scope of their assignment.

6.4.3 “Environment” related factors

Five factors in total were evaluated during Experiment 3. In general, the environment was considered as non-affecting by the majority of participants, gaining sixteen points. Being outdoors as a factor (“Outdoors”) scored two points along with “Phone calls”. Participants also did not considered the “Weather” factor as significantly bothering them and they were not being afraid of “Being watched” (one point) by occasional observers while performing their activities in the VW.

Experiment 4 participants (see Table 33) considered the environment as non-disturbing (15 points). They found the classroom conditions supportive and not distracting, unlike the home environment, where ‘*there is always something, like TV or your siblings or phone calls*’.

Table 33. “Environment” section factors as seen by Experiment 3 and Experiment 4 participants

Experiment 3		Experiment 4		
Impact	This factor affects me	Disagree	Agree	Affects me
	Environment			
1	Weather	5	13	Further research
1	Being watched	9	13	Yes
2	Phone calls	7	12	Yes
2	Outdoors	3	14	Further research
16	Not disturbing	7	15	Yes

Though participants rated “Outdoors” (14 points) and “Weather” (13 points) as quite significant factors affecting them while they were building their showcases, it remains unclear why they considered these specific factors applicable to the outdoor environment only. Being in a climate-controlled indoor environment of the university lab it is very unlikely that those two factors will really disturb

participants. One participant, however, during one of the focus groups sessions reported that '*It is good that we can change the weather in virtual world as an option*', reflecting that adjusting the weather conditions helps to create a more visually appealing place. But that indicates, that participant actually misunderstood the question and required correction from the facilitator. The use of the survey does not allow such flexibility, hence, these two factors will remain as required further investigation.

"Being watched" factor gained thirteen points and thus, considered as affecting the participants as they reported that "privacy is an issue with the system". Participants found quite disturbing the fact the construction site is visible for other groups' members and "they can actually steal our ideas which might affect our marks".

"Phone calls" (12 points) were considered as affecting factors since participants reported them as one of the disturbances if they receive phone calls during their work. It was noted also, that in university labs that factor plays less important role since the use of the phones is not allowed by lab rules.

6.4.4 "Device" related factors

Four factors (see Table 34) have been evaluated during Experiment 3. "Mobility" has been pointed by four users as a factor, allowing users to be more flexible with their location and experience more privacy, using the tablet at their convenience (two points by "Privacy" factor). One participants have found the "Touch screen" (one point) as not convenient to use.

The "Screen size" factor has drew more attention from the participants, spreading their responses among positive, negative and neutral sides. Three participants considered the 7-inch screen size as convenient and "handy to use", allowing them more freedom of movements. Negatively responded to that factor five participants, who considered that size as too small and inconvenient. Nine participants have given a neutral response to this factor, indicating that it does not affect them too much.

Experiment 4 group prioritised "Screen size" factor as the main one, giving seventeen points to it, pointing that they would prefer bigger than 19 inches screen, used in computer lab (see Table 34).

Table 34. "Device" section factors as seen by Experiment 3 and Experiment 4 participants

Experiment 3		Experiment 4		
Impact	This factor affects me	Disagree	Agree	Affects me
	Device			
1	Touch screen	7	12	Further research
2	Privacy	5	9	Yes
4	Mobility	4	16	Further research
3,5,9	Screen size	3	17	Yes

"Mobility" and "Touch Screen" are those two factors, which gained sixteen and twelve points respectively from Experiment 4 group on approving side. However, it is not clear enough how these two factors might be related to the stationary devices, used during Experiment 4 since users did not leave any other comments, concerning these factors, except for one user, who pointed out, that "it depends whether you play or work", regarding "Mobility". During discussion in focus groups this also was not been considered as affecting factors. Hence, these factors should be considered as factors for further investigation.

6.4.5 "User" related factors

Twelve factors have been pointed out during Experiment 3 (see Table 35). The most significant factor, as participants described it, was "Fear to be ashamed of playing game", gaining four points.

"Motivation" has been pointed out as another factor (3 points) lack of which could certainly decrease interest of participants. Lack of challenge ("Felt like an idiot – tasks too simple") gaining the same three points, indicates that participants need more complex tasks to resolve in order to feel more involved in what they are doing. For more details concerning Experiment 3 participants responses please see section 5.5.

Experiment 4 participants prioritised “Motivation”, “Feedback from the system” and “Learning (novelty)” as the most affecting them, giving to all three factors 19 points each (see Table 35).

Table 35. “User” section factors as seen by Experiment 3 and Experiment 4 participants

Experiment 3		Experiment 4		
Impact	This factor affects me	Disagree	Agree	Affects me
	User			
1	Fear to get addicted	14	8	No
1	Amount of efforts	4	17	Yes
1	Learning (novelty)	2	19	Yes
1	Fear to waste time	10	10	No
1	Not a gamer	17	6	No
1	Circumstances	7	3	No
1	Previous negative experience	15	2	No
2	Skills level match	7	9	Yes
2	Feedback from the system	5	19	Yes
3	Felt like an idiot - tasks too simple	14	9	No
3	Motivation	1	19	Yes
4	Fear to be ashamed of playing game	10	0	No

“Amount of efforts” factor was assigned 17 points, indicating that efforts applied by participants should be sufficient in order to feel interest to their Virtual Worlds activities.

“Fear to waste time” factor gained equally 10 points from both approving and disapproving sides and the equality of scores indicates that participants consider the possibility of improper use of time, though the time they spend on the tasks works towards completion of their assignments.

“Skills level match” factor (9 points) indicates, that participants are interested in such activities in Virtual World which adequately meet users’ level of utilising Virtual Worlds tools and instruments, not being too complex but at the same time satisfying users’ needs to adequately utilise their skills.

"Felt like an idiot – tasks are too simple" which gained 9 points as well lies closely to the "Skills level match", indicating the link between user's satisfaction of his activities and accomplishments in Virtual World and user's skills to perform well while doing those activities. This factor refers more to the task nature and complexity rather than to the participants' skills level.

"Not a gamer" gained 17 points on disapproval side, indicating that participants did not feel affected by the fact that they were not really computer gamers.

"Previous negative experience" (15 points) also did not affect participants, hence, they did not consider this factor as one of the critical ones.

Interesting to point, that "Fear to be ashamed of playing games" as a factor gained zero points amongst Experiment 4 group, whereas Experiment 3 participants considered this factor as significant, giving it highest 4 points. Such a difference in opinions most likely lies in cultural difference between Experiment 3 participants, recruited in Russia and Experiment 4 participants, who were residing in Britain. However, since the evaluation of the influence of the cultural differences was not the purpose of this research, that question remains open for further investigation.

6.4.6 Not affecting factors

Amongst 47 factors forming the framework, 32 factors (or 68.08%) were considered as affecting and 15 (31.91%) were considered as not affecting participants of Experiment 4. Table 36 summarises the factors, considered as not affecting participants in Experiment 4.

Table 36. Factors considered as "not affecting" by participants of Experiment 4

Experiment 3		Experiment 4		
Impact	This factor affects me	Disagree	Agree	Affects me
	Virtual World			
1	Commercial aspect	14	13	No
2	More emotions	9	9	No
3	Less linear	9	8	No
5	Real Life simulator	10	6	No
8	No Real Life or Wrong Type	6	6	No
	Avatar			

1	Closer to Real Life	12	11	No
1	Realism	12	11	No
1	Less control over avatar	12	8	No
	User			
1	Fear to get addicted	14	8	No
1	Fear to waste time	10	10	No
1	Not a gamer	17	6	No
1	Circumstances	7	3	No
1	Previous negative experience	15	2	No
3	Felt like an idiot - tasks too simple	14	9	No
4	Fear to be ashamed of playing game	10	0	No

The “User” related section of the framework received the highest number of not affecting factors (7 in total) amongst other sections. This section reflects the user related factors, which affect the users whilst they perform their activities in the Virtual World. In other words, the participants’ intrinsic characteristics, influencing their experience in VW are the reason for these factors to be considered as not affecting one. “Fear to get addicted” for instance, was considered important and affecting factor by the Experiment 3 group but Experiment 4 participants did not confirm that this factor is affecting them as well though it scored 8 points on approval side. “Fear to waste time” was the closest factor to be considered as affecting one, scoring equally 10 points on each approving and disapproving sides. As participants described this factor during focus group discussion, they had that concern, that they were wasting time during Experiment 4, which was conducted as a workshop for students, since they were not sure that the knowledge, gained during that workshop will be useful for them and applicable to their project. Participants also did not find that the tasks were too simple (“Felt like an idiot - tasks too simple” factor). In contrast, they were complaining that the whole idea is too complicated in terms of building technique and usability of the system and that it will take much more time than expected. Hence, this factor also was not thought as affecting one. It is needed to point that this factor relates also to the VW’s section, not solely in users’ intrinsic characteristics since users are affected by VW characteristics as well, such as variety of building options, convenience of the tools to use, etc. The fact, that users were not gamers (“Not a gamer”) did not affect participants, they

did not consider that lack of the gaming experience might decrease their performance. By “Circumstances” it is meant other conditions which might affect performance of participants, e.g. tiredness, not enough sleep prior night, etc. They are not intrinsic characteristics of the users, but since they have been identified within Experiment 3 and became a part of the framework, they were needed to be included in Experiment 4 as well. However, Experiment 4 participants did not prioritise this factor as affecting them. “Previous negative experience” with VW was not considered as a factor, affecting Experiment 4 group due to the fact that they did not have negative experience with this Virtual World according to their comments. “Fear to be ashamed of playing game” did not receive any scores from the Experiment 4 participants. They did not feel that playing games is something one should be ashamed of. In contrast, they provided with the comments, that game experience might help user to learn VW environment faster.

The “Virtual World” related factors received 5 points from Experiment 4 group brining this section to the second place by numbers of non-affecting factors. “Commercial aspect” factor gained 13 points on approval side and 14 points on disapproval which are quite close numbers, indicating, that this factor was not considered as affecting one just marginally. Experiment 3 participants found (one response) that if the VW they have used would have commercial application, using the Virtual World for retail, for instance, the use of the VW would be more sensible and the whole idea more attractive for users. Both parties of Experiment 4 group on each approval and disapproval sides voted almost equally. “More emotions” gained equally 9 points on each approval and disapproval sides, reflecting equal impact on Experiment 4 participants for having or not having more emotionally appealing VW environment. Participants of Experiment 4 group did not find the “Less linear” factor (8 points on the approval side) affecting them, considering that for structure building purposes the linearity of the system does not play a negative role. They also did not see the virtual world as a “Real Life simulator” since their activities in the VW did not require such a simulation. Participants rather viewed that virtual environment as a training spot for their university course project associated activities, not complaining about the “No Real Life or Wrong type” factor as well for the same reasons: users, who are involved in a certain kind of technical activity,

such as constructing a presentation pavilion, were not much concerned about real life features and options as Experiment 3 participants, for instance. Experiment 4 participants also did not find the virtual world as a “Wrong type” of environment since the VW was designed to provide the necessary basics to fulfil their building needs.

“Avatar” related factors “Closer to Real Life” and “Realism” are quite close in definition and both scored 11 approving points and hence, were not considered as affecting factors. In Experiment 3, however, participants pointed out the slight difference between them: by “Realism” it was meant the graphics resolution, which should be more supportive in representing the avatar in a more “real” way, whereas “Closer to Real Life” was explained as the wish to have an avatar “as close as possible to real human character”. Experiment 4 participants did not express any concerns about how the lack of those two characteristics might affect them in their activities since, as they pointed out, the realism in avatar appearance does not really help in building impressive structures in their virtual world. In Experiment 4, users also did not appreciate the option of the “Less control over avatars”, expressing the opposite opinion, that controlling an avatar was not that smooth, especially in terms of observing and approaching the building site. In contrast, they would prefer to be able to switch to “no avatar” mode, allowing for more flexible utilisation of building tools.

It is necessary to emphasise that non-affecting factors in this experiment means that these factors are not affecting users under these particular conditions, set up for this particular experiment. The fact that a certain number of factors are considered as non-affecting does not mean that they should be ignored as not deserving consideration since the experiment, similar to Experiment 4, can be repeated several times and each time results might be different, depending on test conditions, such as test environment, number of participants, their general and professional background, etc. Thus, Experiment 4, conducted for this set of data, indicates that this data does make sense for participants as affecting or not affecting them within certain limitations, outlined by the Experiment 4 test conditions. Non-affecting factors, evaluated by Experiment 4, indicate that Experiment 4 users disagree with

Experiment 3 participants in some matters, concerning how these factors affect this particular group of Experiment 4 participants under these particular test conditions.

6.4.7 Affecting factors

"Affecting" factors are presented in Table 37 indicating that these factors were considered by Experiment 4 participants as affecting while performing their activities in the VW.

Table 37. Factors considered as "affecting" by participants of Experiment 4

Experiment 3		Experiment 4		
Impact	This factor affects me	Disagree	Agree	Affects me
	Virtual World			
1	Clear goal outlined	4	18	Yes
1	Preview	1	15	Yes
1	More focused	6	18	Yes
1	Time limit	11	14	Yes
1	Scale	3	20	Yes
2	Clearer instructions	7	18	Yes
3	Faster	5	17	Yes
4	Real people behind	2	19	Yes
5	Hints from system	4	24	Yes
6	More real life	5	12	Yes
7	Graphics	5	20	Yes
8	Plot	12	18	Yes
8	Tasks	6	17	Yes
	Avatar			
1	Adjustable	5	18	Yes
1	More avatars	4	16	Yes
1	Communication	2	19	Yes
7	Not enough choices	11	15	Yes
13	Need association with my avatar	5	12	Yes
	Environment			
1	Weather	5	13	Yes
1	Being watched	9	13	Yes
2	Phone calls	7	12	Yes
2	Outdoors	3	14	Yes
16	Not disturbing	7	15	Yes

	Device			
4	Mobility	4	16	Yes
3,5,9	Screen size	3	17	Yes
1	Touch screen	7	12	Yes
2	Privacy	5	9	Yes
	User			
1	Amount of efforts	4	17	Yes
1	Learning (novelty)	2	19	Yes
2	Skills level match	7	9	Yes
2	Feedback from the system	5	19	Yes
3	Motivation	1	19	Yes

The fact that these factors were considered as affecting participants does not mean that they form a more valuable portion of the framework in comparison to non-affecting factors. It should be pointed out again that these factors are affecting participants only under the specific test conditions of Experiment 4, indicating the personal opinion of participants of the Experiment 4 group. Under different circumstances the results of this experiment might return different proportions of affecting and non-affecting factors.

6.5 Summary of Experiment 4 results

Experiment 4 indicated that its participants had different opinions about the factors affecting participants in Experiment 3. There could be several reasons for such differences, including different environments, both physical and virtual, different tasks proposed, different cohorts of people with different technical, educational and cultural backgrounds, which reflected in their answers during the focus group discussions and the survey. Analysis of the answers (see Table 36.) indicate that the differences occur mostly due to the different nature of the tasks proposed to participants of Experiment 4 as virtual structure building activities of their own choice in the sequence of actions of their own convenience. In Experiment 3, on the other hand, participants were asked to use the Sims 2 environment in a way suggested by the system itself, though that involved a good portion of constructing buildings as well (see section 4.3.3). Cultural differences between participants of both experiments 3 and 4, as they represented participants in Russia and England, might play a role as well, which could be illustrated by different reactions for factors

“Fear to waste time” and “Fear to be ashamed of playing game”. In Experiment 3 participants pointed these two factors as affecting them (see sections 5.5.1 and 5.5.2). Participants in Experiment 4 did not indicate that these two factors might affect them anyhow. Moreover, the factor “Fear to be ashamed playing games” received a portion of criticism from one participant, pointing out that it should not be a matter of concern for anyone around who could spot him playing games (see section 6.3.1).

At this moment, it can be only assumed that cultural difference is the main reason for such a difference in opinions about these two factors since there is not enough data to make such a conclusion. Neither experiment 3 nor 4 aimed to explore the influence of cultural difference on participants’ answers and thus, questions for interviews and the survey were not tailored to address that. However, it could be very interesting to continue to explore the topic in this direction in future research since it has a huge potential and might help to refine further development of the framework (see section 9.6).

7 Literature Review

7.1 Grounded Theory approach to literature review writing

The use of literature in grounded theory causes quite a debate among theorists. Though the necessity of the literature review remains undisputable, the stage of research when the review should be done and applied is the reason for disagreement. Most of the debate is stimulated by the use of the literature at the beginning of a grounded theory study. A formal literature review in grounded theory is delayed to prevent the researcher imposing existing theories and knowledge on the study results. Glaser and Strauss (1967) as founders of grounded theory admit, however, that researchers normally do not enter the research site with blank minds. Later, in 1992, Glaser reaffirmed the importance of avoiding literature reading in the core area of the study (Birks and Mills, 2011). Charmaz (2006) discussing the point of choosing the proper time for literature review also outlines that

> "…classic grounded theorists… advocate delaying the literature review until after completing the analysis. They do not want you to see your data through the lens of earlier ideas, often known as 'received theory'. The intended purpose of delaying the literature review is to avoid importing preconceived ideas and imposing them to your work." (Charmaz, 2006, p.165)

However, she also outlines that researchers very often have to visit library months earlier than the actual research starts, following requirements for research or grant proposal writing. In such a case, Charmaz suggests allowing the material gathered to "lie fallow" until the categories and relationships between them are developed (Charmaz, 2006). Birks and Mills (2011) propose the same approach, advising limiting the breadth and depth of the formal preliminary review to the necessary minimum.

Summarising the opinions and suggestions given above, it would be sensible to bring here Barney Glaser's (1998) stance on the topic to do preliminary literature review of the area of study, not letting other authors and opinions expressed by them to drag researcher into their predetermined and preconceived theories and ideas to

avoid contamination of researcher's own emerging theory and to delay the literature review in the substantive and related areas until the grounded theory is nearly sorted and completed. Following all these suggestions, the literature review on different aspects of user immersion is provided at this point (see also section 2).

7.2 Immersion as a topic of research

Before going into deep with the phenomenon under study, it is normally a good idea to give a detailed definition of the subject under discussion. What is immersion experience all about and how (if ever) could it be classified, highlighting different sides of the same phenomenon? Here, it is necessary to outline again to avoid further confusion, that the term "presence" in this section is used along with the term "immersion" to define user immersion as other researchers call it (see section 2.1).

In their seminal text "At the heart of it all" first published in 1997, Lombard and Ditton provide probably the most comprehensive description of different types of presence. The necessity of such exploration, as the authors outline, comes from quite unsystematised efforts, coming from researchers with different backgrounds from academia, industry and even government. Researchers need to understand psychological and physiological processes as they occur, how humans organise and interpret information in their environment. To accomplish that researchers often use mediated stimuli as a substitute for the non-mediated stimuli of interest and assume that their findings are applicable in both contexts. In the understanding of the authors, the assumption that non-mediated stimuli are exactly the same as mediated stimuli (i.e. presence inducing) might be wrong. Thus, better understanding of presence (immersion) will allow refining and improving the psychological theories. Researchers in media, for instance, need to understand how people are influenced by media presentations and what factors play roles in the process. Authors also point out that the phenomenon of presence (immersion) "has not yet been carefully explicated operationalized or studied" (p.4) and the work done in the area so far "was fragmented and unsystematic partly because people who are interested in presence come from many different fields, including communication, psychology, computer science, engineering, philosophy and the arts" (Lombard and Ditton,

1997, p.4). They conceptualise six forms of presence and before moving any further it is necessary to outline each of those forms.

7.2.1 Presence as social richness

Presence is viewed as sociable when it is used to interact with other people. Presence as social richness is related to two important concepts: intimacy and immediacy. "Interactants", as authors define persons who interact within an environment, vary such factors as "physical proximity, eye-contact, intimacy of conversation, amount of smiling" (p.7) to optimise the level of intimacy in communication. Thus, when the environment is friendly to social richness, it allows adjusting the settings for these variables and bringing the whole environment closer to the participants' needs.

This was reflected in participants' answers in experiments 2 and 3 of this research, when they outlined that they need more flexible control over environment and avatar customisation (see sections 4.2.7 and 4.3) since the control elements they had in the VWs of both experiments did not allow them to utilise their ideas and bring the environment closer to their needs, which affected their immersion experience, as was reflected in users' answers (see sections 4.2.7.1 – 4.2.7.3).

7.2.2 Presence as realism

This is the degree to which the medium can accurately reproduce real objects, events and people. The authors here put an emphasis on the importance of distinction of two key types of realism – social realism and perceptual realism. By social realism meant to what extent a media is "true to life" whilst representing such, reflecting events in non-mediated world. Presence as realism also includes perceptual realism which is separate element since it can occur in cases where social realism is low or does not exist at all, i.e. in science fiction films or scenes where objects and people can be represented with a high degree of "realism" which means how they are expected to be if they really exist. At the same time, the media material can be rich in social realism, for instance, in animated presentation, but perceptual realism might be low due to non-realistic representation of the image.

In this research, the perceptual realism was reflected in participants' answers in experiments 2 and 3 as a necessary element, the lack of which affected users'

immersion experience (see sections 4.2.7 and 5.1). Participants argued that the realism of the VW environment was somehow "not realistic enough" to get them to be involved in their activities and if the level of "realism" were higher, they would feel more immersed in the VW surroundings. Here is necessary to outline that by "realism" most likely they meant the perceptual realism, since the VWs used for experimentation in this research by definition were artificial and the social realism element was not expected to be high, if it ever exists in those environments. However, the direct question "Do you mean social or perceptual realism?" has not been proposed to participants who took part in this research.

7.2.3 Presence as transportation

Within this type of presence, Lombard and Ditton point to three types of transportation, outlining them as "You are there", "It is here" and "We are together". With the first type of transportation ("You are there") the person, no matter what type of participation he or she is involved in, oral or written narrative, phone conversation or TV programme is transported to another place. This concept is often linked to description of virtual reality, which is presented as an environment, capable of taking users to the "suspension of disbelief that they are in a world other than where their real bodies are located" (Slater and Usoh, 1993, p. 1). Here the authors are pointing out the difference between so-called "telepresence" and "virtual presence", pointing out that the former one is the presence on the remote site, which can be also a physical site, whilst the latter form of presence occurs in a virtual environment, though both types are quite close to each other from the user's perspective. Two factors have been identified in correlation with this type of presence – "departure" from a non-mediated environment and "arrival" in a mediated one, as the authors refer to the work of Kim (1996). Questionnaires, used by other researchers, such as Slater and Usoh in their work "Representations Systems, Perceptual Position and Presence in Immersive Virtual Environments" published in 1993 explored the subject of transportation presence, trying to assess the degree of such.

In this research, participants were also asked about their feeling of being "there" and how they would assess that phenomenon – being more "here" or "there" in

terms of “real” (non-mediated) world and “virtual” (mediated) or do they feel transported finally to the virtual world while performing their activities or still staying in “real world” where they are located physically (see sections 4.2.7 and 4.3.5).

“It is Here” is another form of presence of this class, which brings the objects to the media user’s environment. Lombard in his earlier work “Direct responses to people on the screen” (1995) experimented with a group of participants, watching video on TV screens of different sizes. Apart from the influence of the screen size on users’ responses, Lombard points out, that the reaction of the viewers to what they see on the screen is of “direct nature” or in other words, “identical to responses in non-mediated contexts” (Lombard, 1995, p. 316). Another important conclusion that the author made is that those direct responses from viewings of television were not limited to “relatively primitive” stimuli such as colours, shapes, novelty or movements. In contrast, direct responses occur to the most complex types of stimuli such as other people and interpersonal distance, which has no intuitive counterpart in television settings. That means responses to television that mimic responses to the non-mediated scenes suggest that television viewers respond not only to symbolic images but directly to the events as if they (events) are “here” at immediate presence (Lombard, 1995).

“We are Together” as a third form of transportation relates more closely to video conferencing and virtual reality. As Lombard and Ditton (1997) point out, the pioneers of virtual reality technology viewed this at that time emerging technology as having a great potential as collaborative space, where people could “gather together” in one room being in fact geographically dispersed in a real world. This refers closely to what Slater *et al.* (2009) called “correlational presence”, when users in a virtual world feel the presence of other users, reacting to their body language, which constitutes one of the factors affecting their immersion experience (see section 7.2).

In this research, users reported similar emotions when appearing in the lonely and abandoned virtual campus of Carlton University, used in Experiment 2. The reaction of users indicated that they were certainly missing this sort of phenomenon,

not having anyone around, even if they did not intend to communicate with other users in the campus centre, they still expressed quite a strong feeling that "they would not feel so lonely and abandoned" if there were other people around (see section 4.2.7 for more).

Lanier and Biocca (1992) in their paper "An insider's view of the future of virtual reality" bring a very interesting dialogue between these two authors, discussing how in their opinion the future of virtual reality could be outlined. Answering this question, Jaron Lanier, as one of the researchers who brought the phenomenon and terminology of virtual reality to public, said the following:

> "Well, it's striking to me if you read the rhetoric associated with each introduction of other media technologies in the past, it seems as though virtual reality was the thing being described…There's a sort of …ability to be free of physical constraints on the sources of experience… But I think the idea that technology would be a route to cope with that condition is uniquely Western and goes back a long way…So, now the question is whether virtual reality comes the closest to realising this. I think, in a sense it can, but only if there's a culture of use that grows up along with it. It's very important to understand that the technology itself doesn't necessarily have any cultural or spiritual quality. It has cultural or spiritual potential, but can only be realised by cultural development that springs alongside it." (p. 156)

The quotation is quite long but it is left as close as possible to the original since it contains vital points, characterising VR as a collaborative space, which later Lombard and Ditton called the "We are together" phenomenon. It is quite interesting to point out here that Lanier back in 1992 had already foreseen the potential limitations and even danger for misuse of the technology and outlined necessary conditions under which the full richness of virtual reality could be utilised. Having a look at VR progression now in 2016 it can be noticed that his words were indeed prophetic.

7.2.4 Presence as immersion

Presence as immersion is the fourth form of presence, described by Lombard and Ditton (1997). Here it is necessary to point out that the term "immersion" is used here as a process of "dipping" the user into an immersive virtual environment, provided by dedicated equipment such as a head mounted display, head phones and gloves. This definition relates closely to Slater and Usoh's (1993) definition of what should be understood by what other researchers, such as Cairns *et al.* (2006), call "immersion". Lombard and Ditton describe this type of immersion as it happens to somebody, when a participant is isolated from the real world by "immersive" equipment, such as HMD, headphones and gloves. In this case, the physical isolation of the participant plays a vital role in helping her or him to achieve the mental state of presence. Referring to the work of Biocca and Levy of 1995, authors compare this sort of experience to the case of "reading a book in a quiet corner", when the "reader is swallowed by the story" but the book, like those virtual reality elements, covers all the senses of the reader, providing the necessary prerequisites.

Loomis *et al.* (1999) describing the potential of head mounted displays back in 1999, when this technology was at its beginning, pointing out that this sort of equipment or system for immersive virtual environment had certain advantages over highly immersive environments, such as CAVE systems, due to lower cost and practically the same immersive capability. Head mounted displays also have an advantage over "traditional" 2D displays since they provide more immersive VR, which potentially might lead to more immersion or presence experience (see also sections 2.2.3 and 2.2.4).

In this research, those types of specialised "immersive" equipment were not used. Participants in all experiments utilised regular 2D computer monitors or 7-inch tablet PCs (see sections 4.1.5, 4.2.4, 4.3.2 and 6.2). The reason for such a decision lies in the nature of this research which aims to explore the factors affecting immersion in regular 2D displays in lab and field environments (see section 1.2).

7.2.5 Presence as social actor within medium

This is the fifth type of presence, identified by Lombard and Ditton (1997). They bring quite an interesting example of this class of presence, whilst referring to the

fundamental work of Horton *et al.*, "Mass Communication and Para-social Interaction: Observation on Intimacy at a Distance", published in 1956. Back in the 1950s, when virtual worlds or any forms of virtual reality were not really on the agenda yet, the phenomenon of presence already had drawn the attention of the researchers. Horton *et al.* (1956) point out that new mass media, such as radio, television and cinema (however, strictly speaking in the 1950s, cinema could not be called "new" any more) give the illusion of face-to-face communication and relationship with the performer. Here, "performer" means the person "behind the screen", in a radio or TV studio or participating as an actor in a film. The spectator views the performer as if the performer is "in the circle of one's peers" (p.215) or in other words in contact with the spectator as normally happens in real life. This sort of relationship between them Horton *et al.* called "para-social relationship" (p.215).

In this kind of interaction the performer uses the form of direct address to the spectator in order to achieve this subtle connection between them. This "simulacrum of conversational give and talk" (p.215) is called para-social interaction. Radio and television created quite a suitable environment for such an interaction, bringing to the surface another type of media performer, "whose existence is the function of the media themselves" (p.216). Those are quizmasters, announcers, show-busyness interviewers, who are, as a rule, not prominent in any social spheres beyond the media and identified them as "personae" (p.216).

Lombard and Ditton (1997) point out, while referring to Horton *et al.*'s (1956) work, that people respond to such an interaction and even talk to presenters on the television screen even though it is not logical to do so. The mediated nature in such a case is ignored and "the media personality is incorrectly perceived as a social actor" (p.12). Furthermore, such an illogical mediated "persona" is not only applicable to the television. Virtual actors, guiding users through computer interfaces, the "Tamagotchi" character, which was quite popular at that time or "intelligent computer agents of the future" (p.12), as Lombard and Ditton defined, serve as a "social interface" between user and mediated environment.

In this research, participants in Experiment 2 faced such situations, when wandering around Carlton Virtual they were trying to interact with avatar-bots, whose function was initially intended to be welcoming and greeting people, but such a functionality had not been added yet to the virtual world of Carlton at the time of Experiment 2. This is a good indication, which has been confirmed by participants' answers, that users were so eager to communicate with somebody in "that empty and abandoned place" that they were trying to do so even with bots, not actually knowing that they are just bots, not "real" avatars with real people behind them (see sections 4.2.2 and 4.2.7).

7.2.6 Presence as medium as social actor

This type of presence is described by Lombard and Ditton (1997) as taking place when media users respond to the medium itself rather than media entities such as people or computer-generated characters. The reason for this phenomenon is that computers, for instance, are using natural language, interact in real time and act as a traditional social role actor (bank teller or teacher), which normally used to be a prerogative of human beings, exclusively. It is applicable not only to computers as a medium, but to television as well. Viewers react to what they see on television not only when a TV presenter is communicating with them, but they regard the television itself as a communicative partner. In this example, users, as the authors point out, ignore the "mediated nature of a communication experience" (p. 14), though it seems to be not logical.

In this research, participants demonstrated some such examples in Experiment 2, when they were trying to communicate with different objects, such as signs, hoping that they were interactive or information posts, equipped with menus or buttons to get a response when pressed. However, it is necessary to say here that this kind of attempt at interactions did not prevail in the participants' activities to find somebody in Carleton Virtual to communicate with. Mostly, as already outlined in section 7.2.5, users were willing to communicate preferably with avatars with real people behind them.

7.3 Witmer and Signer's approach

Witmer and Singer (1998) link the "sense of presence" to the effectiveness of a virtual environment and define presence as the "subjective experience of being in one place or environment, even when one is physically situated in another" (p.225), highlighting the questions of what actually forms the phenomenon and which factors might affect it. The authors identify three stages or degrees of presence: involvement, immersion and presence.

Involvement is defined as "a psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events" (p. 227). Involvement, as the authors point out, depends on how much significance the user attaches to the stimuli. The more they focus on the activities or events in a VR, the more they feel involved. In contrast, if users are preoccupied by real-life problems or focused on the activities outside of the VR, involvement drops accordingly.

Immersion, according to Witmer and Singer (1998) is "a psychological state characterised by perceiving oneself to be enveloped by, included in and interacting with the environment that provides a continuous stream of stimuli and experiences" (p.227). The level of presence depends on the level of immersion, produced by the VR. That level can be affected by factors of isolation from the physical environment, perception of self-inclusion in the VR.

Both involvement and immersion are necessary for achieving a state of presence, as these authors argue. A high level of involvement can be achieved not only in a VR but also when reading books or watching television, while immersion depends on perceiving yourself as a part of the VR. Fully immersed users perceive that they are interacting directly with the environment, feeling that they are actually a part of it.

Authors also outline a number of factors affecting presence. They are grouped into four major groups: control factors, sensory factors, distraction factors and realism factors. Within the categories, factors almost certainly interact; they may also interact across categories. Near each factor (see Table 38), outlined by Witmer and

Singer, there is a comment indicating whether or not this factor has been reflected in this research findings.

Table 38. Factors hypothesized to contribute to a Sense of Presence (Witmer and Signer, 1998)

Control factors	Reflected	Sensory factors	Reflected	Distraction factors	Reflected	Realism factors	Reflected
Degree of control	Yes	Sensory modality	No	Isolation	Partly	Scene realism	Yes
Immediacy of control	Yes	Environmental richness	Yes	Selective attention	Yes	Information consistent with objective world	Yes
Anticipation of events	Yes	Multimodal presentation	No	Interface awareness	Yes	Meaningfulness of experience	Yes
Mode of control	Yes	Consistency of multimodal information	No			Separation anxiety/ disorientation	No
Physical environment modifiability	Yes	Degree of movement perception	No				
		Active search	Partly				

7.3.1 Control factors

Degree of control: The more control a person has over the task or in interacting with the VR, the greater the experience of presence. Reflected in experiments 2 and 3: participants expressed the need for more control over the task elements.

Immediacy of control: Noticeable delays between the action and the result negatively affect the sense of presence in a VR. Reflected in Experiment 2: participants outlined the effect of latency, complaining about the delays between their actions and the system's response.

Anticipation of events: Participants experience a greater sense of presence if they can predict or foresee the future steps in VR activities. Reflected in Experiment 3: participants expressed a need for preview of further actions in VR.

Mode of control: Presence may be enhanced if users' interactions with that environment are performed in a natural way or if they are well-practiced. Reflected in experiments 2 and 3: participants complained that they were not interacting with the environment in preferable, natural way and needed to adjust their manners to that particular environment.

Physical environment modifiability: Presence should increase with one's ability to modify physical objects in that environment increases. Reflected in experiments 2 and 3: participants outlined that they need to be able to modify objects in the VR with more flexibility and more options.

7.3.2 Sensory factors

Sensory modality: A hierarchy of modalities may influence how much presence is experienced (e.g. visual, audio etc.). Visual information perhaps plays a greater role than the others. Not reflected in any of the experiments: participants did not express any concerns that they lack other than visual and audio channels of communication with the VR.

Environmental richness: An environment that contains a great deal of information to stimulate the senses should generate a strong sense of presence. Reflected in experiments 2 and 3: participants expressed the wish to have the whole VR with greater details, having more objects to interact with.

Multimodal presentation: Complete and coherent senses stimulation enhances presence experience (e.g. normal movement with added kinaesthetic motion and proprioceptive feedback) should enhance presence. Not reflected: due to the nature of the experimentation – video and audio channels were used in all four experiments; participants did not express any need to add more.

Consistency of multimodal information: The information through all modalities should describe the same objective world. If there is a mismatch among information

via different channels of information, presence may be diminished. Not reflected: in all experiments audio information corresponded to the visual information.

Degree of movement perception: Presence can be enhanced if the observer perceives self-movement through the VR, and to the extent that objects' movements appear relative to the observer. Not reflected: none of experiments had a goal to explore the relationship between self-movement and immersion experience.

Active search: An environment, permitting users to control the relationship of their sensors to the environment enhances presence (e.g. to modify their viewpoint or to reposition their head to affect binaural hearing, or to search the environment haptically). Reflected partly: the VRs used for all four experiments allowed modification of the users' viewpoint, but did not allow to change hearing. Haptic devices were not used. Users in Experiment 3 expressed the need to have more options for a view change.

7.3.3 Distraction factors

Isolation: Devices that isolate users from their actual, physical environment may increase presence in a VE. For example, a head-mounted display that isolates users from the real world may increase presence in the VE in comparison to a standard two-dimensional, flat screen display. Headphones that reduce local ambient noise could also increase presence even when no VE-associated auditory input is provided. Reflected partly: headphones are used in Experiment 2, but only if the participant did not object to that. Some participants did, saying that they don't need that. Comparison of the results of users with headphones and users without them did not return any significant differences in their immersion experience as they described it during the interviews.

Selective attention: The observer's willingness or ability to focus on the VE stimuli and to ignore distractions that are external to the VE should increase the amount of presence experienced in that environment. Reflected in all four experiments: those participants who expressed genuine interest in different virtual environments, used in all experiments, demonstrated better performance and willingness to stay longer in the environments than was even needed, having a great deal of interest in "what's happening" there. Interview answers also supported this observation since these

participants shared more feelings and seemed to be more involved in what they were doing.

Interface awareness: An unnatural and clumsy interface if used with the virtual environment might decrease the immersion experience of the users. Reflected in all four experiments: numerous complaints from participants during experiments, that the interfaces they were using were not really "interfaces" designed to help users to interact with virtual worlds. Participants expressed different opinions, pointing out different aspects of the interfaces, such as awkward control or poor graphics (again, compared to what they utilised previously in games or other activities in VR), saying, that they would certainly increase this or that option of the control or have scenery drawn better with more details, etc.

7.3.4 Realism factors

Scene realism: By scene realism it should be understood such components as scene content, texture, resolution, light sources, field of view, etc. All together, they create a realistic image, which might increase presence. Scene realism does not require real-world content, the content used might stay artificial and imaginary, but providing continuity and connectedness of stimuli. Reflected in Experiment 3 and partly in Experiment 2: participants complained that the whole scenery was not "real and convincing", though they had less objections to the resolution itself. In Experiment 3, mostly concerns were raised due to the unnatural "bird's view" which some participants did not like. In Experiment 2, the concern was raised that buildings were drawn in an unnatural way. On my question about what it means, the answer was that "it should be more convincing and nicer done".

Consistency of information with the objective world: The virtual world should reflect the real world as much as possible and that might increase the presence. Reflected in experiments 2 and 3: participants pointed out in Experiment 2 that though the virtual world's objects looked nice enough, they did not resemble those in real life and everything looked too "artificial", as one user mentioned in interview. In Experiment 3, users were complaining that the city "did not look like the real city", lacking several key buildings like school, shops, etc. and if they could

redo the city layout, they would certainly add more objects to bring the whole landscape closer to reality.

Meaningfulness of experience: If the whole virtual world experience is meaningful to the participant, the sense of presence might increase. Meaningfulness might relate to other factors such as motivation to participate in actions in the VR or motivation to learn or building up on the user's previous experience. Reflected in all four experiments: participants who expressed stronger motivation for or interest in the activities or to the whole idea seemed to be more immersed in the environment, demonstrating the wish and ability to explore "hidden corners", tasks or sub-tasks which were not really required to be performed. That was reflected in their interview answers, when such participants showed a good enthusiasm and willingness to go deeper into the topic.

Separation anxiety / disorientation: VE users may experience disorientation or anxiety when returning from the VE to the real world. The amount of this disorientation may increase as the presence experienced in the VE increases. Not reflected: during all of the four experiments, participants did not report any disorientation once they "returned" to the real world. This can be a result of lack of immersion, though some participants demonstrated a wish to stay in the VR more than the technical capabilities of the device allowed, running out of tablet PC battery time in Experiment 3.

Furthermore, after the analysis of all factors affecting immersion (presence), Witmer and Singer (1998) presented the questionnaires which they used for presence-measuring in virtual environments. The questionnaire is divided into two portions – the presence questionnaire (PQ) that serves the measuring task, and the immersive tendencies questionnaire (ITQ) to measure differences in the tendencies of individuals to experience presence.

7.3.5 Criticism on Witmer and Signer's approach

Witmer and Singer's approach received criticism from Mel Slater (1999) who defined factors, evaluated by the authors (i.e. control factors, sensory factors, realism factors and distraction factors) as too subjective, arguing that the

questionnaires proposed by Witmer and Singer elicit opinions rather than providing the objective overview of the phenomenon (Slater, 1999).

In earlier work, Slater and Wilbour (1997) defined that presence includes three aspects:

- The sense of "being there" in the virtual environment
- The extent to which the virtual environment "dominates" the physical environment or in other words, the extent to which participants will be responding to the virtual rather than the physical environment
- The extent to which participants remember the virtual environment as a "place" visited rather than just seeing computer-generated images.

The authors argue that the main purpose of any research about presence in VR is to maximise that experience and to evaluate which characteristics of the system will influence such an increase. By the "system" they mean not only the technical aspects of computer hardware and software, but also the characteristics of the VR itself, how the system responds to users' actions and very importantly users' self-representation in the VR. This relationship between the subjective and behavioural phenomenon that Slater and Wilbour called "presence" and the degree of system immersion was regarded by these authors as a valid scientific problem. They also view presence as an increasing function of immersion, "mediated through two filters… the task context and the perceptual requirements of the individual" (Slater and Wilbour, 1997, p.5). The extent to which the scenario of activities the participant needs to follow in the VR, absorbs him or her and defines the chances of presence to be higher or lower. This theory was confirmed by the results of this research in experiments 2 and 3, where participants have expressed concerns about the plots that the virtual worlds provided to them as a sequence of activities, finding that the whole idea sometimes was not "catchy enough" (see sections 4.2.7 and 5.1). Here it is quite important to remind again that these authors use the term "immersion" as a technical aspect of the system, the degree or extent to which a "display system can deliver an inclusive, extensive, surrounding and vivid illusion of virtual environment to a participant" (Slater and Wilbour, 1997, p.1), which

differs from the terminology used in this research, where immersion is a psychological state of mind (see also section 2.1).

7.4 Other authors who studied immersion (presence)

Jennett *et al*. (2008) experimented within non-mobile VR environments and the user's goal was clearly identified: to find a hidden object or to play predefined games. In games or, for instance, training simulators, the most immersed users, as indicated by the experiments' results, demonstrated better performance. (Jennett *et al*., 2008; Slater *et al*., 2009). However, there is also the "less is more" approach. Gaps and omissions stimulate engagement (Pausch and Proffitt, 1997) since the reader fills the gaps of what happens between each panel of the illustrated story (Cairns *et al*., 2006). But how much immersion would be enough and which factors can possibly affect the immersion experience? In previous experiments, researchers put emphasis on different factors that might affect immersion experience in a virtual world. Bangay and Preston (1998), for instance, specify excitement of the experience, comfort of peripherals and environment during the experience, quality of the sound and images and age of participants as factors influencing the effectiveness of immersion in a virtual reality environment. Mount *et al.* (2009) devise their affecting factors rather like themes, e.g. the learning activity, representation of self, interaction with others, etc.

As described in (Slater *et al*., 2009), immersion experience can be affected by technical factors, e.g. vividness of the graphics, wide field of view, surround sound, haptic feedback, etc. However, the possibility to communicate with other people in a virtual world and to see their reaction to that communication seem to play a vital role (Warburton, 2009). '*I could feel the "real class" when I saw bunch of you gathering at the outside of the ground floor. I felt that finally I would meet all my classmates (even though it was not real)*' – this is how one of participants commented on his feelings after an experiment described by Carr and Oliver (2009).

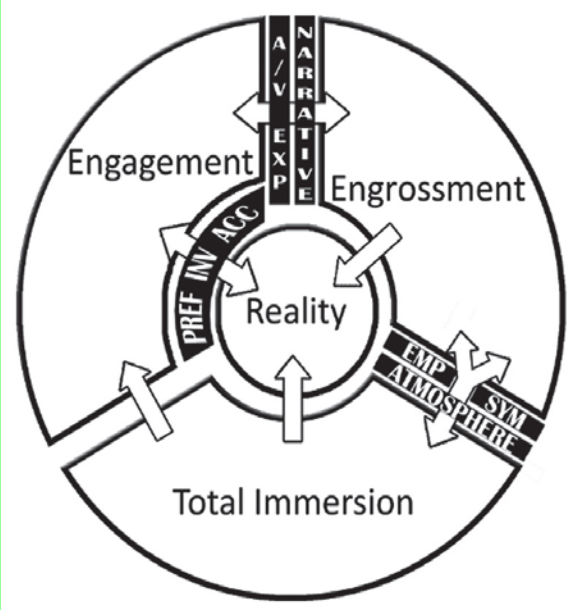
Correlation between a user's activities and the feedback from other users also might affect immersion experience. Correlational presence as it has been described by Slater *et al.* (2009) is a phenomenon when the user can see the visible reaction of other people to his actions, e.g. nodding, turning heads and making gestures. That

brings the user the feeling of genuine interaction with other people. Whilst in the real world those symbols of interaction play their important role in the background, in a virtual world they might play a greater role due to the lack of body language visibility on avatars (Slater *et al*., 2009). Correlational presence, as common sense might suggest, depends greatly on the number of users in a virtual world which can potentially be involved in such an interaction. These two aspects – communication and correlational presence – play a vital role in achieving immersion experience.

Another approach to explore immersion was demonstrated by Bjorner *et al.* (2016), in their study of how spectators experience immersion in 3D short film in contrast to exploring immersion in a 3D virtual environment. The short film was developed by the authors for this particular purpose to see how distraction factors might affect users' experience. Their study bears the main research question formulated as "how can we describe and measure obstacles to narrative immersion in a film experience designed to achieve total immersion?" (p.102). Since the main objective sounds quite complex, the authors divided it into three sub-questions:

- What obstacles can be found in such an experience and how they are interrelated?
- Why distractors cause viewers to drop immersion at some stages but not at others?
- Do distractions affect viewers individually or in groups?

To address these questions authors propose a Wheel of Immersion, a graphical representation of the framework that focuses on the narrative experience and its story-related features (see Figure 19).



Obstacles:
- PREF: Preference
- INV: Investment
- ACC: Access
- NARRATIVE: Narrative
- A/V EXP: A/V expectation
- EMP: Empathy
- SYM: Sympathy
- ATMOSPHERE: Atmosphere

Figure 19. The Wheel of Immersion (Bjorner *et al*., 2016)

The main idea of the Wheel of Immersion is that participants go through a dynamic progression of different levels of immersion by overcoming obstacles to narrative processing. The wheel is divided into four levels: (own) Reality, Engagement, Engrossment and Total immersion. Those different levels represent the degree of the user's immersion and how he or she is aware of the surroundings in the physical world. Arrows point at other levels potentially achievable by the user from his current level. When a user is on the level of engagement, he or she can either return to the level of reality or progress further to the level of engrossment. However, the user cannot reach the level of total immersion by directly bypassing the level of engrossment.

The research findings indicated that a user's distraction did not depend on whether the experiment was conducted individually or in a group. The majority of distractors, according to the authors, demonstrated distraction at a certain period of time of the film viewing (Bjorner *et al*., 2016). The distraction point, as the authors outline, was evaluated by timing and filming the whole process, when "[participants] were forced into a state of reality by the loud, frequent bell sound and colour image" (p. 115). Here, it is not too clear, however, what particular role the wheel was playing in the results analysis and how it helped to make research

conclusions, though overall it seems to be a good instrument to highlight different aspects of immersion and in particular, to indicate how different states of immersion can merge into each other.

Another example of a framework intended to help 3D virtual environments development was proposed by Catanese *et al.* (2011). It is a framework for developers, consisting of several open source software components designed to meet the VR development requirements and to ease the efforts of VR creators (see Figure 20).

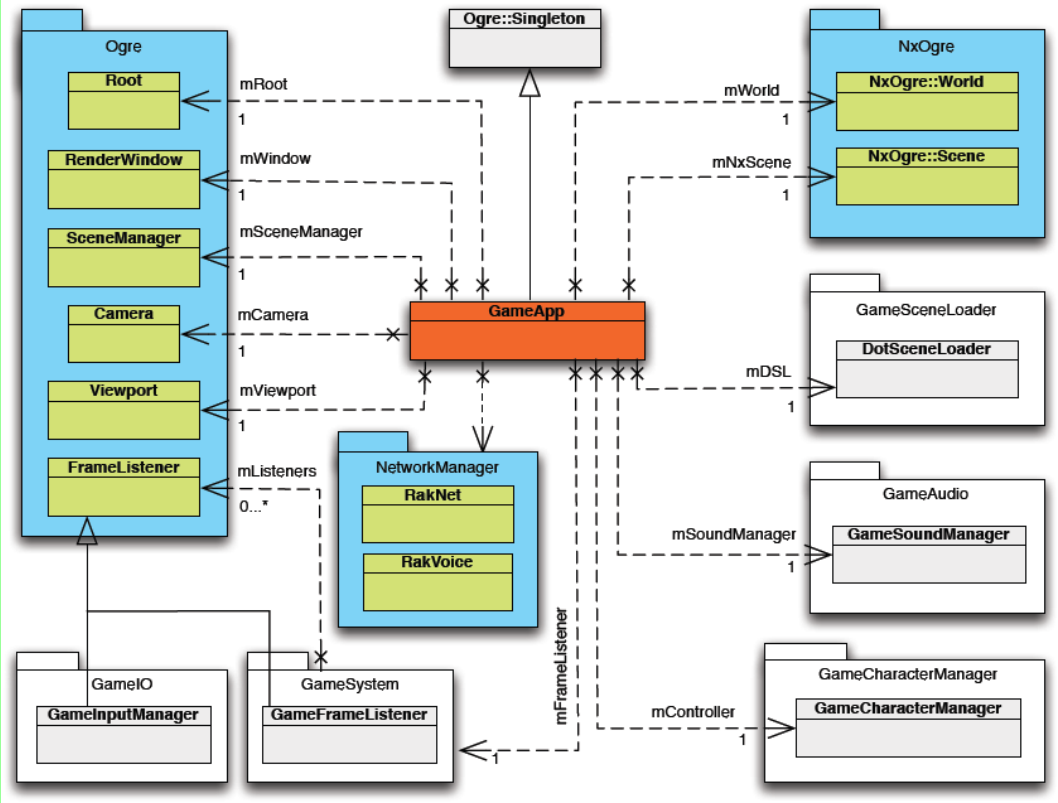


Figure 20. The structure of the framework, presented by Catanese *et al.* (2011)

However, as can be seen from Figure 20, this framework addresses only the technical matters of VR development, not serving as a tool for immersion factor evaluation which is equally important for virtual world designers when they intend to develop a truly immersive environment for users.

8 Comparisons of the findings with pre-existing studies

In this chapter the comparison between existing research on immersion and the proposed framework is presented. Findings of existing research are placed against this research's outcomes to show the correlation between them.

Several definitions concerning the nature of immersion, provided by Lombard and Ditton (1997), for instance, were reflected in the experimentation phase of this research, as outlined in corresponding sections:

Presence as social richness (see section 7.2.1)

This type of presence was reflected in experiments 2 and 3, being reported by participants as the need for more flexible control over environment and avatar customisation.

Presence as realism (see section 7.2.2)

The perceptual realism was identified by participants in experiments 2 and 3 as an element which could increase and improve immersion experience since it relates to the realism of a virtual world in its perceptual meaning.

Presence as transportation (see section 7.2.3)

Participants pointed out in experiments 2 and 3 that the lack of sense of "being there" was not of enough level while in these virtual worlds and that decreased the level of immersion, especially concerning correlational presence in Experiment 2, where some of the participants reported the feeling of loneliness in the Carleton Virtual due to lack of population (see section 4.2.7).

Presence as immersion (see section 7.2.4)

This type of presence relates to the "immersiveness" of the virtual environment as an ability to provide an environment where users could feel immersed. Here it is necessary to clarify again that "immersion" in this sense is not the phenomenon which is under research in this study but rather technical characteristics of the system. As such an environment is normally provided by highly immersive

equipment such as head mounted displays or even CAVE rooms, this type of user immersion was not reflected in the present research.

Presence as social actor within medium (see section 7.2.5)

Participants in Experiment 2 reflected in their answers that they were trying to interact with bot-avatars while in the Carleton virtual world, thinking they were "real" avatars with real people behind them, able to respond and maintain conversations.

Presence as medium as social actor (see section 7.2.6)

Participants in Experiment 2 were trying to communicate with unanimated objects such as signs, information posts, etc. hoping for some response from them due to the lack of any communication in this virtual environment.

As can be seen, this research's findings have confirmation in Lombard and Ditton's (1997) work in general. The proposed framework goes, however, into more details, presenting factors of influence ranked by impact, which seek to benefit virtual world builders.

8.1 Witmer and Signer's Framework

Witmer and Singer's (1998) factors, as already discussed in section 7.3, have also been reflected/confirmed in this study, as indicated in Table 38. Table 39 indicates how these findings would be plotted against the proposed framework factors, identified in this research.

Table 39. Proposed framework factors and their comparisons to Witmer and Signer's (1998) framework

Proposed framework			**Witmer and Signer's framework**
Impact	***Section of the framework and its factors***	***Explanation***	***Corresponding factor***
	Virtual World	**The in-world, as opposite to real world**	**Factor**
1	Clear goal outlined	The goal of scenario is not clear	Meaningfulness of experience

	Commercial aspect	Options to make money is needed	Not reflected
	Preview	Preview of next step is needed	Anticipation of events
	More focused	More objective plot is needed	Meaningfulness of experience
	Time limit	Time limit is needed to avoid excessive use by kids	Not reflected
	Scale	The scale is too limited	Physical environment modifiability
2	More emotions	The plot needs to involve more emotions	Meaningfulness of experience
	Clearer instructions	Instructions from the system are not clear	Meaningfulness of experience
3	Less linear	The events flow is too predictable	Meaningfulness of experience
	Faster	The events flow is too slow	Meaningfulness of experience
4	Real people	Real people behind avatars are needed	Information consistent with objective world
5	RL simulator	VW is viewed as life simulator	Not reflected
	Hints from system	More hints from the system are needed	Anticipation of events
6	More real life	VW is needed to be closer to realities	Scene realism
7	Graphics	Graphics require improvements	Environmental richness
8	Plot	Plot to be more engaging	Meaningfulness of experience
	Tasks	Tasks in VW should be more interesting	Meaningfulness of experience
	No RL or Wrong Type	The Sims is a wrong type of VW for these users	Not reflected

Impact	Avatar	Graphical representation of user	Factor
1	Closer to Real Life	Avatar is too unreal and awkward	Degree, Immediacy and Mode of control
	Realism	More realistic image is needed	Scene realism
	Adjustable	More flexibility in avatar customisation	Physical environment modifiability
	More avatars	Larger avatar population in VW	Environmental richness
	Less control over avatar	More freedom for avatar in actions	Degree of control
	Communication	Ability to communicate to own avatar	Not reflected
7	Not enough choices	More avatar choices	Environmental richness
13	Need association	Users need association with their avatars	Not reflected
Impact	**Environment**	**The real-world environment**	**Factor**
1	Weather	Weather elements, such as rain, sunshine, etc.	Selective attention
	Being watched	Fear of being observed by other people in the real world while participating in the experiment	Selective attention
2	Phone calls	Incoming phone calls to the participant's phone	Selective attention
	Outdoors	Being out of building, on open space such as park, street while using tablet PC for experiment	Selective attention
16	No disturbance	The real-world environment does not disturb users in any aspect	Selective attention

Impact	Device	Tablet PC	Factor
1	Touch screen	This user does not like touch screens	Not reflected
2	Privacy	Users found privacy more achievable on tablet PC than on a desktop	Not reflected
4	Mobility	Users found mobility of tablet PC as a convenient option	Not reflected
3	Screen size (Positive)	A small 7” screen size is considered as a plus	Not reflected
5	Screen size (Negative)	A small 7” screen size is considered as a minus	Not reflected
9	Screen size (Neutral)	A small 7” screen size is considered as neither plus nor minus	Not reflected
Impact	**User**	**A person, participating in experiment**	**Factor**
1	Fear to be ashamed of playing game	User considered playing “games” shameful	Not reflected
	Motivation	More motivation is needed to do activities in VW	Not reflected
	Felt like an idiot - tasks	Tasks are too simple	Not reflected
	Feedback from the system	More feedback is needed from the system	Not reflected
	Skills level match	User’s skills level should be matching the complexity of the tasks in VW	Not reflected
	Negative experience with Sims	Previous negative experience with Sims	Not reflected
	Circumstances	Personal circumstances, preventing the user from	Not reflected

		being involved in what the user is doing	
2	Not a gamer	User is not a gamer and does not like computer games	Not reflected
	Fear to waste time	Playing computer games considered to be a waste of time	Not reflected
3	Learning (novelty)	Need novelty in activities and learning opportunities	Not reflected
	Amount of efforts	Amount of user's efforts should be sufficient to feel satisfaction	Not reflected
4	Fear to get addicted	Due to previous experience and / or nature of these users they expressed some fear that they might get addicted to what they were doing in experiment	Not reflected

As can be seen from Table 39, Witmer and Signer's factors cover the corresponding areas of the proposed framework: "Virtual World", "Avatar" and "Environment" (physical). The "Device" and "User" areas of the proposed framework do not have corresponding coverage in Witmer and Signer's concept. Whereas the "Device" area is more concerned about technical aspects, trying to address questions about how a tablet PC would serve as an immersive mobile system for users (see section 2.3), the "User" area addresses questions about the user's emotions, feelings, background, experience or in other words, his "inner world" and how variables of that world help or prevent his or her immersion experience in a virtual world.

As a result of this comparison and analysis of how the proposed framework corresponds and adds to Witmer and Signer's work, all non-reflected factors can be combined into new categories, representing areas of the proposed framework. These new categories are: "Virtual World suitability", "Avatar adjustability", "Device specifications" and "User's intrinsic characteristics". These new findings add to Witmer and Signer's existing work, complementing their characteristics and

factors and forming a new, improved framework with broader and more categorised factors of influence, which are proposed to help virtual world developers to achieve immersive virtual environments.

8.2 Brown and Cairn's investigation on immersion

Brown and Cairns (2004) proposed several stages of a user's psychological state which occurs in the user during activities in a virtual world. The authors outline those stages as engagement, engrossment and total immersion, applying grounded theory to create robust divisions among these three levels. The authors argue that total immersion is difficult to achieve and the user needs to break through certain barriers, which can be viewed from both human and system perspectives (Brown and Cairns, 2004). Brown and Cairns's idea of barriers could be described as a process of breaking though the different layers, which are initially "wrapping" the user (as illustrated in Figure 21).

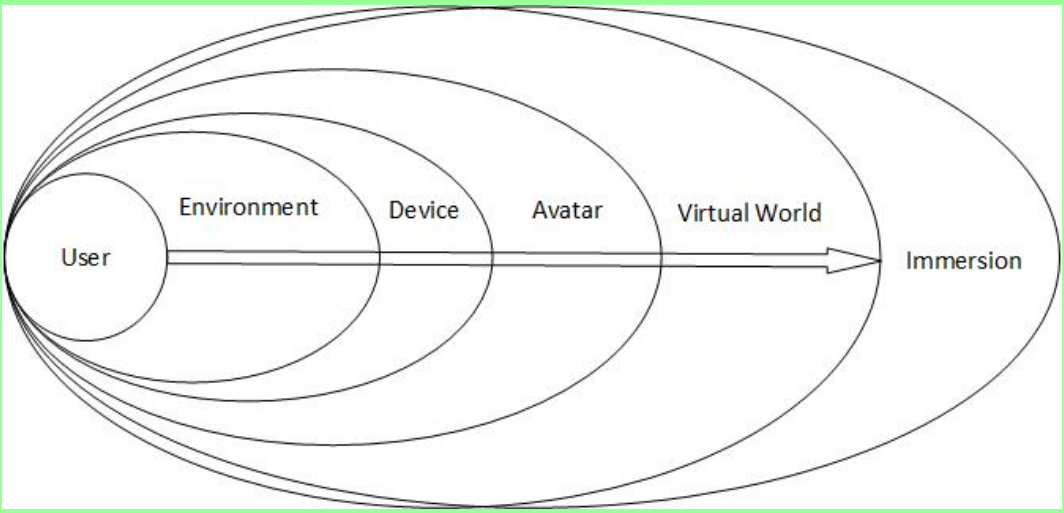


Figure 21. Onion layers wrapping up the user on the way to immersion

Each of these extrinsic areas (i.e. "Environment", "Device", "Avatar" and "Virtual World") might play both positive and negative roles whilst the user is trying to achieve a state of immersion.

To illustrate how the proposed framework developed in this research benefits and adds to Brown and Cairns's theory, the framework areas are positioned in correspondence to the barriers and levels of immersion, as outlined by Brown and

Cairns (see Figure 22). Along with levels of immersion, namely Engagement, Engrossment and Total Immersion, Brown and Cairns outline five barriers (i.e. Access, Investment, Game construction and Atmosphere) which the user should go through in order to get to each of the immersion levels.

- *Access.* This barrier lies on the way to engagement as a lowest level of immersion and refers to the user's preferences. If the user does not like the game, he or she will not be willing to engage with it. Secondly, the game control should match the user's skills and allow progress through the game (Brown and Cairns, 2004).
    - This barrier corresponds to framework areas "User" and "Virtual World". Users in experiments 2, 3 and 4 expressed their preferences, assessing the suitability of the virtual environments for given activities. For more, see sections 4.2, 4.3 and 6.

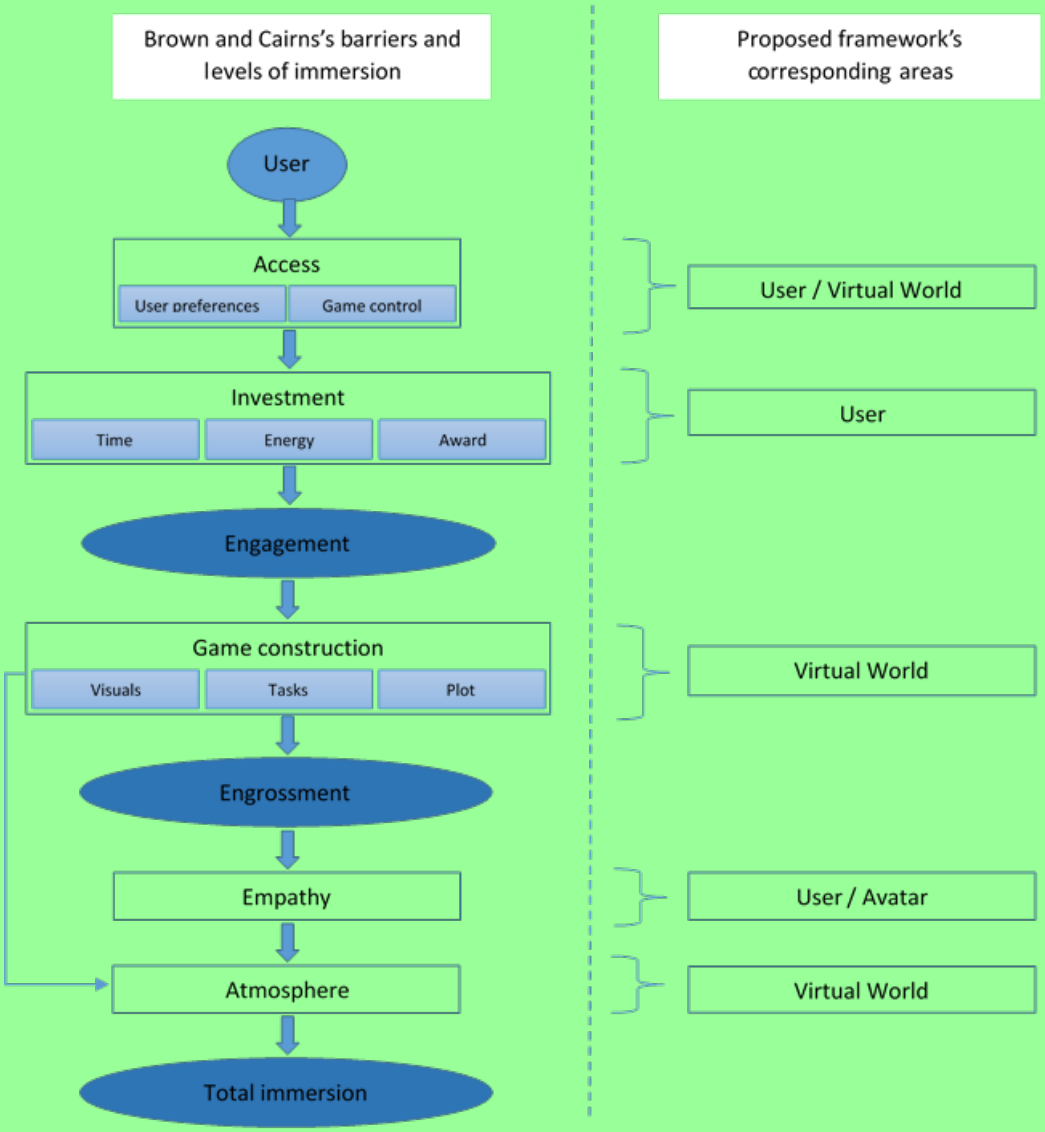


Figure 22. Barriers and Levels of Immersion, adopted from Brown and Cairns (2004) and corresponding framework areas

- *Investment.* This is the second barrier user meets on the way to engagement. The user must invest time, effort and energy to become more focused on the game and to remove this barrier. He or she might at this point lose track of time, which, as Brown and Cairns point out, subsequently might cause a sense of guilt. The effort the user invests relates to the energy he or she spends on learning how to play. This leads to awards expectations which should be proportional to the amount of effort spent.
    - The corresponding area of the framework is "User". Here it is interesting to return to the factor "Feeling guilty of playing games in

public" outlined in Experiment 3 by participants in Russia. It looks like these two factors – the feeling of time wasting, as outlined by Brown and Cairns and the feeling of being ashamed of playing games, as indicated by Experiment 3 – are closely related to each other, however, this matter requires further investigation as a part of future research.

- *Game construction.* This is the barrier to the next level of immersion, outlined by Brown and Cairns as engrossment. Game construction refers to how the game features are combined to affect gamers' emotions and includes visuals, tasks and the plot of the game.
    - The corresponding area of the framework is "Virtual World". Participants of experiments 2, 3 and 4 outlined that features they found in the virtual worlds were affecting them in both positive and negative ways while they were performing activities (see sections 4.2, 4.3 and 6).
- *Empathy.* Empathy is the barrier to the state of total immersion formed by certain game features, relevant to the game character. The player needs to feel empathy with the character he or she is playing and controlling throughout the game flow, where gamers assumed a character, as Brown and Cairns reported.
    - This barrier corresponds to the framework areas of "User" and "Avatar". As participants of experiments 2 and 3 reported, there is a need for them to be associated with their avatars and they were trying to achieve that association through modifications and adjustments of the avatar, noting that they need more choices and options for that. For more about user-avatar associations, see sections 4.2 and 4.3.
- *Atmosphere* as a barrier is created from the same elements as game construction, combining the graphics, plot and sounds. The key difference here, as the authors point out, is the relevance to the actions and location of the game characters which leads to the attention gamers should pay. The more attention gamers pay to the game events, the more possible it is for

them to achieve immersion. The level of immersion seems to correlate with the amount and number of attentional sources (Brown and Cairns, 2004).

- This barrier corresponds to the area of "Virtual World". Participants in experiments 2 and 3 outlined that plot or, in their case sequence of actions, plays a vital role in their virtual world experience. Graphics were also mentioned as contributing to their immersion experience (see sections 4.1 and 4.2).

As can be seen from Figure 22, the barriers outlined by Brown and Cairns (2004), correspond to the areas of the proposed framework. The proposed framework, however, explains the influence of the factors in more detail, classifying each area and dividing them into smaller factors of influence. This adds to the existing study of Brown and Cairns.

8.3 Bjorner *et al.*'s (2016) framework

The framework presented by these authors illustrates how the user is moving from one state to another on his or her way to achieve immersion (see section 7.3.5). In principle, this work is based on Brown and Cairns's (2004) work as the authors outline. The authors took the idea of immersion divisions further and developed a circular model, illustrating how the user is moving from one stage to another towards achieving immersion. In principle, all the corresponding areas between Bjorner *et al.*'s (2016) work and this research remain the same as with Brown and Cairns's (2004) study.

9 Conclusion

9.1 Overview of each experiment in this research

9.1.1 Experiment 1

As a result of Experiment 1, the factor of "Population" was evaluated and confirmed as playing a vital role in users' experience. The decrease in number of users populating the virtual world at the time of the participants' activities there affects participants' immersion in VR. "Population" as a factor was also confirmed in Experiment 2 and contributed to forming the framework. For more about Experiment 1, see section 4.1.

9.1.2 Experiment 2

Experiment 2 helped to evaluate several factors such as "Purpose", "People", "Graphics", "Navigation", "Avatar customisation" and "Control" and confirmed the factor of "Population" ("People") as contributors to the framework. The "Purpose" or goal of participants for "being there" was marked by users as something they would like to be more clearly outlined. This factor also found its place in the framework. It is necessary to point out here that the initial goal of Experiment 2 was to explore the factor of environmental disturbance or how the real-world environment would affect users while they were active in a virtual world. The results, however, proved that environmental factors, such as noise, music or people around do not play that as significant a role as was expected. In contrast, new factors appeared on the stage and the "Purpose" was affected the users the most. For more about Experiment 2, see section 4.2.

9.1.3 Experiment 3

Experiment 3 forms the backbone of the framework. Most of the factors were evaluated within and due to that experiment. One of the reasons for such a contribution probably is that the whole experiment was conducted and data analysed with the guidance of grounded theory, which suggests to be open to any unexpected turns in the experimentation and data analysis (see section 3.5). Thus, analysing users' responses to the interview questions, new factors became apparent and formed the framework. For more about Experiment 3 and its results, see section 4.3.

9.1.4 Experiment 4

Experiment 4 was tailored to evaluate existing factors by introducing them to a new set of users involved in the building of a virtual world, contributing by figuring out users' opinions about the framework and introducing new factors which appeared as a result of this experiment. These new factors also became a part of the framework. For more about Experiment 4 and its results, see section 6.

9.2 Summary of findings

As a result of the experimental phase, a framework of factors potentially affecting immersion has been developed, consisting of the following areas:

- Virtual World
- Avatar
- Environment
- Device
- User

These factors are ranked by the level of impact on user (see section 5). Impact indicates the significance of the factor for the participants, according to their responses.

The framework, developed as a result of the series of experiments in this research, is intended to be used as reference material by creators of immersive 3D virtual environments in order to design immersive virtual environments. The factors contained in this framework indicate the areas of importance in terms of user immersion and suggest to developers what should be taken into consideration whilst creating an immersive 3D environment.

In order to test the robustness of the framework, the framework was presented to another group of users who actually were involved in a virtual world building process, resulting in obtaining another set of data, evaluated by that group of participants during Experiment 4. Participants for that experiment were recruited among students of University of Bedfordshire. Thirty-two factors (68.08%) out of 47 were confirmed as affecting the users while performing activities in a VW and 15 factors (31.91) were evaluated as not affecting them.

The data obtained in Experiment 4 serves as extra material to help VW designers in developing immersive VR structures by taking into consideration all the factors identified in this experiment.

9.3 Practical use of the results

The practical use of the results of this research could be described as the development of the framework as a working tool which could be used by designers of 3D virtual worlds. The framework factors, evaluated as factors of significance affecting users and developers of virtual environments, will suggest the areas of attention to be considered by virtual environment designers in order to construct immersive virtual worlds. These areas lie in the domain of psychological immersion, addressing issues affecting users' immersion experience through their emotions and feelings while acting in a virtual world. Taking into consideration those areas reflected in the framework factors, developers will benefit in virtual world development.

9.4 Strengths and weaknesses

The limitations of this research may be outlined as follows:

- Higher number of participants, for instance, in the quantitative part could help to get more data for analysis.

  Countermeasure: qualitative methods, used in this research, helped to minimise this limitation of the quantitative method and since they were also combined together, it allowed collecting richer data.

- Data could be collected from more diverse groups of participants.

  Countermeasure: Experiment 3 was conducted under conditions different from the previous two to minimise this limitation and to collect more data from a different batch of participants.

- The platforms, used for different experiments in this research could be more uniform to provide a more homogeneous virtual environment for more precise comparisons of the test results among the groups of participants.

  Countermeasure: grounded theory, used in the majority of the experiments (in 3 out of 4) for data analysis, allowed obtaining and

using unexpected data, which came to the surface during the experimentation and enriched the research results.

As strengths of this research, the following may be outlined:

- Sufficient number of experiments (four in total), allowing not only rich data gathering but also verification of data by different groups of users in different environments.
- Combination of qualitative and quantitative methods of data gathering and analysis to improve reliability and validity of the data.
- The use of non-homogeneous test groups, consisting of participants of different age, gender, education and background when it was possible.
- Experiments were conducted in sequential way, with each of the following experiments based on the previous one to achieve the legacy of the research flow.
- Practical contribution of the research through the introduction of the framework as a tool to help designers of virtual worlds in creation of immersive environments.

9.5 Contributions of this research

The major contribution of this research is the development of the framework, intended to be used as an aid for developers building immersive virtual worlds (see sections 5.6 and 9.3). The main findings suggest that psychological immersion prevails over perceptual immersion, which is confirmed by the experimental phase of this research. Findings in the literature indicate that this research results are in line with pre-existing studies and add to them in certain areas, such as the psychological aspect of immersion, related closely to users' emotions and feelings about the virtual world experience (see section 8).

Lombard and Ditton's (1997) characteristics of different types of immersion are also reflected in the experimental part of this research, as can be seen in section 8, with some exceptions (i.e. "Presence as immersion" type), which is mainly due to the nature of the experiments conducted in this research, where immersive devices such as HMD or CAVE were not meant to be used.

Results of this research indicate that the perceptual part of the immersion plays less important role in the user's virtual world experience than the psychological part. Users are more concerned about their feelings and emotions while in a VW rather than technical characteristics of the system. Findings of this research address psychological and behavioural aspects of virtual world construction, rather than the technical ability of the system to provide immersive environment for users.

9.6 Future work

The future work is viewed as further exploration of the phenomenon of immersion but covering a broader area, which may be divided into four major sub-areas:

1. Further exploration of areas identified in this research, but not addressed yet, such as cultural differences potentially influencing immersion experiences. This could be arranged as an additional set of experiments, tailored for systematic studies of cultural differences between Russian and British students and the influence of those differences on their behaviour in a VW.
2. Evaluating immersion by applying framework factors to stationary 3D virtual spaces which are enhanced by newer technologies such as HMD and haptic devices.
3. Evaluating immersion in new virtual environments such as augmented reality would add to the benefits of this research since this topic is currently becoming more and more prominent with the advent of Smart Homes, Smart Cities and the Internet of Things as emerging fields for future research.
4. Quantifying immersion in virtual world would also be a possible continuation. Though there are a number of studies done in the past addressing this topic, certainly much more work could be performed here.
5. Merging immersion and usability research into a view of the creation of immersive virtual worlds would certainly benefit developers and users since these two areas are closely related and usability studies should not be overlooked whilst addressing immersion issues.

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Appendix A: Questions for Experiment 2

1. So, how do you feel?
2. Was it useful?
3. What did you feel when you just appeared in VR, first minute impression?
4. Did you modify your avatar?
   4.1. *If yes* -Why did you choose that particular avatar?
5. How would you describe your association with your avatar?
   5.1. (very much associated- - - - not at all)
6. Did you feel like interacting with environment?
   6.1. *If yes* – Was the avatar or you interacting?
7. How would you describe your feelings (emotions) while being in VR?
8. Did you lose the sense of time while in VR?
9. How could you describe your experience in VR:
   9.1. Was it engaging?
      9.1.1. *If yes* - What did you find particularly engaging in this VR?
   9.2. Engaging a bit?
   9.3. Or not at all?
10. Did the task hold your attention?
    10.1. *If yes* - Can you describe it?
11. Did you talk to anyone there?
    11.1. *If no*- Why?
    11.2. *If yes* - Any difference you observed between conversation in VR and real world?
12. Did you find the environment of test venue disturbing?
    12.1. Which of these factors you would call the most disturbing:
      12.1.1. Non-work atmosphere
      12.1.2. General noise
      12.1.3. People walking around
      12.1.4. Music
      12.1.5. Anything else
13. Did you find any of those tutorials difficult to understand?
    13.1. Why?

14. What can you tell us about design of VR and its elements?
15. What would you change in VR to make it more attractive for users?
16. Any additional comments you would like to make (impressions, feelings, etc. *– try to use synonyms in informal way to make him talk, especially when camera is off already)*

Appendix B: Questions for Experiment 3

17. Ну как ощущения?

    So, how do you feel?

18. Что вы почувствовали сразу после «прибытия туда», первые ощущения?

    What did you feel right after "arrival", your first impressions?

19. Вы изменили внешность своего аватара?

    Did you change the appearance of your avatar?

    19.1. (Если ДА)- Почему вы выбрали именно этот аватар?

    (If YES) - Why did you choose that particular avatar?

20. Как бы вы описали свою связь с аватаром, если таковая существует?

    How would you describe your relationship with your avatar, if such ever exists?

    20.1. (очень сильно ощущаемая связь- - - - совсем нет связи)

    (*very strong relationship ------ no relationship at all*)

21. Почувствовали ли вы, что вы взаимодействуете с окружающей действительностью?

    Did you feel you were interacting with the environment?

    21.1. (Если Да)- Это аватар взаимодействовал или вы сами?

    (If YES) – Was that the avatar, who was interacting or yourself?

22. Как бы вы описали свои эмоции, чувства пока находились там, в виртуальном мире?

    How would you describe your emotions, feelings while being there, in virtual world?

23. Вы теряли чувство времени, пока там находились?

    Did you lose sense of time while being there?

24. Как бы вы описали ваше пребывание в виртуальной реальности:

    How would you describe your stay in virtual reality?

    24.1. Это было увлекательно?

    Was that engaging?

    24.1.1. (Если ДА) - Что именно было наиболее увлекательным ?

    (If YES) – What exactly was the most interesting?

    24.2. Немного увлекательно?

Interesting a bit

24.3. Совсем не увлекательно?

Not interesting at all?

25. Удерживало ли то, что вы делали, ваше внимание?

Did you activities hold your attention?

25.1. (Если ДА) - Как бы вы это описали?

(If YES) – How would you describe it?

26. Находите ли вы окружающую вас сейчас обстановку раздражающей?

Do you find this environment around us distracting?

26.1. Какие их следующих факторов вы бы назвали наиболее раздражающими?

Which of the following factors you would call the most distractive?

26.1.1. Нерабочая атмосфера

Non-work oriented atmosphere

26.1.2. Общий шум

General noise

26.1.3. Люди вокруг

People around

26.1.4. Музыка (если звучит на месте)

Music (if playing on venue)

26.1.5. Что либо иное?

Something else?

27. Что бы вы могли сказать о дизайне, общем и отдельных элементов?

What could you say about design, in general and particular items?

28. Что бы вы изменили в виртульном мире что бы сделать его более привлекательным?

What could you change in virtual world to make it more engaging?

29. Какие либо комментарии, которые приходят вам на ум, эмоции, чувства, т.д.?

Any other comments that might come to your mind, emotions, feelings, etc.?

Appendix C: Chi-Square distribution table

df	0.005	0.01	0.025	0.05	0.1	0.25	0.5	0.75	0.9	0.95	0.975	0.99	0.995
1	0.000039	0.00016	0.00098	0.0039	0.0158	0.102	0.455	1.32	2.71	3.84	5.02	6.63	7.88
2	0.01	0.0201	0.0506	0.103	0.211	0.575	1.39	2.77	4.61	5.99	7.38	9.21	10.6
3	0.0717	0.115	0.216	0.352	0.584	1.21	2.37	4.11	6.25	7.81	9.35	11.3	12.8
4	0.207	0.297	0.484	0.711	1.06	1.92	3.36	5.39	7.78	9.49	11.1	13.3	14.9
5	0.412	0.554	0.831	1.15	1.61	2.67	4.35	6.63	9.24	11.1	12.8	15.1	16.7
6	0.676	0.872	1.24	1.64	2.2	3.45	5.35	7.84	10.6	12.6	14.4	16.8	18.5
7	0.989	1.24	1.69	2.17	2.83	4.25	6.35	9.04	12	14.1	16	18.5	20.3
8	1.34	1.65	2.18	2.73	3.49	5.07	7.34	10.2	13.4	15.5	17.5	20.1	22
9	1.73	2.09	2.7	3.33	4.17	5.9	8.34	11.4	14.7	16.9	19	21.7	23.6
10	2.16	2.56	3.25	3.94	4.87	6.74	9.34	12.5	16	18.3	20.5	23.2	25.2
11	2.6	3.05	3.82	4.57	5.58	7.58	10.3	13.7	17.3	19.7	21.9	24.7	26.8
12	3.07	3.57	4.4	5.23	6.3	8.44	11.3	14.8	18.5	21	23.3	26.2	28.3
13	3.57	4.11	5.01	5.89	7.04	9.3	12.3	16	19.8	22.4	24.7	27.7	29.8
14	4.07	4.66	5.63	6.57	7.79	10.2	13.3	17.1	21.1	23.7	26.1	29.1	31.3
15	4.6	5.23	6.26	7.26	8.55	11	14.3	18.2	22.3	25	27.5	30.6	32.8
16	5.14	5.81	6.91	7.96	9.31	11.9	15.3	19.4	23.5	26.3	28.8	32	34.3
17	5.7	6.41	7.56	8.67	10.1	12.8	16.3	20.5	24.8	27.6	30.2	33.4	35.7
18	6.26	7.01	8.23	9.39	10.9	13.7	17.3	21.6	26	28.9	31.5	34.8	37.2
19	6.84	7.63	8.91	10.1	11.7	14.6	18.3	22.7	27.2	30.1	32.9	36.2	38.6
20	7.43	8.26	9.59	10.9	12.4	15.5	19.3	23.8	28.4	31.4	34.2	37.6	40
21	8.03	8.9	10.3	11.6	13.2	16.3	20.3	24.9	29.6	32.7	35.5	38.9	41.4
22	8.64	9.54	11	12.3	14	17.2	21.3	26	30.8	33.9	36.8	40.3	42.8
23	9.26	10.2	11.7	13.1	14.8	18.1	22.3	27.1	32	35.2	38.1	41.6	44.2
24	9.89	10.9	12.4	13.8	15.7	19	23.3	28.2	33.2	36.4	39.4	43	45.6
25	10.5	11.5	13.1	14.6	16.5	19.9	24.3	29.3	34.4	37.7	40.6	44.3	46.9
26	11.2	12.2	13.8	15.4	17.3	20.8	25.3	30.4	35.6	38.9	41.9	45.6	48.3
27	11.8	12.9	14.6	16.2	18.1	21.7	26.3	31.5	36.7	40.1	43.2	47	49.6
28	12.5	13.6	15.3	16.9	18.9	22.7	27.3	32.6	37.9	41.3	44.5	48.3	51
29	13.1	14.3	16	17.7	19.8	23.6	28.3	33.7	39.1	42.6	45.7	49.6	52.3
30	13.8	15	16.8	18.5	20.6	24.5	29.3	34.8	40.3	43.8	47	50.9	53.7
31	14.5	15.7	17.5	19.3	21.4	25.4	30.3	35.9	41.4	45	48.2	52.2	55
32	15.1	16.4	18.3	20.1	22.3	26.3	31.3	37	42.6	46.2	49.5	53.5	56.3
33	15.8	17.1	19	20.9	23.1	27.2	32.3	38.1	43.7	47.4	50.7	54.8	57.6
34	16.5	17.8	19.8	21.7	24	28.1	33.3	39.1	44.9	48.6	52	56.1	59
35	17.2	18.5	20.6	22.5	24.8	29.1	34.3	40.2	46.1	49.8	53.2	57.3	60.3
36	17.9	19.2	21.3	23.3	25.6	30	35.3	41.3	47.2	51	54.4	58.6	61.6
37	18.6	20	22.1	24.1	26.5	30.9	36.3	42.4	48.4	52.2	55.7	59.9	62.9
38	19.3	20.7	22.9	24.9	27.3	31.8	37.3	43.5	49.5	53.4	56.9	61.2	64.2
39	20	21.4	23.7	25.7	28.2	32.7	38.3	44.5	50.7	54.6	58.1	62.4	65.5
40	20.7	22.2	24.4	26.5	29.1	33.7	39.3	45.6	51.8	55.8	59.3	63.7	66.8
41	21.4	22.9	25.2	27.3	29.9	34.6	40.3	46.7	52.9	56.9	60.6	65	68.1
42	22.1	23.7	26	28.1	30.8	35.5	41.3	47.8	54.1	58.1	61.8	66.2	69.3
43	22.9	24.4	26.8	29	31.6	36.4	42.3	48.8	55.2	59.3	63	67.5	70.6
44	23.6	25.1	27.6	29.8	32.5	37.4	43.3	49.9	56.4	60.5	64.2	68.7	71.9
45	24.3	25.9	28.4	30.6	33.4	38.3	44.3	51	57.5	61.7	65.4	70	73.2
df	A=0.005	0.01	0.025	0.05	0.1	0.25	0.5	0.75	0.9	0.95	0.975	0.99	0.995