



Title: Designing an engaging learning universe for
situated interactions in virtual environments

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DESIGNING AN ENGAGING LEARNING UNIVERSE FOR SITUATED INTERACTIONS IN VIRTUAL ENVIRONMENTS

Athanasios Christopoulos

A thesis submitted to the University of Bedfordshire,
in partial fulfilment of the requirements for the degree of
Doctor of Philosophy (PhD)

Institute for Research in Applicable Computing
School of Computer Science & Technology
University of Bedfordshire

July 2018

Declaration

I, Athanasios Christopoulos, declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

Thereby, I confirm that:

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3. Where I have cited the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
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Athanasios Christopoulos

26/07/2018

Abstract

Studies related to the Virtual Learning approach are conducted almost exclusively in Distance Learning contexts, and focus on the development of frameworks or taxonomies that classify the different ways of teaching and learning. Researchers may be dealing with the topic of interactivity (avatars and immersion are key components), yet they do so they mainly focusing on the interactions that take place within the virtual world. It is the virtual world that consists the primary medium for communication and interplay.

However, the lines are hard to be drawn when it comes to examining and taxonomising the impact of interactions on motivation and engagement as a synergy of learners' concurrent presence. This study covers this gap and sheds light on this lack—or, at least, inadequacy—of literature and research on the interactions that take place both in the physical and the virtual environment at the same time. In addition, it explores the impact of the instructional design decisions on increasing the learners' incentives for interplay when trying to make sense of the virtual world, thus leading them to attain higher levels of engagement.

To evaluate the potential of interactions holistically and not just unilaterally, a series of experiments were conducted in the context of different Hybrid Virtual Learning units, with the participation of Computer Science & Technology students. One of the goals was to examine the learners' thoughts and preconceptions regarding the use of virtual worlds as an educational tool. Then, during the practical sessions, the focus was placed on monitoring students' actions and interactions in both the physical and the virtual environment. Consequently, students were asked as a feedback to report their overall opinion on these actions and interactions undertaken.

The study draws a new research direction, beyond the idea of immersion and the development of subject-specific educational interventions. The conclusions provide suggestions and guidelines to educators and instructional designers who wish to offer interactive and engaging learning activities to their students, as well as a taxonomy of the different types of interactions that take place in Hybrid Virtual Learning contexts.

Acknowledgments

My deepest thanks go to my supervisors Dr. Marc Conrad and Dr. Mitul Shukla. Their patience, motivation and consistent support during my PhD journey created the best supervisory team I could have ever imagined.

My sincere thanks also go to Dr. Mark Childs, for enlightening me the first glance of research. His insightful comments and suggestions for enhancement of the research instruments incited me to widen my research.

I am also grateful to all and each one of the students who participated in my experiments and everyone who helped with the data collection reported in this thesis.

Working in the School of Computer Science and Technology has been a pleasure. I would, therefore, like to kindly thank all the academics, fellow labmates and colleagues for the stimulating discussions, the endless hours we were working together in the laboratories and for all the fun we have had in the last five years.

Special thanks go to Miss Krystallia Katsarou for proofreading the final version of this dissertation.

Next, I would like to thank Dimitri (for being the best flat mate ever), Gianni (for always being there, in good and bad times), Mark (for always giving me the extra push I need), and Maarja (for constantly reminding me that everything has a positive side).

Last but not the least, I am immensely thankful to my family, my father Johnnie, my mother Filio, my sister Maria-Aliki, and my girlfriend Athina for believing in me and helping me by all means. Their unlimited love, support and encouragement make me think that I am the luckiest person on earth. Thanks for everything!

Without all of these people, this dissertation, funded by the University of Bedfordshire, would have not been written.

*To my parents, sorella & Athina
for all your unending love...*

Publications

Refereed Book Chapters

- Christopoulos, A., Conrad, M. & Shukla, M. (2018). The Added Value of the Hybrid Virtual Learning Approach: Using Virtual Environments in the Real Classroom. In J. Qian (Ed.) *Integrating Multi-User Virtual Environments in Modern Classrooms* (pp. 259-279). IGI Global.
- Christopoulos, A., Conrad, M. & Shukla, M. (2017). Co-Presence in The Real and The Virtual Space: Interactions Through Orientation. In G. Costagliola, J. Uhomoihi Zvacek, S. & McLaren B.M. (Eds.) *Communications in Computer and Information Science* (pp. 71-99). Springer.

Refereed Journal Articles

- Christopoulos, A., Conrad, M. and Shukla, M. (2018). Interaction with Educational Games in Hybrid Virtual Worlds. *Journal of Educational Technology Systems*, 1-29.
- Christopoulos, A., Conrad, M. & Shukla, M. (2018). Increasing Student Engagement through Virtual Interactions. How?. *Virtual Reality*, 1-17.
- Christopoulos, A., Conrad, M. & Shukla, M. (2016). Between Virtual and Real: Exploring Hybrid Interaction and Communication in Virtual Worlds. *Journal of Social Media and Interactive Learning Environments*, 4(1), 23-42.
- Christopoulos, A., Conrad, M. & Shukla, M. (2014). Objects, Worlds, and Students: Virtual Interaction in Education. *Education Research International*, 2014, 20 pages.

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- Christopoulos, A., Conrad, M. & Shukla, M. (2018). Implementing Learning Models in Virtual Worlds from Theory to (Virtual) Reality. In *Proceedings of the 10th International Conference on Computer Supported Education*, pp. 226-234.
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List of Abbreviations

2-D	two-demensions/two-dimensional
3-D	three-dimensions/three-dimensional
AI	Artificial Intelligence
CA	Cochran-Armitage Trend Test
CL	Collaborative Learning
CSCL	Computer Supported Collaborative Learning
DGBL	Digital Game-Based Learning
F2F	Face-to-Face
GBL	Game-Based Learning
GUI	Graphical User Interface
HCI	Human-Computer Interaction
HVL	Hybrid Virtual Learning
ICT	Information & Communication Technology
IM	Instant Message
KW	Kruskal-Wallis <i>H</i> Test
LSL	Linden Scripting Language
NPC	Non-Player Character
PA	Pedagogical Agent
PBL	Problem-Based Learning
TPACK	Technological Pedagogical Content Knowledge
VL	Virtual Learning
VLE	Virtual Learning Environment
VoIP	Voice over IP
VR	Virtual Reality

Chapter 1: Introduction

1.1 Introduction

The term 'Virtual Reality' (VR) was first coined in or around the 1950s, as part of the wider concept of science fiction and the initial development of electronic computers, whereas the first attempts to materialise this idea emerged roughly a decade later (Mazuryk & Gervautz, 1996; Ellis, 1994). As a result, while this emerging technology field was expanding and evolving, the attention and interest of various stakeholders got attracted, mainly due to the fact that virtual worlds were capable of covering a wide variety of needs in a relatively low cost (Gregory *et al.*, 2016; Herbet, Thompson & Garnier, 2012).

The existence of virtual worlds signaled the start of a new era with an increasing number of educationalists shifting towards using this approach (Christopoulos, 2013). Moreover, despite the fact that no explicit theories or models have been developed to contextualise Virtual Learning (VL), instructional designers have successfully employed the traditional approaches with positive results on learners' motivation and engagement. To this end, researchers (e.g. Hockey *et al.*, 2010; Miller *et al.*, 2010; Vosinakis, Koutsabasis & Zaharias, 2011) also agree that virtual worlds provide a fertile ground for a wide variety of educational activities, thus catering for different learning styles.

The main advantage of Desktop VR is that it enables learners to interact with each other both in the physical classroom and in the 3-D (three-dimensional) virtual environment. Therefore, the purpose of this thesis is to investigate the different types of interactions that take place both in the physical classroom and the virtual world, examine the synergies that are

developed as part of this interactions' network, classify them, and provide clear guidance to educators and instructional designers who aim to offer their learners interactive learning activities and engaging experiences. In addition, in the same context, the study also examines the impact that the instructional design has on learners' interactions and, therefore, engagement with the virtual world and the learning material.

1.2 Definition of Key Terms

1.2.1 Learning

Learning, both as a process and as an outcome, is a topic that has been widely investigated by representatives from different scientific fields. Therefore, each school of thought, based on its governing principles, attributed a different definition to determine *what learning is* and *which factors influence it* (Section 2.2). Behaviourists, for example, consider learning as the ability to demonstrate the right behaviour in response to a given stimulus. According to Cognitivists, learning is the development of mental structures through the information that individuals receive from the environment. Constructivism describes learning as the active involvement of individuals in a set of given actions, while Social Constructivism refers to learning as the result of collaborative and socialisation practices which occur among individuals or groups of people (Greeno, 1997).

Gagné (1984, p. 377), after broadly encompassing all the attributes that the aforementioned learning theories outline, defines learning as:

'a change of state of the human being that is remembered and that makes possible a corresponding change in the individual's behavior in a given type of situation. This change of state must, of course, be distinguished from others that may be effected by innate forces, by maturation, or by other physiological influences. Instead, learning is brought about by one or more experiences that are

either the same as or that somehow represent the situation in which the newly acquired behavior is exhibited’.

Based on the generic definition of Gagné (1984), it can be concluded that all the aforementioned theories attribute the main characteristic of change in learning, which can be either change in the individuals’ behaviour (Behaviourism), or changes in the individuals’ mental structures (Cognitivism), or changes in the collective understanding of the world (Constructivism). In other words, the change defines the final objective of learning. Contrary to that, Connectivism considers learning as a lifelong and collective process, due to the fact that information is constantly changing. Consequently, Connectivism refers to learning as the individuals’ ability to identify and manage information, as well as adapt their behaviour accordingly. In fact, it is the continuous flow and change of information that attributes this fluid nature to learning, and implies the need for continued re-adaption and adjustment (Siemens, 2005).

The definition adopted for the needs of this study is the one proposed by Lachman (1997, p. 477) describing learning as:

‘the process by which a relatively stable modification in stimulus–response relations is developed as a consequence of functional environmental interaction via the senses’.

It is mainly opted for due to its amplex to cover the definitions of all the aforementioned theories, and the fact that it perceives learning as a ‘process’. In particular, it is generic and wide enough to cover the definitions of all the aforementioned learning theories. Moreover, it refers to a ‘*relatively stable modification*’ which includes the elasticity of Connectivism in regard to the permanence of change. As to the ‘*stimulus–response relation*’, even though it might strongly resemble the behavioural approaches, it also alludes to the

principles of the rest of the theories, as all of them investigate how individuals learn by reacting to the environmental stimuli, though with different focal points. To conclude, whichever approach chosen, learning is *'the result of functional environmental interaction via the senses'*, and these interactions are the ones that trigger individual's corresponding responses to the stimuli.

1.2.2 Virtual Learning

Various terms are used to describe VR products. In this thesis, the term 'virtual world' is translated into a computer-generated, 3-D multi-user environment, whose representations are designed and shaped by individuals, through the use of avatars, in real time.

Virtual worlds—be it a computer game with manufactured conflicts, achievements and objectives, or user-developed platforms like Second Life¹®, OpenSimulator²© (OpenSim), ActiveWorlds³© or OpenWonderland⁴©—have been inherently designed to mirror the real-world settings in a vivid and realistic 3-D environment (Loke, 2015). Moreover, their highly customisable and shared (virtual) space, as well as the existence of avatars (virtual 3-D representation of the users), allow for multiple types of interactions to occur in real time, both with the content of the world and with other users (Smart, Cascio & Paffendorf, 2007). Indeed, the fact that virtual worlds provide the necessary context for various types of interactions encouraged scholars to utilise them for research and educational practices. Examples of such interactions are: object creation (Allison *et al.*, 2012) and manipulation (Bredl *et al.*, 2012), terrain editing

¹ <http://secondlife.com/>

² http://opensimulator.org/wiki/Main_Page

³ <https://www.activeworlds.com/web/index.php>

⁴ <http://openwonderland.org>

(Allison *et al.*, 2012) and navigation around the world (Herbet *et al.*, 2012), but also communication among their users either synchronous or asynchronous, verbal, written or non-verbal (avatar gestures and other forms of in-world visual interactions) (Carter, 2012; Hockey *et al.*, 2010; Johnson *et al.*, 2009).

As Jones (2013) suggests, learners have the ability to actively affect, alter and enhance the content of these *synthetic worlds* in a way that will enable them to construct their cognitive schemas and engage with the phenomena they study. Others, further expanding on the aforementioned claim, suggest that the learning process become more self-directed and student-centered, while educators assume the role of the supporter of activities that aim to engage students in the subject under investigation (Anasol *et al.*, 2012; Schrader, 2008; Zhao *et al.*, 2010). Indeed, the impact of VR technology and its capabilities or potential in education has been acknowledged by researchers (Jarmon *et al.*, 2009; Schrader, 2008), whilst others also highlight the value and benefits of 3-D virtual worlds to learner motivation and engagement (de Freitas *et al.*, 2010; Pellas & Kazanidis, 2015).

1.2.3 Hybrid Virtual Learning

The extensive utilisation and positive results of virtual worlds in Distance Learning led to their (partial) incorporation in the traditional F2F (face-to-face) education, so as to enrich and enhance the learner experience (Omieno *et al.*, 2012). A plethora of definitions related to the Blended Learning model exist. The most predominant one describes this approach as the combination of online and F2F instruction and interaction among both learners and educators (Bliuc, Goodyear & Ellis, 2007; Graham, 2013; Picciano, 2009).

The outcomes of these studies are, indeed, very substantial and useful to educators and instructional designers who aim to develop immersive learning activities for their learners. Nevertheless, when it comes to the Hybrid Virtual Learning (HVL) approach, which was utilised for the needs of this study, the detailed examination does not fully apply. Hence, HVL is defined as the context within which the traditional classroom and the virtual world are overlapping. In other words, in the HVL scenario, educators and learners are simultaneously co-present, interacting with each other in real-time, both in the physical and in the virtual environment.

1.3 Motivation of the Study

The review study that Robins, Rountree & Rountree (2003) conducted, highlighted various issues, obstacles and difficulties that Computer Science educators face when teaching programming to novice learners. Indeed, teaching complex syntax structures and algorithms or abstract concepts—with the use of professional programming languages—is a challenging task (Esteves *et al.*, 2008; Jenkins, 2002; Miliszewska & Tan, 2007), which also justifies the high dropout rates in this scientific field (Lahtinen, Mutka & Jarvinen, 2005; Schulte & Bennedsen, 2006). On the other hand, the integration of animation to illustrate code execution has been proposed as an effective approach to reduce the impact of the aforementioned issues (Soloway, 1986; Stasko *et al.*, 1998). Modern virtual worlds such as Alice[©] (Cooper, Dann & Pausch, 2000), Second Life[®] or OpenSim (Esteves *et al.*, 2011), offer learners the opportunity to program the behaviour of 3-D objects—using simple scripts—and receive instant visual feedback. In addition, such platforms enable multiple users to connect, interact and communicate with each other both in real-time and asynchronously.

Studies related to the utilisation of virtual worlds in Higher Education are broadly driven by a set of common-interest research and practice directions. The main conclusions, presented briefly below and in more detail in Chapter 2, are classified in four expansive categories.

In particular, work related to VL:

1. originates mainly from distance learning contexts. Therefore, the reported outcomes elaborate and discuss the learning benefits or limitations that may be achieved and encountered during the development and deployment process (Chapter 2).
2. focuses on the educational potential of virtual worlds. More precisely, the attempts that have been made to contextualise this learning approach provide:
 - guidelines related to the integration of the established learning theories, with an emphasis on knowledge acquisition and transfer (Section 2.2).
 - recommendations related to the application of the traditional learning models, with an emphasis on the particular scientific domains and fields (Section 2.3).
 - instructions related to the design and evaluation process of the learning activities, interventions and objectives (generic directions relevant to e-learning) (Section 2.4).
 - frameworks for the classification of the available environments in regard to their educational potential and affordances (Section 2.5.2.1).
3. examines the elements that affect virtual worlds' interactivity. The relevant taxonomies provide educators with guidelines and the tools required to measure how interactive their virtual worlds are (Sections 2.5.2.2-2.5.2.4).

4. discusses the role of interactions on learner experience. More precisely, the different types of interactions that learners encounter while being in virtual worlds, are considered as one of the main factors that influence their achievements, satisfaction and participation (Sections 2.5.2.5-2.5.2.6).

Such studies offer valuable insights to those educators who are inexperienced with the VL approach or want to further expand their knowledge base. Nevertheless, what motivated the conduct of this study is the fact that the researchers' focus lies almost exclusively on the intrinsic elements of virtual worlds, yet utterly disregard the perspective of learning in the physical classroom while using a virtual world. Moreover, the role of instructional designers is primarily associated with the development of content whose nature is directly linked to or required for the conceptualisation of discipline-specific subjects. Typical examples include the development of virtual campuses and classrooms in which immersive simulated training experiences—with particular focus on the field of 'hard' sciences such as physics, chemistry, biology, anatomy, astronomy, architecture, and so on—can be facilitated (Koutsabasis *et al.*, 2012; Potkonjak *et al.*, 2016; Vrellis *et al.*, 2010). In addition, teaching and learning activities that include the virtual reconstruction of archaeological and historical sites, including libraries and museums, are also amongst the most frequently used instructional design approaches that educators and content designers utilise (Urban, Marty & Twidale, 2007). However, in the aforementioned examples, the main concern lies on the development of authentic content—tailored to suit particular learning objectives and goals—and not on the provision of diverse stimuli which can potentially increase the incentives for interaction, both between the users and the virtual world and among the users themselves.

Lastly, even though the topic of interactivity receives great appreciation (especially in regard to its impact on the attainment of the learning objectives), researchers consider interactions as one of the many factors that influence learners' motivation and engagement, and thus do not examine them in isolation, or else, in depth, by extension. In this study, however, interplay is the dominant theme and, thus, the complex network of interactions that is developed in HVL setups is examined holistically from different, though complementary, perspectives (i.e. in the physical classroom and in the virtual world), as well as various points of view related to the methodological approaches used.

As a result, mapping and classifying the complex network of interactions—which learners experience while working in a HVL setup—and further correlating their impact with motivation and engagement, is a topic that remains blurred. Moreover, shifting the role of the instructional designer from that of the *discipline-specific content creator* to that of the *general-purpose educational content creator* is yet another topic that has not been holistically investigated. Regarding the former role of the educator, the focus lie on the development of teaching-learning activities related to specific scientific subjects. As to the latter, the aim is to increase the incentives for interaction and, therefore, motivate learners to engage with the virtual world and the educational activities, by extension. Hence, the issue that also emerges is that of the clash between learners' preconceptions or misconceptions, towards the use of virtual worlds and the HVL setup, and the instructional designer's choices.

1.4 Purpose of the Study

This study envisions to pave a new research and development avenue where the role of the instructional designer shifts from that of a subject-specific production

manager to a consultant who facilitates, inspires and leads learners to self-discovery and mastery. This, effectively, sets the main purpose of the study which entails the provision of clear guidelines and recommendations to instructional designers who wish to experiment with an alternative or additional instructional design technique.

In addition, the lack of pedagogical underpinning (see Section 2.2), which surrounds the educational practices that take place in virtual worlds, led to the decision to develop and introduce a theoretical and conceptual framework—adjusted to the VL model—through the presentation of an in-depth literature review. This, in turn, flags the second purpose of this research.

Finally, the scarcity of studies that systematically examine and evaluate the impact of hybrid interactions on learner motivation and engagement, motivated the emergence of a taxonomy (called DELUSIVE⁵) which would map, highlight and properly describe the full range of interactions both positive and negative.

1.4.1 Problem Statement

One of the main challenges that educators face concerns learners' engagement with the learning material. The main idea of this study is that interactions in virtual worlds, which have been modified to cover educational needs, can enhance the levels of learner engagement. That said, the more interactive the virtual world is, the higher the levels of engagement with the learning activities learners can reach. Respectively, the interactions that take place in the physical classroom, related to the use of the virtual world, can assist in achieving that goal. In HVL settings students are co-present and interact simultaneously in

⁵ Designing an Engaging Learning Universe for Situated Interactions in Virtual Environments

both environments, thus receiving stimuli related to the learning material from both directions.

Accounting the above, the main *hypothesis* of this study is formed, suggesting that:

Interplay in HVL settings can increase learners' engagement with the virtual world, whilst instructional designers can further enhance and promote interactivity and, therefore, engagement with the learning material, through the use of different interventions.

1.4.2 Aim of the Study

Based on this hypothesis, the *aim of the study* is to identify and determine whether interactions in HVL settings and instructional design affect learner engagement with the virtual world and the educational material, by extension. In addition, in the wider context of the study, the following instructional design interventions are also examined:

1. the use of example content developed by former students
2. the impact of the orientation/induction⁶ process
3. the influence of the gamification/edutainment approach
4. the adoption of pedagogical agents

1.4.3 Research Objectives & Questions

In order to examine this hypothesis, the following *research objectives* were used as milestones:

- O1.** Investigate student perceptions and attitudes towards virtual worlds in HVL models.

⁶ As 'orientation/induction process' is defined the induction of users to the use of a virtual world through which they learn the basic tools and mechanisms of it.

- O2.** Identify potential improvements or alterations to facilitate interactions in HVL settings.
- O3.** Analyse how the instructional design and learner attitude can influence engagement.
- O4.** Deliver a prototype virtual world model and an educational taxonomy tailored to educational settings capable of enhancing learner interactions.
- O5.** Provide a framework with recommendations and guidance to educators/instructional designers who aim to offer engaging and interactive learning experiences to their learners in HVL contexts.

Subsequently, the study aims to answer to the following **Research Questions (RQs)**:

RQ1. Is learner engagement with the virtual world and the educational activities due to the interactions occurring both within the virtual world and the physical classroom when HVL approaches are used?

RQ2. Do learners' personal choices and preconceptions, towards the use of virtual worlds in education, enhance or constrain educators' plans?

RQ3. What are the stimuli that instructional designers should offer to learners when designing educational interventions in virtual worlds in order to establish interactive and engaging learning activities?

RQ3a. How does the use of example content, developed by former students, influence engagement?

RQ3b. How does the orientation process influence engagement?

RQ3c. How does the use of edutainment content influence engagement?

RQ3d. How do pedagogical agents influence engagement?

The links bonding the aforementioned *research objectives* and *questions* are as follows (Table 1.1):

Table 1.1 The correlation between the research objectives and questions.

Research Questions	Research Objectives				
	O1	O2	O3	O4	O5
RQ1 (factors influencing learner engagement in HVL settings)	✓		✓		✓
RQ2 (learners' preconceptions & personal choices)	✓		✓		✓
RQ3 (instructional design stimuli)		✓	✓	✓	✓
RQ3a (use of example content)		✓	✓	✓	✓
RQ3b (use of induction/orientation process)		✓	✓	✓	✓
RQ3c (use of gamified content)		✓	✓	✓	✓
RQ3d (use of pedagogical agents)		✓	✓	✓	✓

O1 will be achieved after answering **RQ1** and **RQ2** as these focus in studying learner perspectives and choices, as well as the way that these affect interactions and therefore, their engagement.

O2, which aims to explore possible improvements or alternations as to the use of HVL settings, will be achieved through the answer of **RQ3** and its *sub-questions* that study several stimuli that enhance virtual worlds' interactivity.

O3 will be achieved after answering *all* the **RQs**.

O4 intends to highlight the nature of the stimuli that will enhance learner interactions and implement them in a virtual world. Thus, **RQ3** and the corresponding *sub-questions* will precisely highlight these characteristics.

O5 is the ultimate goal of this research, and thus *all* the **RQs** contribute to its achievement.

1.5 Significance of the Study

According to Konstantinidis, Tsiatsos & Pomportsis (2009), in HVL contexts, learning becomes more student-oriented and cooperative, whilst teaching is more interactive and rewarding. Moreover, as reported by Lee *et al.* (2010), most of the existing literature examines and reports how VR *influences* learning, yet very few studies have been conducted to understand how VR *enhances* learning. An example of this argument is the topic of interaction and engagement.

Fernández-Gallego *et al.* (2013) stress the importance of interactions in the learning activities, whilst Dillenbourg, Schneider & Synteta (2002) underline the lack of understanding of how to develop interactions for different learning objectives. The importance of interactions in learner engagement is undeniably a well-discussed topic (Barnett *et al.*, 2005; Lee, *et al.*, 2010; Salzman *et al.*, 1999). Nevertheless, there is no record of any attempts to introduce taxonomies and frameworks that map and evaluate them, especially in HVL.

Interestingly, even when interactions are under the researchers' attention, the focus is almost exclusively on the interactivity of the virtual world *per se* (e.g. the capabilities of avatars/objects/tools) and not on the interactions that need or have to be developed in order to cover the learners' needs and enhance the learning process (Bronack *et al.*, 2006; Camilleri *et al.*, 2013; Chodos *et al.*, 2012; de Freitas & Oliver, 2006; Fardinpour & Reiners, 2014; Grivokostopoulou *et al.*, 2016).

On the antipode, the studies that discuss interactions holistically (i.e. both in the physical classroom and the virtual world), report findings that have been derived from experiments which included the use of external hardware devices (Bailenson, 2006; Bowman *et al.*, 1999; Klompmaker, Paelke & Fischer, 2013; Kronqvist, Jokinen & Rousi, 2016). However, such devices might not be available to all educators/institutions due to their prohibitive cost. Therefore, following the common practice route to integrate the outcomes of studies which have been performed in mixed/augmented reality contexts in a strictly desktop-based HVL model, would be a far-fetched practice.

Ultimately, disregarding partly or even completely the network of interactions that is developed between the 'real' and the 'virtual' world—between the 'real' students and the 'avatars'—simultaneously, diminishes or

even dismisses the essence of the HVL approach, as well as restricts educators and instructional designers from reaching its maximum potential.

This overview related to the lack of a common taxonomy for describing and classifying the types of interactions that take place in HVL contexts and their impact on learner engagement is a limitation that needs to be systematically examined and evaluated.

Thus, in the context of this study, the most relevant and applicable to virtual worlds learning theories and models are contextualised and discussed from the instructional designer's perspective. Consequently, the author's perspective and understanding, in regard to the content and activities that educational virtual worlds should include, are presented and examined, with a particular emphasis on interactions. The combination of the above lead to the development of the aforementioned taxonomy, which includes suggestions and guidelines to educators and instructional designers who are particularly interested in utilising virtual worlds in HVL contexts.

1.6 Thesis Outline

The structure of the remainder of this thesis is organised as follows:

- **Chapter 2** presents an overview and comparison of the established learning theories, learning models and instructional design approaches which consist of the theoretical framework and contextual background of this dissertation. In addition, there is an overview of the existing educational frameworks that have influenced the development of the present framework, and which grounds the argument to examine the impact of interactions in HVL contexts. The chapter concludes with common instructional design scenarios and approaches that have been successfully employed in educational virtual worlds.

- **Chapter 3** presents an overview of the institutional context, such as the teaching units, their educational aims, objectives and duration. In addition, building on the outcomes of Chapter 2, Chapter 3 brings together and links the theoretical background with the instructional design decisions that framed the experiment setup of this study, as well as the chronology of the PhD progression through time.
- **Chapter 4** presents an overview of the research methodology and the research methods that were utilised. The relative merits and demerits of each approach are discussed, and the design elements of the data collection tools are described. In addition, the chapter elaborates on the reasons that led to the selection of this specific sample and the approaches that were followed for the analysis of the collected data. The chapter concludes with the data triangulation approach that was employed to ensure the validity of the study.
- **Chapter 5** presents the analysis and discussion of the collected data, derived from both research approaches, in accordance to the conducted experiments.
- **Chapter 6** develops the core interplay categories that emerged after combining the collected data via triangulation and discusses the main characteristics of the HVL approach used for grounding the conclusions of this study.
- **Chapter 7** summarises the initial hypothesis and the contributions made with respect to the requirements of a PhD. In this chapter, the *DELUSIVE* taxonomy is presented and an overall conclusion is drawn. The chapter concludes with the limitations of this research and proposes further research directions.

Chapter 2: Background of the Study

2.1 Introduction

The importance that educators be well-aware of the available learning theories (Section 2.2), so as to apply the most relevant ones in the design of their educational activities, is highlighted in the scholarly literature (Ally, 2004; Snelbecker, 1974). Grounded on these theories, various learning models (Section 2.3) emerged to describe the ‘ingredients’ for developing educational interventions. In the same vein, Ertmer & Newby (1993) urge educators to identify the most effective model that will foster learner engagement and enhance the learning outcomes.

Nevertheless, as Snelbecker (1974) suggests, there is no best approach that educators should follow, as there are many factors to consider (e.g. context, students, instructional stage), while each case is unique. Indeed, what does not facilitate learning is the abundance of abstract information related to the way that individuals learn (theories) or the corresponding models that—in a sense—break these complex concepts into manageable units. The problem lies in the fact that there is a lack of ‘know-how’. In order to overcome this issue, the so-called ‘*Instructional Design Models*’ were developed to formulate the ‘*recipes*’ for organising and delivering the learning content, in a meaningful for the learners way. They also aim to provide educators with clear guidelines and instructions on how to utilise the available tools appropriately and efficiently, as well as under which conditions and in what particular contexts (Section 2.4).

The aforementioned guidelines and instructions were (primarily) developed to aid the traditional teaching-learning approaches, while—during

the past decades—they were adjusted, altered and enhanced to address matters related to e-Learning (e.g. 2-D Learning Management Systems). As a result, the available literature related to the integration of virtual worlds for educational practices—especially during the early attempts—was limited or even non-existent. Nevertheless, neither the lack of case studies nor the considerable shortcomings and unanticipated results, affected educators' interest to further investigate the potential of these environments. In fact, a new area for research emerged, on the basis of which several conceptual frameworks and taxonomies were developed (Section 2.5).

In the final section (Section 2.6), the issues presented and discussed are the various design approaches, techniques and interventions related to the stimuli and incentives that instructional designers should offer to learners. Their aim is to help learners overcome the steep learning curve that such environments present, to reduce or even eliminate the impact of their preconceptions, as well as to facilitate interaction and, therefore, motivate them to engage in the task and learn.

Consequently, the aforementioned topics form the basis and one of the main goals of this study, the great contribution of which lies in this understanding and theorising of how the most relevant—to virtual worlds—mechanisms (i.e. learning theories/models, instructional design approaches, conceptual frameworks and design interventions) are applied in HVL contexts. It is this whole theoretical framework that will help educators and instructional designers to determine what their students can learn, and consequently practically apply the most appropriate—to each case—combination to achieve the best possible results.

2.2 Theoretical Framework: Established Learning Theories

2.2.1 Introduction

Theorising how learning occurs enabled educators to better understand learners' needs and therefore, develop the instructional experiences in a more effective way (Gagné & Briggs, 1974; Grassian & Kaplowitz, 2009; Gredler, 1997). On the same grounds, educators who utilised virtual worlds for educational and research practices, conducted their educational activities and experiments grounded on the established learning theories (Twining, 2009).

Nevertheless, one of the main advantages of such environments is the opportunity and freedom given to educationalists to replicate events occurring in real life or even explore new methods for teaching and learning (Good *et al.*, 2008). Therein, this freedom has resulted in lack of theoretical underpinning related to the relationship between the established learning theories and their application in virtual worlds, especially after considering that most of the studies related to VL are empirical and usually report the learning benefits of virtual worlds in different educational fields (e.g. Dalgarno, 2002; Dickey, 2005a; Jarmon *et al.*, 2009; Kaufmann, Schmalstieg & Wagner, 2000).

This problematic issue (i.e. lack of ad hoc learning Virtual World theory) consists the under-theorisation of research in the field. In detail, Savin-Baden *et al.* (2010) underline that the pedagogical basis for using virtual worlds is under-theorised, while Dalgarno & Lee (2010) suggest that the design of virtual worlds is more intuitive than theory-based. Moreover, according to Wang & Burton (2013), educators who use virtual worlds have more pragmatic or practical-oriented targets than some theoretical focus.

Therefore, in the sections that follow (2.2.2–2.2.5), the learning theories that have been successfully implemented in virtual worlds are briefly discussed (summarised) and correlated, with a view to support the instructional designer's role in designing educational activities and learning content.

2.2.2 Behaviorism

From Pavlov's (1897) '*classical conditioning*' to Thorndike's (1898), Watson's (1913) and Skinner's (1974) '*operant conditioning*', Behaviourism, is relying on the mechanism of '*stimulus*', '*response*' and '*reinforcement*'. According to behaviourists, learning occurs when the subject's behaviour provides the desired response (operant behaviour), after being exposed to a specific environmental stimulus (operant conditioning). To achieve the desired feedback or outcome, special emphasis is given on the importance of the consequences (reinforcement), which can be either intrinsic or extrinsic, positive and rewarding or negative and punishing (Bullock, 1982; Ertmer & Newby, 1993; Thorndike, 1911).

The success of this approach derives mainly from the subject's—or, in this case, the learner's—ability to first observe a given situation, then register the expected results as natural facts, and finally formulate them into laws to be applied in the future in the form of generalisations. To achieve this behaviour, periodic practicing is required, until the subject's readiness to provide the correct response becomes immediate (Cole, 1996; Schunk, 1991; Tomic, 1993). Another factor is the quality of the given information (stimuli) which, in turn, affects the quality of the final outcome (response) (Cooper, 1993). Furthermore, Tomic (1993), highlights the importance of scaffolding the given activities, as the learner is expected to have developed (at least) the minimum required knowledge of a learning task prior to moving on to a new one.

Behaviourism, as an educational approach, has received great criticism. On the one hand, supporters claim that the performance of students who are less motivated to work or have poor academic skills is more likely to be improved, as they perform better in well-structured environments (Breslow, 1973; Cooper, 1993; McGowan & Clark, 1985; Snow, 1977; Snow, 1984). On the other, the fact that this method concentrates on the development and acquisition of low-level skills—which are not linked to higher level cognitive schemas that are required for the processing of complex tasks—limits learners’ abilities and prevents them from becoming active thinkers (Schunk, 1991; Thompson, Simonson, & Hargrave, 1992; Wundt, 1921).

The ease with which information and feedback is repeatedly transmitted to learners in virtual worlds makes ‘operant conditioning’ viable, as it enables them to observe their progress and receive valuable (positive) reinforcement (Beetham & Sharpe, 2013; Charles *et al.*, 2011). In addition, behaviourists stress on the importance of the physical environment where the learning process takes place. However, Smith & Ragan (1999) suggest that the impact or the influence of the ‘*environment*’ (per se) is reduced, as it only contextualises the stimulus that the instructional designer controls and transmits to learner. Thereby, Nelson & Erlandson (2012) warn instructional designers not to develop complex activities with large-scale goals, as this will deconstruct the essence of the Behaviourist idea. Instead, what needs to be developed is a set of small tasks, which will build upon the feedback of interactions, until the learning goals are reached.

2.2.3 Cognitivism

Piaget (1936) developed the Cognitive Constructivism theory after associating learning with deep mental processes (*‘assimilation’*, *‘accommodation’*,

'equilibrium'). Cognitivism is acknowledged as the theory of *'mind and brain'*, and views learning as the process of intellectual growth and continued adjustment to the world (Wadsworth, 2004). According to this theory, knowledge is constructed mentally in individuals' minds and acquires a symbolic form (blocks of knowledge), named schemas (Bartlett, 1932). Consequently, learning becomes the process of imprinting these symbolic representations on memory—the so-called *'knowledge-base'*—so as to be processed and correlated in future situations (Bordwell, 1989).

During the earliest stage of cognitive development, knowledge is acquired through sensory experiences and objects' manipulation (Piaget, 1965). Subsequently, *'assimilation'* is the mental process of using existing schemas to deal with new knowledge, whereas *'accommodation'* signals the inability of the human brain to correlate new schemas with existing ones, thus, making apparent the need for adjustments or changes to be made. Lastly, *'equilibrium'*, describes the required 'force' for the knowledge to be constructed through assimilation, whereas *'disequilibrium'* refers to the accommodation process (Piaget & Cook, 1952).

Even though virtual worlds consist of non-existent objects, they lift many limitations that exist in the real world by transforming complicated or abstract concepts into concrete visualisations (Burdea & Coiffet, 2003; Jonassen, 2000). Indeed, such environments provide fertile ground for the so-called *'visualisation of cognition'*, as they allow instructors to visualise activities, scenarios, information, or even knowledge (Sanchez, Barreiro & Maojo, 2000). As a result, the users' cognition is enhanced and the *'deep learning process'* is facilitated through their vivid, visually-appealing and interactive content (Hanson & Shelton, 2008).

Nevertheless, learners with limited prior knowledge or experiences—as well as with preconceptions or misconceptions related to the non-traditional educational approaches—may influence the learning process and outcome (Moos & Azevedo, 2008; Shin, Jonassen & McGee, 2003). Indeed, lack of domain-specific knowledge may put the success of this approach at risk (Kim & Hannafin, 2011), which is why researchers (Gagné, 1988; Merrill, 2002) emphasise the importance of assimilation, when it comes to instruction planning.

Indeed, educators should consider various aspects when creating content under the principles of this theory. The learners' (past) learning experiences, and the structure or the transfer of knowledge from the virtual to the real world context, are but a few examples (Stepich & Newby, 1988). To this end, researchers (Bryceson, 2007; Weigend, 2014) suggest that instructional designers should offer learners multiple representations of content, especially when the subject is highly interconnected and complex, in order to help them organise and relate new information to their existing cognitive schemas. However, this opinion comes in opposition to the belief that others hold (e.g. Artino, 2008; Chandler & Sweller, 1991), referring to the limited processing capacity of the human brain. Indeed, the inclusion of massive visual, textual, and auditory information, as well as the complex nature of such environments, have the potential to cause '*cognitive overload*'. Therefore, when embedding virtual worlds in their teaching agenda, instructional designers are advised to follow the guidelines and frameworks that have been explicitly developed for the contextualisation of VL, so as to secure the meaningfulness of the learning outcomes (Erlandson *et al.*, 2010).

2.2.4 (Social) Constructivism

The Constructivism learning theory, as described by Dewey (1916), suggests that learners construct their cognitive structures, knowledge, and skills through interactions, while it is engagement through any kind of activity that motivates them to learn (Jonassen, 1991). Instructionism distances learners from critical thinking (Kanuka & Anderson, 1999) and perceives learning as the outcome of being taught facts or processes (Jonassen, 1991; von Glasersfeld, 1984). Contrary to that, Constructivism signalled the shift from the passive learning paradigm, where learners act as the receivers of information, to a more student-centered learning approach, where learners experiment and actively test hypotheses (Dewey, 1938; Mahoney, 2004, Huitt, 2003). According to the constructivist view, learners actively develop their knowledge by interpreting their experiences and observations, instead of seeking connections and links between past (existing) experiences or discovered knowledge (Bednar *et al.*, 1991; Bruner, 1961; Maclellan & Soden 2004; Schunk, 1991; Walker, 1990).

However, learning is also social and, thus, the social version of Constructivism (Vygotsky, 1978) suggests that interaction with multiple peers or other students leads to the development of a better understanding towards a given problem or task (Cho & Schunn, 2007). Under the prism of this approach, learners acquire knowledge through a dynamic social interaction (Snowman & Biehler, 2000; Wurst, Smarkola & Gaffney, 2008), which, in turn, enables them to communicate their understanding, thoughts, and ideas, as well as examine their perceptions towards and/or against the views and opinions of others through verbal interaction (Lee & Hannafin, 2016; Lundstrom & Baker, 2009).

Virtual worlds allow learners to develop, alter, and enhance their content in accordance to their personal learning needs and, therefore, construct their

cognitive schemas and engage with the phenomena they study (Dalgarno, 2002; Gül, Gu & Williams, 2008). Such environments feature various communication tools (synchronous and asynchronous) (Maher & Simoff, 2000), which is an essential component for the successful implementation of the Social Constructivism approach. Moreover, constructivists believe that the learner and the context in which learning takes place are connected and interdependent (Gauvain, 2001; Lave, 1988; Rogoff, 1990). Nevertheless, when the debate comes to artefact construction—which is a typical example of the application of the constructivist approach in virtual worlds—the literature is divided. On the one hand, Hmelo, Holton & Kolodner (2000) contend that artefact construction might be perceived by students as some kind of art or craft and not as part of the learning process. On the other, Harel & Papert (1991) counterargue that learning occurs when students actively design and produce tangible artefacts, as it enables them to embody understanding.

Such environments are, by definition, unable to offer learners a truly ‘real-world’ (tangible) experience (Vrellis *et al.*, 2010). However, the fact that knowledge acquisition and transfer are ‘indexed’ by experience leads to the assumption that the design of the task, the authenticity of the experience and the individuals’ ability to mentally process it and make some meaningful use out of it, are critical factors that instructional designers shall take into account when designing educational activities (Brown, Collins, Duguid, 1989; Hannafin *et al.*, 1997; Loke, 2015). Moreover, after considering that interactions—be it with the content of the virtual world or other learners—constitute the means that frame and enhance the learning experience, particular emphasis shall be given to the conclusion drawn by Aiello *et al.* (2012). According to the authors, users of such systems enter the spectrum of immersion even after interacting

within a virtual environment for as little as a couple of minutes. The lack of consciousness or awareness, also known as sense of presence, affects users' physiological condition (cognitive-sensory mechanism), and thus, leads them to perceive the simulated (i.e. non-tangible) experience as real (Riva *et al.*, 2009). Similarly, knowledge which has been actively explored and constructed in a specific context (environment) can be transferred and validated to other content areas through social negotiation (Ertmer & Newby, 1993). Hence, knowledge constructed in virtual worlds can be transferred and applied in the 'real world', under the consideration of the (Social) Constructivism principles (Cooper, 1993; Dede, 1992; Loke, 2015).

The successful implementation of the aforementioned theories in virtual worlds also relies on the shift of the educators' role (starting to emerge in the early/middle '90s) from a knowledge transmitter to that of a designer, instructor, supporter, and facilitator (Ben-Ari, 1998; Jonassen, 1991; Reigeluth, 1983). Indeed, researchers make particular mention of the shift from the teacher-centered instruction to a more learner-centered model, where the instructional goals are negotiated with the students instead of predetermined by the instructor alone. In addition, special attention should be given to the scaffolding of the task until students gain complete control of the whole process (Oliver & Herrington, 2001; Tharp & Gallimore, 1988; Yilmaz, 2008). Dalgarno (2002) warns educators that the 'real-world' experience cannot be fully simulated, as learners will miss important conclusions which can only be drawn from the real and actual experimentation. Thus, educators are advised to ensure that there is a clear correlation and explanation of the virtual world experience with regard to the real-world application (Loke, 2015). Lastly, as Vygotsky (1978) also discussed about the importance of learning by playing, instructional designers'

focus should be on developing interactive tasks with particular emphasis on the social tools of virtual worlds. In doing so, the incentives for student collaboration increase and enable learners to develop their (in-world) social presence as part of the knowledge construction process (Anderson & Dron, 2011; Dickey, 2005b; Ertmer & Newby, 1993; Zimmerman, 2001).

2.2.5 Connectivism

As the aforementioned learning theories (Behaviourism, Cognitivism and Constructivism) emerged prior to the revolution of Information and Communication Technology (ICT) and, therefore, the invention of the Internet and the World Wide Web (Dunaway, 2011), the need for development of new pedagogical approaches—aligned with the vast and ongoing evolution of technology—became apparent (Gu, Gül & Maher, 2007). Connectivism or Distributed Learning, as introduced and discussed by Siemens (2005) and Downes (2012), was a newly-formed learning theory that was established after developing understanding on how online environments can serve as networks to facilitate learning. Siemens (2006) developed the main idea behind Connective Knowledge after correlating the benefits of each of the existing learning theories and trying to counteract the limitations of each one to describe how learning occurs in the digital era (Anderson & Dron, 2011). Driven by the principle of knowledge creation and consumption, learners are becoming part of a wider information network which is generated in accordance to the individuals' needs and understandings.

As the whole Connectivism discussion was focusing on matters beyond the scope of the traditional learning theories (Bell, 2011), the practitioners' interest was attracted and debates emerged. Kop & Hill (2008) argue that Connectivism should not be regarded as a mere learning theory. Instead, they suggest that

educators should perceive it as a paradigm of autonomous learning or a theoretical framework for distributed knowledge (crediting Downes, 2006). Verhagen (2006) acknowledges the need for an educational paradigm shift but critically argues that Connectivism remains attached at the curriculum level, as its principles do not differ from the traditional theories. On the other hand, supporters of the connectivist approach acknowledge that networked learning communities enable learners to access information from multiple resources (Dunaway, 2011), promote personal development (Couros, 2009), and enable individuals to legitimise what they are doing (Cormier, 2008). Nevertheless, as learners are exposed to a continuous and changing information flow, their ability to carefully collect current and relevant information becomes a critical factor (Kop & Hill, 2008).

According to the Connectivism theory (Siemens, 2005), learning resides outside of people, as information is manipulated by technology and stored in various nodes (including virtual and augmented reality environments) (Green, 2011; Ohler, 2008). Indeed, the unique attributes and mechanisms of the virtual worlds—such as their interactive content and highly interconnected nature—led educators to consider their potential as community networks, as well as their capabilities to aid the learning process and enhance learner engagement (Bidarra & Cardoso, 2007; Carmigniani *et al.*, 2010; Chen *et al.*, 2011; Dawley, 2009; Mayer, 2001; Yuen *et al.*, 2011).

Even under the principles of this theory, the role of the educator or instructional designer is, once again, crucial. Bonk (2007) (cited from Froughi, 2015) suggests that educators should guide and direct learners to explore additional nodes (resources) which might not have been initially considered, identified, or discovered. Moreover, Ruiz (2014) (cited from Froughi, 2015)

considers the role of the educator in online environments as that of an instructor, mentor and facilitator, who monitors students' interactions (physically or as an avatar) and provides them with guidance and support by posing questions for thought and collaboration. Lastly, as Anderson & Dron (2011) suggest, the successful application of this theory in virtual worlds also relies on the available nodes (e.g. content and examples) with which instructional designers provide learners (e.g. shareable example-artefacts developed by experts or past students).

2.2.6 Summary

The discussed learning theories constitute the teaching and learning paradigm shift from the teacher-centered model (e.g. Behaviourism) to the student-centered approach (e.g. Connectivism). Unlike Behaviourism, which perceives learning as a mimicking or analogising process—where knowledge is highly dependent on the external stimuli that learners receive—Cognitivism relies on learners' mental (inner) ability to collect, process, critically examine and evaluate information prior to constructing knowledge. The success of Constructivism lies in the interaction that learners have with the environment or subject, whereas Social Constructivism—sharing the same principles with Constructivism—also emphasises on the importance of social interaction, as learners construct their knowledge through collaboration and communication with others. Lastly, Connectivism, makes possible the distribution of information and knowledge derived from various individuals in online communities and networks.

All and each one of the aforementioned theories share common properties but, also, differ greatly at specific points (Table 2.1). Similarly to the purpose of this study—which is to combine these theories in the most effective and

conducive-to-learning way so as to design instructional material and interactive learning experiences of high educational value—instructional designers, with the same goals, are advised to work accordingly and make the most out of these theories, too.

Table 2.1 Learning theories’ causes and effects.

Learn. Theory	Behaviorism	Cognitivism	Constructivism	Social Constructivism	Connectivism
Changes in...	...what individuals do (behaviour)	...individuals’ cognitive schemas	...how individuals think		...how knowledge is distributed
Cause	New behaviours due to new consequences	Cognitive conflict	The independent investigator	Assisted performance	Online communities/networks (shared knowledge)

2.3 Theoretical Framework: Established Learning Models

2.3.1 Introduction

The application of these models in the era of the so-called modern education contextualised, initially, the traditional and distance education and, at a later stage, the educational activities in virtual worlds. In the following Sections (2.3.2–2.3.7) the most relevant and applicable to VL models are described and discussed, through the perspective of the educators and instructional designers and the role they wish to adopt.

2.3.2 Experiential Learning

Kolb (1984), building upon the work from Dewey (1916; 1938), Lewin (1957) and Piaget (1936; 1965), formed and described Experiential Learning as a four-stage cycle process: ‘*concrete experience*’, ‘*reflective observation*’, ‘*abstract conceptualisation*’, and ‘*active experimentation*’ (Kolb, Boyatzis & Mainemelis, 2002).

The mechanism of this model suggests that when an individual encounters a new experience or reinterprets existing ones, followed by observation and reflection, in order to formulate abstract concepts (e.g. generalisations/conclusions), knowledge is created and can be applied in future situations to actively examine hypotheses. The aforementioned stages are presented in a logical order (Figure 2.1). Nevertheless due to their interdependency, McLeod (2017) proposes that the learning process can start at any stage, as long as the learner executes all of them.

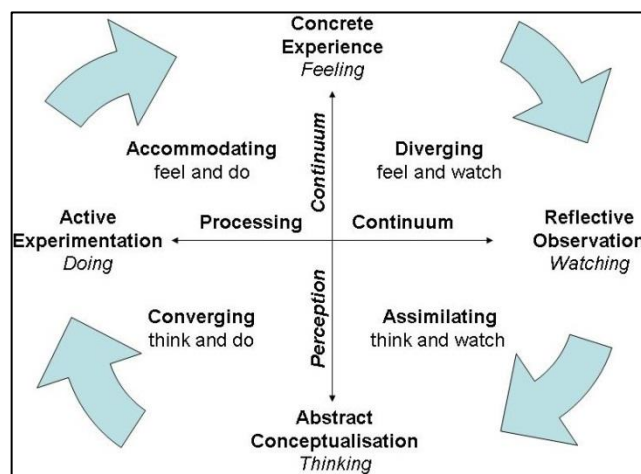


Figure 2.1 Kolb's Experiential Learning theory (Leonard & Roberts, 2016).

Experiential Learning, by definition, places students at the centre of the learning process, whilst teachers maintain the role of the facilitator and supporter. However, as Estes (2004) reports, educators often misinterpret the theoretical underpinning and principles of this model, as they maintain high levels of authority and control over their students. This can be evident especially during the reflection process, thus preventing students from making sense of the whole experience based on their own interpretation (Estes & Tomb, 1996). Therefore, educators are urged to recognize the effort required for the paradigm shift (i.e. from the teacher-centered approach to the student-centered model) and apply the techniques and guidelines from established frameworks to aid and enhance the learning process (Estes, 2004).

Reinventing the role of the educator as a facilitator of the learning process, Warren (1995) suggests that teachers should act as the ‘resource’ that guides and coaches students through their ‘journey’ of knowledge. It should be noted that students are the ones who decide by themselves what they need to learn and the teacher just urges and motivates them towards their goal (Wilson, 1995). Shor & Freier (1987) hold the opinion that the learning process should be more focused on the collaboration aspect (referring to both involved parts, i.e. teachers-students), so that learners can be enabled to create metaphors and correlations of the undertaken experience through a reflective discussion (Estes, 2004). Nonetheless, Sugerman *et al.* (2000) oppose the aforementioned statement suggesting that the reflection process should rely less on the practice of discussion and more on utilising creative techniques. However, as Brown (2002) highlights, discussion is a critical element of the reflection process and, thus, it cannot be disregarded. Consequently, Brown’s suggestion to educators is to recognise their influential role on students and reconsider their attitude accordingly.

Chittaro & Ranon (2007) have acknowledged the potential of virtual worlds to accommodate Experiential Learning, while a generic agreement can be identified in their views regarding its application and benefits (Hew & Cheung, 2010; Loureiro & Bettencourt, 2014; Minocha & Roberts, 2008). The aspect of social interactivity, the enhancement of creativity, the opportunity to actively test hypotheses and safely practice a wide variety of skills are but a few examples that—thanks to the sense of presence—enable learners to experience information, in a way similar to the real-world setting, and transfer the developed knowledge to other contexts (Chen, 2009; Jarmon *et al.*, 2009; Kalyuga, 2007).

On the antipode, the technical limitations or dysfunctions of this technology, the learners' preconceptions related to the appropriateness of these environments for teaching-learning practices, as well as their perception towards the value or application of the acquired knowledge in the 'real world' context, affect the levels of immersion in a negative way and may, therefore, deconstruct or even diminish the overall experience (Wood & Hopkins, 2008; Wood, 2009).

Fenwick (2001) argues that knowledge transfer from one context to another is, by default, not feasible, as there are no identical situations or conditions where specific patterns or sequences can be applied. However, what can be fostered is the individuals' ability to critically analyse the encountered situation and determine, based on their former experiences and knowledge, the actions that have to be taken. Indeed, as Loke (2015) suggests, this model is inadequate to explain how learners' experience in virtual worlds is transferred or translated as knowledge and skills in the real-world context. Hobbs *et al.* (2006) argue that in order for this framework to be effective, it is the intrinsic properties and affordances of virtual worlds that should be consolidated and enhanced—through appropriate instructional design with an emphasis on interactions—so as to '*inform transferable skills and provide a rich case study for learning*'. Others highlight the affordances needed to integrate virtual worlds into the classroom (extrinsic elements) (Boulos, Hetherington & Wheeler, 2007; Martinez, Martinez & Warkentin, 2007; Mayrath *et al.*, 2007; Sanchez, 2007). Lastly, as this model stresses the importance of reflection, in order to make sense of the encountered experience, educators are advised to emphasise its similarity to the real world—i.e. as if the experience were undertaken in the real-world context (Loke, 2015; Wood, 2009).

2.3.3 Collaborative Learning

Collaborative Learning (CL) refers to the synchronous social interaction (i.e. dialogue and discussion) in which the members of a group engage, when working simultaneously as a team to develop mutual understanding towards the solution of a given problem or task (Jeong & Chi, 2007; Weinberger, Stegmann & Fischer, 2007). The focus of this section lies on the characteristics of this learning model and, in particular, the affordances and limitations of Computer Supported Collaborative Learning (CSCL) (Figure 2.2).

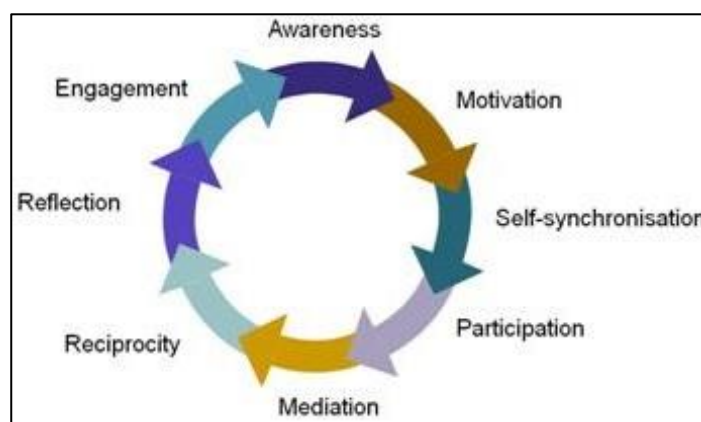


Figure 2.2 The Collaboration Life-Cycle (Creed-Dikeogu, 2015).

As Dillenbourg (1999) suggests, the additional activities (e.g. explanation, disagreement, mutual regulation) that learners perform while having social interaction with their peers, trigger a set of cognitive mechanisms (e.g. knowledge elicitation, internalisation, reduced cognitive load) that would otherwise (cf. individualised learning) occur less frequently. The learning benefits (e.g. social, psychological, academic) of CL have been extensively researched, described and categorised (Laal & Ghodsi, 2012; Slavin, 1990; Johnson *et al.*, 1991). Nevertheless, simply allocating students pair or group work towards the solution of a learning exercise, does not qualify the activity as collaborative (Dillenbourg *et al.*, 1996). Indeed, what differentiates CL from cooperative or even individualistic learning are the elements and mechanisms that frame this approach. Researchers (Johnson *et al.*, 1990; Wang, 2009) identified a set of conditions that have to be met in order for such activities to be effective. These conditions, briefly mentioned, refer to the interdependent

relationship of the team members (reliability), their accountability and responsibility to produce their share of work and communicate it to others as part of their social interactions (peer-tutoring/peer-learning), the social skills (e.g. leadership, decision-making, conflict management) that have to be developed and enhanced through the learning process, as well as the short-term group evaluation milestones that enable learners to identify their strengths and weaknesses so as to function more effectively in the future.

CSCL emphasises the role of social interactions, as the means to connect peers and teachers (online). It also takes into account the potential of technology to shape different forms of F2F interactions (Dillenbourg, Järvelä & Fischer, 2009), as they contribute positively towards the limitations of the individualised learner-system interaction (Dickson & Vereen, 1983). In addition, as Dillenbourg *et al.* (1996) report, various aspects have to be considered when designing CSCL activities so as to facilitate learning. One such example are the conditions under which the learning environment is effective or, more precisely, the conditions under which specific interactions occur and influence the learning outcome. Prinsen *et al.* (2009) also stress the importance of following established instructional design guidelines, so that learners can be enabled to construct shared knowledge and understanding (Dillenbourg *et al.*, 2009), as well as take advantage of the affordances of the involved parties (i.e. teachers-students-designers) and convert them into learning outcomes. Nevertheless, it should be mentioned that students' sociocultural or socioemotional orientations towards the context of the collaborative environment (Anderson *et al.*, 2000) or its tools (Hickey, Moore & Pellegrino, 2001; Järvenoja & Järvelä, 2005), affect their perception, behaviour and motivation in diverse ways. Therefore, research related to this model suggests that new pedagogical approaches and learning environments should be explored (Järvelä, 2001).

Virtual worlds emerged with the concept of (social) interactivity in mind, as they offer, by default, various tools and resources to facilitate interaction between users and the environment and/or other users (Kohler *et al.*, 2009; Prasolova-Førland & Divitini, 2003; Thalmann, 2001). Their potential to facilitate and support collaboration has been well

examined and addressed (cf. Benford *et al.*, 2001; Pinkwart & Oliver, 2009; Yee, 2006), without disregarding their impact on traditional education or distance learning (Gil Ortega & Facloner, 2015; Rahman, 2014; Wiecha *et al.*, 2010). According to Dillenbourg (1999), in order for a virtual environment to be qualified as collaborative, a set of features have to be present. Such features can be the distinction between the users' roles and rights, an interactive context capable of simulating multiple representation forms (similar to the ones of the physical world), the potential to integrate external technologies, as well as the compatibility with e-learning scenarios. The use of avatars notably contribute to the users' sense of shared presence and awareness, whilst it lowers inhibitions and promotes social interactivity (Meadows, 2008; de Lucia *et al.*, 2009). Moreover, the online, interconnected and real-time nature of these environments eliminates the physical distance barrier and enables groups of individuals to work collaboratively (Ehsani & Chase, 2009; Kalyuga, 2007). The aforementioned features, which are integrated in most of the existing 3-D virtual worlds, attracted the educators' interest and led them to utilise their space to implement a wide range of collaborative activities (de Lucia *et al.*, 2009; Konstantinidis *et al.*, 2010) in an equally wide range of educational fields (Salt, Atkins & Blackall, 2008).

Empirical studies related to the implementation of CSCL in virtual worlds report positive results, especially when it comes to learner engagement and motivation. However, researchers do not fail to emphasise the importance of instructional design, especially when integrating such technologies into the traditional classroom (Boulos *et al.*, 2007; Jarmon *et al.*, 2009; Konstantinidis *et al.*, 2009; Konstantinidis *et al.*, 2010; Mayrath *et al.*, 2007; Pirker, 2013; Sanchez, 2007; Thompson & Rodriguez, 2004). Lastly, as in all the aforementioned learning models, in CSCL educators have to reconsider their role and relationship with their students, since they should act as facilitators, instructors and collaborators (Blumenfeld *et al.*, 2006; Laal, Khattami-Kermanshahi & Laal, 2014).

2.3.4 Situated Learning

Lave & Wenger (1991) opposed the idea of passive learning and suggested that learners should actively acquire, construct and associate knowledge, through relevant experiences, in the same context that is applied in practice. Situated Learning is, therefore, fundamentally influenced by the nature of the activity, as well as the context and the culture in which it takes place (Figure 2.3).

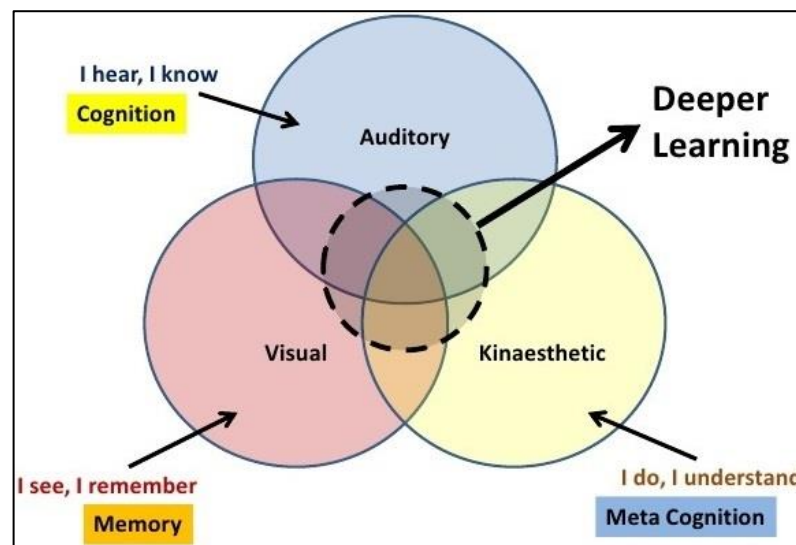


Figure 2.3 Situated Learning Elements (Wheeler, 2012).

As the principles of this model place particular emphasis on the authenticity of the context, Brown *et al.* (1989) suggest that Experiential Learning can be best applied in situations similar to cognitive apprenticeships, as these genuinely enable learners to ‘live’ authentic experiences. Others (Tripp, 1993; Wineburg, 1989), further elaborating on the aforementioned statement, report that the traditional teaching-learning approaches lack the learner-expert (master) interaction and, thus, the application of this model in the traditional classroom becomes unavailing. Contextualisation of learning has been extensively researched and highlighted in studies emerging from the field of experimental psychology (cf. Godden & Baddeley, 1975; Smith, Glenberg & Bjork, 1978). Still, though, grounding strict or explicit generalisations to context sensitivity is more applicable or relevant to cases where the subject is taught

explicitly in a single context (Bjork & Richardson-Klavehn, 1989). Indeed, retrieving knowledge from or applying it in different contexts is expected to be more challenging (Eich, 1985). Nevertheless, that should not lead to the conclusion that knowledge transfer cannot or does not occur (Anderson, Reder & Simon, 1996).

When this model was proposed by Lave & Wenger (1991), computer-supported education—and even less so VR—was not included in the authors’ list as one of the potential extensions or applications. As a result, instructional designers who opted to implement this model at the early stages of computer-based applications received great criticism due to the fact that they were deviating from the idea behind this model (Hummel, 1993). On the other hand, Harley (1993) opposed this belief and emphasised the potential of educational technology to bridge the gap between the real-life setting and the traditional classroom, especially through the use of VR environments, without diminishing or compromising the idea of an authentic context. Likewise, Reeves (1992) highlighted the benefits of offering learners opportunities for simulated apprenticeships and the capabilities of such environments to support educational activities. McLellan (1994) examined the principles of this model and concluded that—aside from the actual work setting—its application can be equally effective in the context of “*a highly realistic or ‘virtual’ surrogate of the actual work environment*”.

Indeed, the implementation of this model in virtual worlds has been highly appreciated over time, as a wide variety of educational activities—from almost all scientific disciplines and subject areas—have been successfully accommodated within the VR contexts (e.g. Dawley, 2009; Hew & Cheung, 2010; Johnson *et al.*, 2007; Warburton, 2009). The successful implementation of this

model significantly relies on the role of the instructional designer and the enhancement of the in-world opportunities for interaction, as they provide learners with the purpose and motivation required to keep them engaged with and interested in the learning environment and activities (de Freitas *et al.*, 2010). Therefore, providing learners with a realistic and interactive content is expected to offer them activities that are authentic enough, so as to make the training experience as similar as possible to real life (Loke, 2015). Van Rooij (2009) stresses the importance of scaffolding the situation under investigation in order to meet the different needs and capabilities of learners, whilst Warburton (2009) suggests that the most powerful motivator is the ability given to learners to design and develop their own content. Others (Barab *et al.*, 2007) draw attention to the role and importance of avatars as the medium that enables learners to develop situated embodiment (sense of presence) (Dede, 2009; Winn, 2003) or communicate with other users (social interaction) (Dawley & Dede, 2014).

2.3.5 Problem-Based Learning

Savin-Baden (2000) identified a gap between the skills (both discipline-related and social-oriented ones) offered to students by academic institutions, and those skills' inadequacy to prepare students to solve real-life problems that require critical thinking and analysis. Problem-Based Learning (PBL) bridges this gap and enables learners to construct their knowledge through various transitions.

As a student-centered approach, great emphasis is placed on the learners' role to work independently and study in a self-directed way (Figure 2.4) (Hamilton, 1976; Neufeld & Barrows, 1974). Likewise, educators also acquire a new role—that of the active observer—as they are expected to interfere only when their students are disoriented or in need of assistance (Allen, Donham &

Bernhardt, 2011; Schmidt, Cohen-Schotanus & Arends, 2009a).

The main principles of this model require educators to:

1. provide learners with a set of problems as the inception point of study,
2. offer flexible guidance during the solution development process,
3. reduce the lecture-hours, and
4. ensure that ample time for self-study is timetabled (Schmidt *et al.*, 2009b).

On the other hand, students are expected to:

1. research and critique a wide range of information,
2. identify the existing and additional skillset that needs to be employed, so as to manage their task more effectively, and
3. work collaboratively with other students that may have different backgrounds, skills, understanding and perception, in order to reach a common solution or the required outcome (Savin-Baden, 2000).

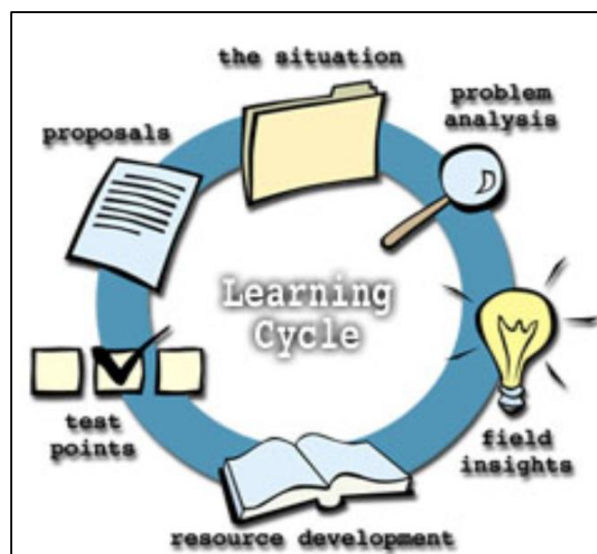


Figure 2.4. The Problem-Based Learning Cycle (Tes Teach with Blendspace, 2018).

However, the emergence of this model triggered various debates regarding the quality of the acquired knowledge (Colliver, 2000), as well as the effectiveness and efficiency of this approach, as the guided instruction that learners get is minimal—compared to even direct instruction (Kirschner, Sweller & Clark, 2006; Klahr & Nigam, 2004). On the other hand, proponents of

PBL, consider it as the cognitive-constructivism approach, where the main objective is to enable students to develop flexible mental models of the world (Hmelo-Silver, 2004; Norman & Schmidt, 1992; Schmidt, 1993; Schwartz & Bransford, 1998). Others (Barrows, 1990; Barrows & Tamblyn, 1980; Hmelo, 1998; Hmelo & Ferrari, 1997) define it as a process of inquiry and emphasise its role to foster the acquisition of inquiry or problem-solving skills. Lastly, taking into account the vast evolution of science, PBL can be considered as a tool for '*learning how to learn*' instead of an approach to teach a specific subject (Schmidt *et al.*, 2009a; Schmidt *et al.*, 2009b; Silen & Uhlin, 2008).

One of the main principles of PBL suggests that students learn by '*mimicking the thinking process of experts*' (Hmelo, 1998; Hmelo & Ferrari, 1997). Therefore, applying this model in the context of virtual worlds—as the learning space to enact, visualise and simulate real-life case-based scenarios (designed and supported in cooperation with experts)—is considered to be highly beneficial (Beaumont *et al.*, 2014; Good *et al.*, 2008; Vosinakis & Koutsabasis, 2012). Others (Garrison *et al.*, 2000; Garrison & Anderson, 2003; Rourke *et al.*, 1999) emphasise the importance of the sense of presence as one of the key elements that make the implementation of this model in virtual environments successful.

However, as opposed to the way that PBL is applied in the real world context—where students may refer to similar cases or identify examples of existing solutions—working in the environment of a virtual world sets learners (ineluctably) in the position of designing and developing solutions almost from scratch (Good *et al.*, 2008). To overcome this problem, Vosinakis & Koutsabasis (2012) propose an instructional design approach that can be summarised in three main categories:

1. design of the PBL activities (organisation, support, scaffolding and technical assistance),
2. design of the virtual world environment (selection of platform, development of interactive tools, construction and configuration of the workspaces), and
3. evaluation of the instructional design process (formative/summative feedback on the activities).

2.3.6 Game-Based Learning

Game-Based Learning (GBL)—also abbreviated as DGBL (Digital Game-Based Learning) when digital games are used—is usually associated with the terms gamification, edutainment or serious games. Considering this diversity of names, several definitions have also been proposed. Prensky (2001) introduced and described GBL as the ‘*marriage of educational content and computer games*’. Deterding *et al.* (2011) refer to gamification as ‘*the use of game design elements in non-game contexts*’. Anikina & Yakimenko (2015) define edutainment as the implementation of technological innovations (e.g. multimedia, computer software) in traditional education, where ‘*games whose first purpose is not mere entertainment*’ (Michael & Chen, 2006) are introduced, aiming to ‘*support learning in its broadest sense*’ (Stone, 2008) and, are hence, classified as serious. Whatever definition is opted for, the main idea of this approach remains the same: students learn through the game instead of how to play the game (Wu *et al.*, 2011) (Figure 2.5).

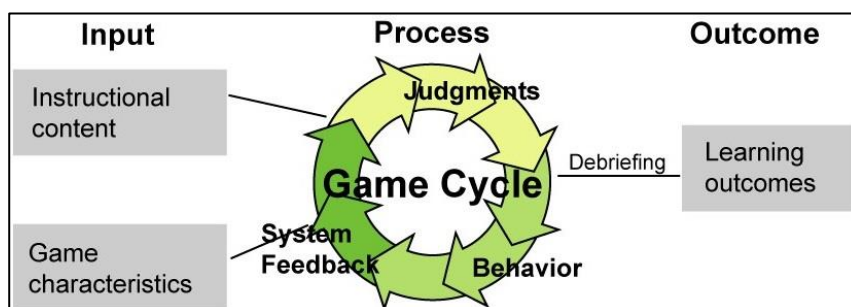


Figure 2.5. Game-Based Learning model (Garris, Ahlers & Driskell , 2002).

Therefore, the essence of this model is to invoke psychological experiences—similar to the ones that games do through their rich and visual appealing aesthetics—and motivate learners to engage with the learning activities (Huotari & Hamari, 2012; Poole, 2000).

Bober (2010) distinguishes GBL activities into two main categories: learning directly from [playing] the game (constructivist approach) and learning from teacher-driven activities related to the game (instructional approach). Proponents of active construction (Aldrich, 2009; Bouras *et al.*, 2004; David & Watson, 2008; Gee, 2003; Kiili, 2005; Mawdesley *et al.*, 2011) emphasise the opportunities offered to learners to practice the so-called soft skills (e.g. decision-making, problem solving, communication, collaboration, team work) that cannot be easily taught in isolation. Those soft skills can, however, be practiced through ‘coopetition’—collaboration with group members and competition between groups—(Fu & Yu, 2008; Ke & Grabowski, 2007) or ‘player-learner’ experience (Warburton, 2009). On the other hand, others consider it essential to employ pedagogical and instructional approaches, so as to maximise the learning benefits and outcomes (Bopp, 2006; Gibson, 2006; Van Eck, 2010). Prensky (2001) bridges these viewpoints and suggests that the consequences of trial and error (failure to achieve the game’s goals) can be transformed or translated into feedback on and explanation of the learners’ actions (through the use of instructional material). This way, students are enabled to evaluate their decisions.

The aforementioned studies grounded the development of frameworks (e.g. de Freitas & Oliver, 2006) that have also been employed in conjunction with other established learning models (e.g. Arnab *et al.*, 2011; de Freitas & Neumann, 2009; White *et al.*, 2007). This bridging has resulted in a great

number of positive outcomes, especially on motivation and engagement, compared to just employing traditional learning techniques (Carnevale, 2003; Kim & Ke, 2017; Kim, Park & Baek, 2009; Knight *et al.*, 2010; Xu, Park & Baek, 2011; Young *et al.*, 2012; Zyda, 2005). However, despite the reported benefits and applications of GBL, researchers still maintain a high degree of scepticism towards its effectiveness on the learning process. Indeed, balancing between playability and pedagogy is a rather challenging task that educators and instructional designers ought to consider carefully and sensibly (Baek & Kim, 2005; Kim *et al.*, 2009).

Even though GBL is yet another example of student-centered learning model, Garris, Ahlers & Driskell (2002) suggest that teachers should not isolate themselves from the learning process, but instead opt to foster participation and engagement through direction and support. Van Eck (2007) advises educators to blend the game elements with the instructional activities, so as to extend the context of the game into the physical classroom. Pivec, Dziabenko & Schinnerl (2004) list a set of factors that educators have to consider before adopting a game-based approach. One such factor is the development of a clear understanding of the subjects that GBL can support, as well as of the skills that can be developed in order to benefit learners. Another factor is the identification of the most suitable game for a given subject, as well as of the learning stage and the instructional method that should be deployed. Others (de Freitas & Jarvis, 2009; Mendez, de Freitas & Gaona, 2009) focus on aspects related to the representation of the game—such as the fidelity of graphics, the interactivity or immersiveness of the context—within which the learning activities take place. As Deterding *et al.* (2011) suggest, gamified activities should be implemented with the same affordances required to design and develop virtual games in order

to motivate and engage learners. Nevertheless, given that the psychological characteristics or affordances that stem from games are not explicitly identified, various instructional design approaches are framed under the gamification idea (Hamari, Koivisto & Sarsa, 2014). To conclude, as Hirumi *et al.* (2010) claim, ‘for the most part, instructional designers know little about game development and video game developers may know little about training, education and instructional design’.

2.3.7 Agent-Based Learning

The main principle of Agent-Based Learning refers to the enrichment of Virtual Learning Environments (VLEs) with autonomous agents so as to support the learning process (Heidig & Clarebout, 2011; Moreno, Mayer & Lester, 2000), improve the Human-Computer Interaction (HCI) experience, and increase learner engagement (Soliman & Guetl, 2010). Kirsh (1997) argues that interaction requires the active cooperation and coordination of at least two intelligent parties, and further mentions that HCI is limited only to the artificial understanding of the machines to which users have to adapt, due to the absence of social intelligence. Undoubtedly, the potential of Artificial Intelligence (AI) is yet to be fully reached (Klüwer *et al.*, 2010). However, the evolution of algorithms to develop AI agents⁷ has advanced and never ceases to evolve. Indeed, the idea of populating virtual worlds with Non-Player Characters (NPCs), as originally introduced by the game industry, has proven to be quite successful and has positively affected player experience (Dickey, 2005c; Umarov & Mozgovoy, 2014).

The design of these entities (usually) includes a combination of image presence, voice and/or text-based personalised language or even non-verbal

⁷ Autonomous virtual characters with a dynamic model driving their actions.

communication (Atkinson, 2002; Clark & Mayer, 2002; Craig, Gholson & Driscoll, 2002; Johnson *et al.*, 2000; Luck & Aylett, 2000; Mayer, Dow & Mayer, 2003; Moreno *et al.*, 2000). According to Garrido *et al.* (2010), the roles and the capabilities that the so-called Pedagogical Agents⁸ (PAs) may undertake, vary.

This variety (Figure 2.6) can be interpreted due to their utilisation in order to provide learners with:

1. additional instructional support and guidance through social interaction (Clark & Choi, 2005; Terzidou & Tsiatsos, 2014; Grivokostopoulou *et al.*, 2016; Soliman & Guetl, 2013),
2. interactive demonstrations (Rickel & Johnson, 1999; 2000),
3. navigational guidance (Lester *et al.*, 1999a),
4. attentional guiding (Lester *et al.*, 1999b; Noma, Zhao & Badler, 2000) or
5. motivational boost (Elliott, Rickel & Lester, 1999; Zakharov, Mitrovic & Johnston, 2008).

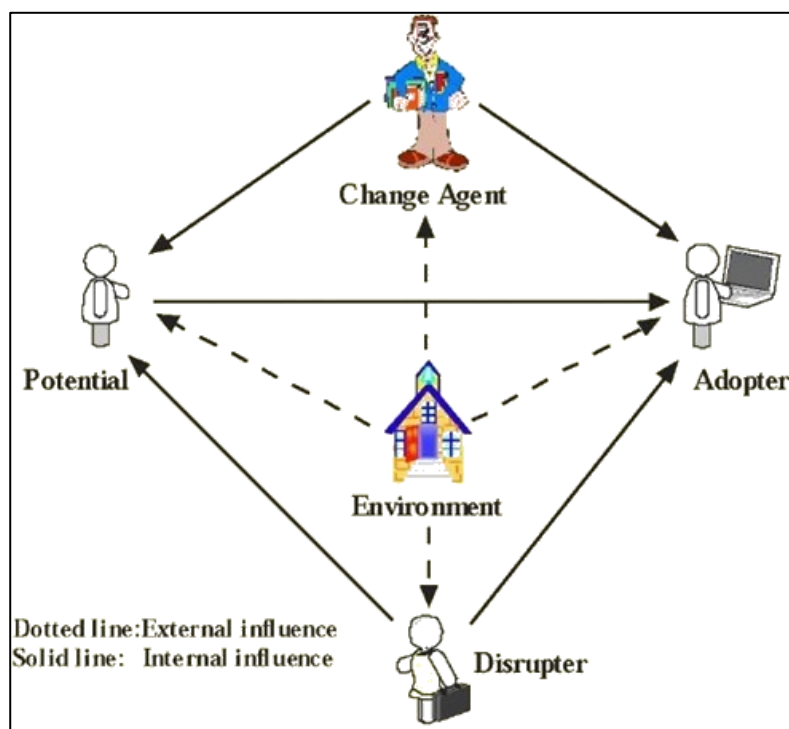


Figure 2.6. Agents and influences (What-when-how.com, 2018).

⁸ Intelligent agents utilised to cover educational needs.

However, the aforementioned viewpoints oppose the opinion of others who argue that PAs make no difference in the learning process and outcome (knowledge retention and/or transfer) (Dirkin, Mishra & Altermatt, 2005; Dunsworth & Atkinson, 2007; Moundridou & Virvou, 2002; Perez & Solomon, 2005), as well as in learner motivation (Baylor & Ryu, 2003; Domagk, 2010). Others suggest that the presence of PAs may even distract learners from the learning content and objectives (Dehn & van Mulken, 2000; Garrido *et al.*, 2010). Lastly, only a few studies report (partially) positive results. Clarebout & Elen (2006) noted some positive outcomes on retention, yet no difference in the knowledge transfer performance, whilst Plant *et al.* (2009) identified a link between the gender of the agents and their impact on learner motivation.

As Heidig & Clarebout (2011) argue, educational studies that report findings from the use of PAs, focus mostly on their technical characteristics (e.g. perceived intelligence and usefulness of the characters, credibility, entertainment value), however completely disregard their educational (didactic) nature. Indeed, besides the aforementioned technical affordances, instructional designers should also consider the role of the ‘persona’ (Baylor & Kim, 2005) and its impact on the learning process (Clarebout *et al.*, 2002). To that respect, Heidig & Clarebout (2011), propose in their review study a set of interdependent elements (referring to them as ‘*conditions*’) which the instructional designers should carefully take into consideration, when designing PAs in VLEs.

These conditions, briefly mentioned at this point and further elaborated in the following sections, are:

1. Learning environment and topic: desktop-VR versus head-mounted display and the learning subject that the PAs will support.

2. Learners' characteristics: cognitive (e.g. prior knowledge, academic competence) and metacognitive (knowledge transfer) factors.
3. Function and role of the PA: the nature of the instructional support that PAs offer (Section 2.6.3.4).
4. Design features of the PA: (classifying them in three layers) global level, medium level, and detail level (Section 2.6.3.4).

The above frameworks (cf. Ahn & Picard, 2005; Domagk, 2010) have attempted to map the principles and address the affordances required to design PAs. Nevertheless, the main conclusion that most of the aforementioned studies have drawn remains the same: whichever approach is used to integrate and adopt this architecture in virtual worlds, the PAs' ability to aid the learning experience and foster the educational process still remains blurred. Likewise, their impact on the learning outcomes is questionable. It should also be mentioned that, after reviewing the literature for this study, no study was identified that would combine all—or at least most of—the aforementioned elements (guidelines) in one PA entity. Therefore, utilising this learning model in virtual worlds requires careful consideration and concurrent support from the teaching team, as AI has not yet fully reached the level of autonomy required to replace efficiently, or to a reasonable extent, the role of educators.

2.3.8 Summary

The interactive nature and the visually appealing aesthetics of virtual worlds provide fertile ground for the integration and implementation of different types of educational activities. Moreover, utilising the principles of the presented learning models to design the instructional interventions maximises the potential and affordances of the VLE, increases the effectiveness of the learning experience, and has positive effects on learner engagement and motivation.

In the same vein as in the discussed theories, the presented models share many common characteristics. However, they also present some unique benefits, as they are specialised in particular tasks and activities. The conclusions drawn from the literature review highlight:

1. the importance of developing authentic activities (similar to the ones that take place in the real world),
2. the opportunity given to students to actively construct and acquire knowledge both as independent learners and collaboratively (through safe trial and error practicing), and
3. the increased opportunities for peer-tutoring and peer-learning (construction of shared knowledge and understanding).

In addition, special emphasis is placed on the impact that the sense of virtual presence (embodiment) has on learner engagement.

Nevertheless, researchers do not fail to mention the challenges, obstacles and limitations that exist when integrating these models in virtual worlds for educational practices. Educators are, therefore, expected to take into consideration certain aspects, prior to employing virtual worlds for educational practices, such as:

1. students' difficulty to adapt and familiarise themselves with the interface or the implemented tools at least during the early stage,
2. the 3-D modeling capabilities and technical limitations of these environments which affect the realism and authenticity of the activities, and
3. the elements that distract students' attention and, thus, prevent them from focusing on their task.

Table 2.2 Learning models: affordances and limitations overview (Highlights of Sections 2.3.2–2.3.7).

Learning Model	Principle	Learning Process	Educators' Role	Instructional Design	Limitations	Knowledge Transfer
Experiential Learning (Section 2.3.2)	Concrete experience – Reflective observation – Abstract conceptualisation – Active experimentation	Active testing of hypotheses & safe practicing of skills	Facilitators, supporters, resource of information	Support & enhance the intrinsic properties & affordances of virtual worlds through interactions Emphasis on & improvement of the virtual world's social tools Design of group-oriented activities	No identical situations to apply specific patterns/sequences	Behaviourism, Cognitivism, Connectivism
Collaborative Learning (Section 2.3.3)	Use of synchronous social interaction to develop mutual understanding towards the solution of a problem	Activities that include role- play, simulation, visualisation, programming	Facilitators, instructors & collaborators with students	Development of highly realistic context & activities	Students' orientations & preconceptions towards the context of the learning environment	(Social) Constructivism
Situated Learning (Section 2.3.4)	Knowledge is actively constructed & acquired through relevant experiences in the context that is created & applied in practice	Impression of undertaking activities authentic enough	Replication of the learner-expert apprentice situation	Development of highly realistic context & activities	Context sensitivity in which the learning activity is undertaken	Cognitivism
Problem-Based Learning (Section 2.3.5)	Development of learners' ability to perform independent & self-directed study	Research information, identify the required skillset & work collaboratively to develop the solution for the given problem	Provide learners with well-designed problems & flexible guidance	Visualise & simulate real- life scenarios Offer flexible guidance	Lack of examples/similar cases to support the solution-finding process	(Social) Constructivism, Connectivism
Game-Based Learning (Section 2.3.6)	Invoke psychological experiences, similar to the ones that games do, to motivate learners to engage with the learning activities	Learn through the game instead of how to play the game	Foster participation & engagement through direction/support	Activities should be designed with the same affordances required to develop virtual games	Balancing between playability & pedagogy	Behaviourism, (Social) Constructivism
Agent-Based Learning (Section 2.3.7)	Offer students one-to-one tutoring benefits in contexts where would otherwise get one-to-many or not at all	Through the use of different instructional approaches (e.g. social, cognitive, conceptual)	Supporters & instructors	Development of sophisticated algorithms to provide immediate & customised instruction/feedback to learners	High design affordances Questionable effectiveness	Behaviourism, Cognitivism, (Social) Constructivism

2.4 Conceptual Framework: Instructional Design Principles

2.4.1 Introduction

Reigeluth (2013) defines instructional design as the process of providing ‘*explicit guidance on how to better help people learn and develop*’. In other words, instructional design theories aim—through the guidelines provided—at helping educators to ‘*translate*’ the abstract concepts of the relevant learning theories and models (Sections 2.2-2.3), and apply them efficiently and effectively on the design of educational interventions.

Even though different instructional design models, frameworks and systems have emerged to support educators in organising and preparing their interventions (Dudhagundi, 2018), their fundamental principles and patterns remain similar. As Reigeluth (2013) suggests, instructional design theories have the following characteristics in common:

- They focus on providing educators with guidance and instruction on how to achieve a set of given objectives in order to facilitate learning and development (*design-oriented theories*), instead of discussing and describing the effects and results of given events (*description-oriented theories*).
- They provide methods of instruction on how to support the learning process and describe the situations in which these methods are applicable.
- Their methods are analysed into more detailed components, so as to provide additional guidelines and instructions to educators related to the different/individual elements, as well as the ways to perform each method.

- Their methods are probabilistic instead of deterministic. In other words, they focus on controlling different variables (in the learning environment) that will potentially increase the chances of attaining the learning objectives, instead of describing the learning objectives or guaranteeing that the learning outcomes will be achieved.

In the following sections (Sections 2.4.2-2.4.4), the most relevant, to *Digital Instructional Design*, theories are presented in the following order:

- **TPACK:** *Know why* instructional designers should combine knowledge and expertise in different fields (Technology, Pedagogy, Content).
- **Bloom's Taxonomy of Educational Objectives:** *Know how* to describe and set the educational objectives.
- **7Cs:** *Know what* the fundamental steps to design and develop educational interventions are, as well as how to evaluate them and their learning outcomes.

2.4.2 The Technological Pedagogical Content Knowledge Framework

The Technological Pedagogical Content Knowledge (abbreviated as TPACK for pronunciation purposes) conceptual framework was developed as a theoretical foundation, after taking into account the intense utilisation and integration of the ICTs in the educational context. Mishra & Koehler (2006), the authors of this framework, utilised the Pedagogical Content Knowledge framework of Shulman (1986; 1987, cited from Mishra & Koehler, 2006), as their theoretical basis, and investigated the aforementioned topic in the context of a five years longitudinal study. The triggering point that led them to explore this area was the assumption that the mere utilisation of ICT to facilitate the educational process is not sufficient. Consequently, their aim was to identify how such

technologies can be integrated and incorporated effectively, so as to support and aid the educational practices. As an initial response, Mishra & Koehler (2006) raised the need for educators' further professional and educational development, and proposed this conceptual framework as the medium to achieve it.

The framework identifies three domains of educational knowledge:

- The ***Knowledge of Content***: knowledge related to the taught subject, the theory that governs it, and the methodologies for investigating matters related thereto.
- The ***Pedagogical Knowledge***: knowledge related to the established learning theories, models and practices (i.e. the way that students acquire and construct knowledge), the perception required to identify the learners' needs, and the approaches that the educator can utilise to facilitate the learning process.
- The ***Technological Knowledge***: knowledge related to the technological literacy and understanding of different technologies with particular emphasis on ICT.

Mishra & Koehler (2006) illustrate the aforementioned elements inside closed curves (circles) and correlate them using a Venn diagram (overlapping circles) to discuss the newly developed knowledge domains (Figure 2.7):

- The ***Pedagogical Content Knowledge***: knowledge related to the utilisation of the appropriate learning methods, approaches and techniques, in order to facilitate students to acquire and construct their knowledge in a particular scientific field.
- The ***Technological Content Knowledge***: knowledge related to the technological tools and applications that can be utilised to perceptualise the content of the subject under consideration.

- The ***Technological Pedagogical Knowledge***: knowledge related to the existence of different technological tools and applications, their usefulness, the ways they can be utilised, and the changes they can implement on the learning process.

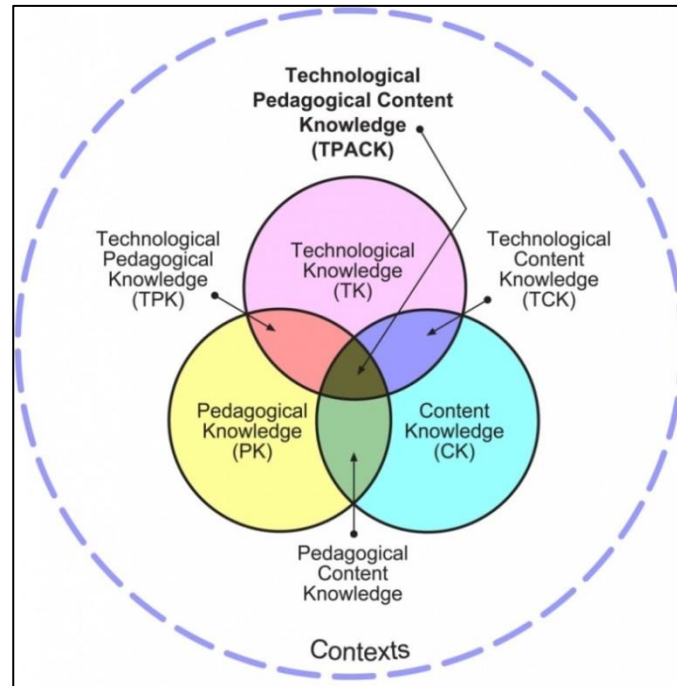


Figure 2.7 The TPACK conceptual framework of Koehler & Mishra (2009).

A well-informed instructional designer, is expected to have a solid knowledge and a clear understanding of all and each one of the discussed areas. However, after considering the presented elements in conjunction with one another, a new knowledge area is developed, as described and summarised by the TPACK framework. Indeed, as the designers of this model underline, *‘TP[A]CK is the basis of good teaching with technology’* (Mishra & Koehler, 2006, pp. 1029). Therefore, acquiring and possessing the competences of this framework, enables designers of educational interventions to appropriately utilise the available technological tools, carefully design their educational activities and, consequently, efficiently and effectively guide their students towards acquiring and constructing knowledge in the various scientific domains.

It can, thus, be concluded that the integration of ICT tools in the educational process is a rather complex venture; especially considering that instructional designers ought to concurrently orchestrate information, knowledge and skills deriving from three different domains, and use them in a dynamic learning environment where the conditions change at a fast pace (Koehler & Mishra, 2009). As the initiators of this framework highlight, its usefulness is attributed to the mapping of the interactivity it offers, as well as the linking of the various forms of knowledge that educationalists have (Koehler & Mishra, 2009). Moreover, it enables them to identify the strengths and weaknesses of the available technological tools. That way, they can be best incorporated into the educational process in a more efficient way.

2.4.3 Bloom's Taxonomy of Educational Objectives

The *Taxonomy of Educational Objectives* (originally published in 1956) is a conceptual framework that enables educators and instructional designers to more effectively hierarchise their educational objectives, when designing activities and interventions (Bloom *et al.*, 1956). Even though the authority of this idea is attributed to Bloom (also known as Bloom's taxonomy), the development of the taxonomy is the outcome of the collective and cooperative work of more researchers (Krathwohl, 2002). The taxonomy (Krathwohl, 2002; Churches, 2008) classifies the educational objectives in six structural levels which are presented in a hierarchical order:

1. Knowledge,
2. Comprehension,
3. Application,
4. Analysis,
5. Synthesis, and

6. Evaluation.

It should be noted that all but the *Application* level expand to additional subcategories.

The revised version of this taxonomy was developed a few decades later, by Bloom's students and former colleagues (Anderson *et al.*, 2001 cited from Krathwohl, 2002), in an attempt to update and modernise the theoretical framework, after considering and including the latest pedagogical advancements (Bümen, 2007) (Figure 2.8).

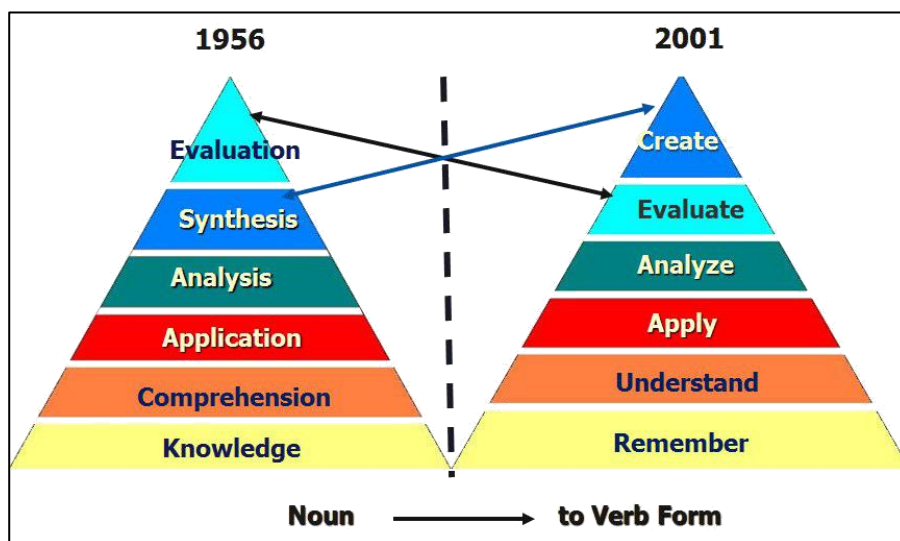


Figure 2.8. Changes in Bloom's taxonomy (Wilson, 2014).

The most significant differentiation between the two versions is the use of *verbs* instead of *nouns* for each level of objectives (Churches, 2008), on the grounds that educators use verbs to formulate their learning objectives and indicate what students will be able to do after the completion of the learning intervention (Krathwohl, 2002). In the same vein, the educational objectives Knowledge, Comprehension and Synthesis were changed to Remember, Understand and Create, while, the objectives Application, Analysis and Evaluation were replaced by their verb forms Apply, Analyse and Evaluate. In addition, a structural change also occurred, swapping the top-tier categories with each other (Krathwohl, 2002).

Krathwohl (2002) describes the new categories and their objectives as follows:

1. **Remember**: learners' ability to recognise and recall relevant knowledge from their long-term memory.
2. **Understand**: learners' ability to manage the information received during the educational process (interpretation, classification, comparison, explanation, giving examples, drawing conclusions, and summarising).
3. **Apply**: learners' ability to perform actions and appropriately use relevant techniques and procedures in specific contexts.
4. **Analyse**: learners' ability to separate the elements of a body of knowledge, recognise the correlation between the constituent parts and their contribution towards the development of an overall structure or purpose.
5. **Evaluate**: learners' ability to perform judgments based on certain criteria and standards.
6. **Create**: learners' ability to compose individual elements in order to create a new and coherent set of elements or a completely new product.

Even though the revised version aligned, to a great extent, with the approaches and tools that educators have been using in the digital learning era, Churches (2008; 2010) developed a *digital-oriented* version of Bloom's taxonomy, after considering the educators' needs when designing activities in these alternative learning contexts. This taxonomy provides additional guidelines and instructions to educators related to the identification, adoption and utilisation of the tools and techniques that will enable them to fulfil their goals.

2.4.4 The 7 Cs of Learning Design Framework

The 7Cs of the Learning Design framework was developed and described by Gráinne Conole (2014) in the context of an interuniversity collaboration between

the Open University (UK) and the University of Leicester. Its primary aim is to guide and support educators to effectively integrate the available ICTs in the design and development process of pedagogically-oriented activities and interventions (Conole, 2016). Moreover, as suggested by Mishra & Koehler (2006), the aforementioned framework has been designed in accordance to, as well as in alliance with the principles and guidelines of TPACK.

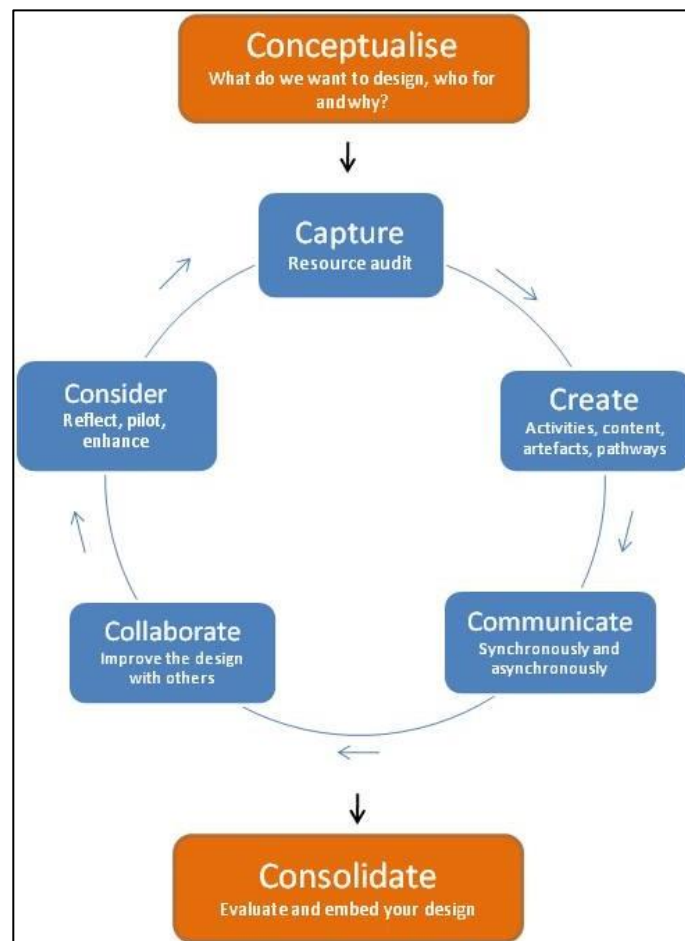


Figure 2.9 The 7Cs of the learning design (Conole & Wills, 2013).

The name of this model (7Cs) derives from the initial letter of all the seven elements that have to be taken into account and be included in the design process of the educational interventions (Conole & Wills, 2013). Figure 2.9 illustrates the stages and the distribution of the structural elements of this framework.

In particular, the first stage (*Conceptualise*) describes the vision that educators have regarding the design of the activity, while the following five elements (*Capture, Communicate, Collaborate, Consider, Create*) are taken into account concurrently during the activity planning stage. Lastly, the final stage (*Consolidate*) refers to the implementation and evaluation of the program.

1. The ***Conceptualise*** element refers to the initial design stage, during which the context of the educational scenario is formulated (Conole & Wills, 2013).

In detail, in this stage (Conole, 2014):

- The learners' characteristics and educational needs are taken into consideration.
- The educational goals are set, since they constitute the guideline for the selection of suitable activities.
- The main principles of the course, in which the scenario is integrated, are highlighted. The key educational points are also identified, so as to ensure that the educational content will be thoroughly covered.
- The pedagogical theories, which form the basis for the activities to be designed in the next stage are identified and reported.
- The approaches that educators will utilise to guide and support their students are noted.
- The types and the content of the activities are reported.
- The methods that will facilitate the collaboration and communication between the stakeholders are designed and organised.
- The methods and tools that will be utilised for student evaluation and self-evaluation are designed and described.

2. The **Capture** element refers to the exploration of the available resources, and the evaluation of their utilisation. It also refers to the identification of the appropriate tools that will enable educators, on one hand, to design and develop their learning activities, and students, on the other, to compose their work. Nevertheless, in the event that the required medium(s) or tool(s) cannot be identified in order to cover the needs of one or more educational objectives, educators are expected to create their own (Conole, 2013; 2014).
3. The **Create** element refers to the process of creating the educational intervention (Conole & Wills, 2013). During this stage, educators define the fundamental characteristics of the activities (i.e. type, nature and content) in which their students will engage. Moreover, the required resources (e.g. materials, tools or applications) are developed. These are the ones identified as shortcomings in the context of the previous element (2. *Capture*), since educators have to create them themselves. The last step of this element requires the development of a timeline that will define the creative inter-connection of all the activities (Conole, 2014).
4. The **Communicate** element refers to the planning process of the communication methods, approaches and tools that will enable the involved stakeholders (i.e. students and educators, both as individuals and/or as members of a team) to communicate efficiently and effectively while the learning activity is conducted. In particular, during this stage educators: (a) define the communication tools that will be utilised, (b) allocate the students' role(s) within the teams (if applicable), and (c) map the communication network that will be developed in and out of the classroom between the involved parties (Conole, 2014). Lastly, as this framework places particular emphasis on the distance or blended learning scenarios,

the selection and use of both synchronous and asynchronous communication tools is highly recommended. That way, the smooth communication and collaboration of the involved parties can be ensured, in cases where F2F social interaction cannot be facilitated (Conole, 2013).

5. The ***Collaborate*** element—which, as a side note, is directly linked to 4. ***Communicate***—refers to the methods and the extent to which students will cooperate (Conole, 2014). In this stage, the educator determines whether the students will be working individually or in groups (of two or more), as well as the approach that will be used for the allocation of responsibilities. However, as this model stresses on the importance of developing collaborative activities, the use of collaborative mediums and tools that will enable students to actively participate in the learning process—both in the physical classroom and in distance/blended learning scenarios—is highly encouraged and recommended (Conole & Wills, 2013; Conole, 2013; 2016).
6. The ***Consideration*** element refers to the methods (guidelines and instructions) that will be utilised to support students in reflecting on their goals and demonstrating their learning outcomes, so as to (also) prepare them for the final evaluation process (Conole, 2014). The evaluation process can be achieved through: (a) the traditional teacher-driven approach, (b) the students’ self-evaluation techniques, or even (c) other students (individuals or groups), depending on the needs of the activity. Moreover, educators are given the chance to evaluate their students’ achievements on an individual, group and class level. An important characteristic of this framework, as regards this element, is that the evaluation process does not take place *exclusively* at the end of the educational activity. In particular, as Conole (2013) suggests, the reflection and demonstration processes may be of a

diagnostic nature (at the starting stage of the program), *formative* one (middle stage) or *summative* (completion stage). In either case, the provision of feedback is an essential component for the completion of the learning process. To this end, educators are advised to design evaluation and self-evaluation activities, in order to enable their learners to achieve their goals and the desired learning outcomes (Conole & Wills, 2013).

7. The final element, ***Consolidate***, refers to the implementation of the educational scenario and its evaluation (Conole, 2014). Unlike the previous stage, which refers to the evaluation of the learning outcomes and the students' achievements, this process examines the efficiency and completeness of the designed intervention. One or more research methods (such as surveys, interviews, student grades, etc.) can be utilised in the evaluation process, in order to enable educators to identify the shortcomings or limitations of their instructional approach, as well as improve the design elements of their future interventions. Lastly, Conole (2013) encourages educators to share the final product of their intervention in open platforms, so that it can be publically available and freely accessible to other educators and institutions.

As Conole (2014) highlights, the main advantage of this framework is the opportunity it offers educators to creatively incorporate the capabilities of the Web 2.0 tools, which allow individuals to:

- Make their work publically accessible and open to peer-critique.
- Generate content and actively contribute towards the development and expansion of the web.
- Communicate and collaborate remotely.
- Create online communities.

- Create web personas (such as avatars).
- Deconstruct the physical boundaries and interact with others across different contexts.

Summarising the aforementioned elements, it can be concluded that the 7Cs framework provides clear guidelines to educators who wish to design interactive, cooperative and creative learning interventions, especially in the context of inquiry or problem based learning scenarios. Furthermore, its usability can expand beyond the boundaries of the traditional (physical) classroom, as it offers the required tools and instructions to cover the needs of distance or blended learning approaches (Conole, 2014).

2.4.5 Summary

To conclude, instructional designers focus more on identifying the most appropriate and effective *mechanisms* (learning theories, models, tools, etc.) to design the learning intervention, and less on making *direct instructional decisions* related to the learning subject, the objectives or the outcomes. Regarding the presented frameworks and taxonomies, the TPACK summarises all the characteristics and elements that a well-informed instructional designer should have. Bloom's taxonomy refers to the identification of the learning objectives, as well as of the tools and the contexts in which the educational intervention will take place. Lastly, the 7Cs of the Learning Design provide explicit guidelines and instructions on how to design, develop, evaluate and share the activities.

2.5 Conceptual Framework: Virtual Worlds & Educational Practices

2.5.1 Introduction

The lack of literature related to the VL approach (Sections 2.2.6–2.3.8) led educators to start utilising and concurrently exploring the potential applications of this alternative educational tool. Moreover, the immersive nature of virtual worlds was considered to be particularly useful in distance learning contexts. As a result, the experiments and conclusions—as regards the affordances of these environments and the educators’ new role—were primarily and mainly drawn from activities that were conducted in distance learning contexts (Childs, 2010; Dalgarno & Lee, 2010; de Freitas & Oliver, 2006; de Freitas *et al.*, 2009; Duncan *et al.*, 2012; McKeown, 2007; Warburton & Perez-Garcia, 2009; Warburton, 2009).

The focus of the present study is explicitly set on the employment of the HVL model. Nevertheless, the lack of conceptual frameworks and empirical taxonomies related to this approach led to the decision to contextualise the theoretical background of this topic using frameworks and taxonomies that derive mainly from the field of Distance Education (Section 2.5.2). As a side note it should be mentioned that these studies examine intensively the interactions that occur within the context of the virtual world, yet disregard the ones that occur in the physical space. However, in order to eliminate the impact of this shortcoming, an extensive review of the literature was conducted, and the most relevant—to the context of this study—literature resources were identified and discussed (Section 2.5.3).

2.5.2 Frameworks & Taxonomies for (Educational) Virtual Worlds

2.5.2.1 Taxonomy of Virtual Worlds' Educational Use

Duncan, Miller & Jiang (2012) conducted a review study—in which over 100 published papers were examined and more than 90 virtual environments were considered—in order to develop an educational taxonomy related to the current use of virtual worlds.

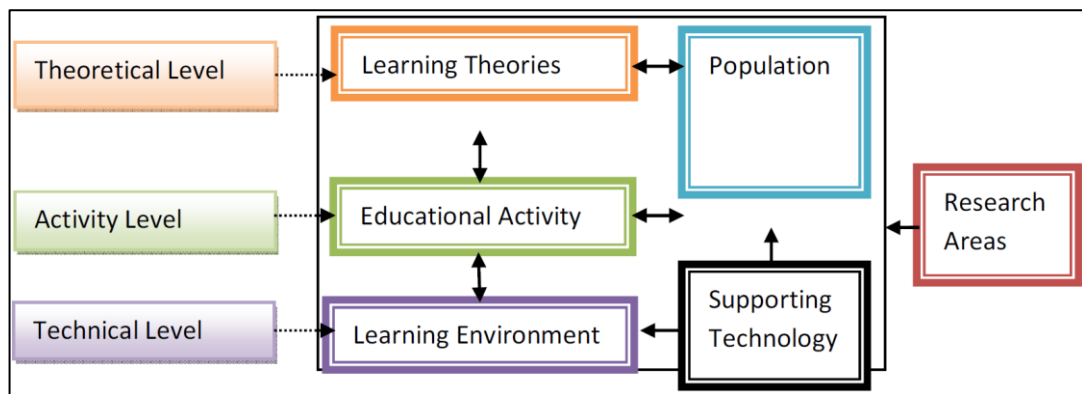


Figure 2.10 Hierarchy relationships between categories within the taxonomy (Duncan *et al.*, 2012).

The taxonomy (Figure 2.10) was developed after taking into account the following elements:

1. the type of the learning environment (cf. 2-D Learning Management Systems versus 3-D web technologies),
2. the integrated supporting technologies (e.g. audio-visual streaming, communication tools, tactile equipment),
3. the environment's population (number of active users and educational disciplines that have been supported within it),
4. the learning theories that have been employed to facilitate learning,
5. the learning models that have been utilised to support and guide the educational activities, and
6. the relevant research areas.

Their main conclusion—related to the advantages of using modern 3-D virtual worlds as an intuitive learning tool—emphasises their educational potential, especially in *distance education contexts*, as they are capable of breaking down the geographical boundaries. Another positive aspect is the opportunity given to learners to construct their knowledge through collaborative, experiential or exploratory learning activities. Furthermore, such environments can accommodate tasks that require both higher (e.g. analysing, evaluating and creating) and lower order thinking (e.g. remembering, understanding and applying). Lastly, the in-world activities are considered to be more interactive, compared to the traditional teaching-learning approaches that take place in the physical classroom.

Regarding the disadvantages, the demanding technological specifications (e.g. hardware, broadband speed) are considered to be one of the main obstacles that educators and learners have to overcome. Moreover, due to the lack of physical co-presence and, therefore, interaction between the involved stakeholders (i.e. teachers and learners), monitoring the educational process and identifying whether or not students truly learn, becomes a challenging task. In addition, the relatively complex nature of virtual worlds generates the need to provide learners with highly contextualised information (available in the virtual world), so as to enable them to acquire all the required knowledge and skills—at least during their initial visits and explorations. In the same vein, offering learners massive content (not necessarily related to the learning task) might distract their attention and have negative effects on their concentration levels. Therefore, balancing between the free ranging activities and the guided instruction is yet another challenging task that educators are requested to deal with. Finally, the value of performing activities that include 3-D

modelling/coding tasks or simulations might be challenged by learners, as regards their impact and application in the real world's context.

2.5.2.2 Taxonomy of Virtual Worlds' Pedagogical Benefits & Affordances

Dalgarno & Lee (2010) identified the unique *features* of 3-D desktop-based VLEs (grouped in two main categories) and correlated them towards their actual and potential *pedagogical benefits* (total of 10 key-points). Educators were the ones who benefited from this study and correlation, receiving guidelines and instructions on *how to design and develop educational activities* in virtual worlds.

Table 2.3 presents a synopsis of the work developed by Dalgarno & Lee (2010), in which the main categories (merged rows) and affordances (left column) are presented explicitly as described by the authors, with a brief summary-explanation deriving from their discussed literature (right column).

Table 2.3 Distinguishing characteristics of 3-D VLEs (Dalgarno & Lee, 2010).

Representational fidelity	
'Realistic display of the environment'	high quality 3-D objects, textures, lighting
'Smooth display of view changes & object motion'	sufficient frames per second refresh rate
'Consistency of object behaviour'	feedback to users' actions or autonomously performed behaviours
'User representation'	avatars, virtual identity, sense of presence & co-presence
'Spatial audio'	cross-directional & distance cueing sound effects
'Kinaesthetic & tactile force feedback elements'	haptic approaches & gestures
Learner interaction	
'Embodied actions including view control, navigation & object manipulation'	contextualisation/experientialisation of knowledge
'Embodied verbal & non-verbal communication'	text, voice, non-verbal (gestures/facial expressions) communication tools
'Control of environment attributes & behaviour'	modification of environment's parameters (e.g. physics)
'Construction of objects & scripting of object behaviours'	3-D content creation, programming

The first category, 'representational fidelity', includes all the attributes that these environments inherently have, and contribute towards the development of the realistic experience that users undertake. On the other

hand, ‘learner interaction’ describes the different types of actions that learners can perform both with the content of the world and with other users.

As to the educational applications of these environments, three broad categories were identified on the basis of which five affordances emerged. Table 2.4 offers an enriched version of the originally developed table (*ibid*). In the *merged rows/left column* can be found the points of the original table, while the *right column* contains a brief explanation based on the highlights of their literature review.

Table 2.4. Virtual worlds’ affordances and educational applications (Dalgarno & Lee, 2010).

3-D simulations and microworlds...	
Affordance 1: ‘3-D VLEs can be used to facilitate learning tasks that lead to the development of enhanced spatial knowledge representation of the explored domain’.	...diminish the physical/distance boundaries thus, enabling learners to explore places or manipulate objects that originate from the real-world but would have been impossible to do otherwise.
Affordance 2: ‘3-D VLEs can be used to facilitate experiential learning tasks that would be impractical or impossible to undertake in the real world’.	...offer fertile ground for the design & development of simulations thus, enabling learners to undertake embodied tasks that would have been expensive, dangerous or risky to perform in the real world.
Affordance 3: ‘3-D VLEs can be used to facilitate learning tasks that lead to increased intrinsic motivation and engagement’.	...allow high levels of personalisation, especially when it comes to the formation, exploration & examination of abstract concepts (non-tangible artifacts/metaphorical concepts), thus, enabling learners to externalise their understanding which, in turn, affects positively their intrinsic motivation & engagement.
3-D environments as interfaces to learning resources...	
Affordance 4: ‘3-D VLEs can be used to facilitate learning tasks that lead to improved transfer of knowledge and skills to real situations through contextualisation of learning’.	...increase the exploration efficiency & conceptual understanding thus, enabling learners to recall more easily & readily the acquired knowledge & apply it more effectively in the corresponding real world environment.
3-D multi-user VLEs...	
Affordance 5: ‘3-D VLEs can be used to facilitate tasks that lead to richer and/or more effective CL than is possible with 2-D alternatives’.	...offer the required context (sense of place) & tools (avatars, chat, modeling & scripting) for the development of CL activities thus, enabling learners to communicate effectively & efficiently with others (students, teachers) & perform various teaching-learning activities (e.g. role-play, artifact development).

The first category, ‘*3-D simulations and microworlds*’, includes the learning potential of virtual worlds (*affordance 1*), their ability to support different learning tasks (cross-disciplinary) (*affordance 2*), thanks to the opportunity given to learners—though motivation and engagement—to personalise the environment in accordance to their choices, needs and goals (*affordance 3*). The second category, ‘*3-D environments as interfaces to learning resources*’, refers to the ease of acquiring, transferring and applying new knowledge and skills in other contexts (e.g. real world), thanks to the first-person experience of information that learners acquire and the consistent interactivity they have with the ideas that are being examined (*affordance 4*). The third and last category, ‘*3-D multi-user VLEs*’, includes the computer-based CL capabilities, techniques and opportunities (e.g. communication, content exploration/development, shared tasks) that virtual worlds offer to non-physically co-located users (*affordance 5*).

2.5.2.3 Taxonomy of Virtual Worlds’ Affordances to Conduct Educational Activities

The taxonomy developed by Warburton (2009)—and further extended by Warburton & Perez-Garcia (2009)—presents a set of positive and negative elements that determine the required affordances used to conduct educational activities in virtual worlds.

On the ‘positive’ side there can be found the *extended or rich opportunities for interaction*, such as:

1. the visualisation and conceptualisation of different artefacts and simulations, which refers to the development of authentic content,
2. the existence of avatars, which contribute towards the development of the virtual identity, while they enable and help users from different locations

and cultures to co-exist and develop the feeling of belonging in a group or community, and

3. the integration of multimedia tools (which allow users to extend the barriers of the world) that positively contribute towards the experience of the sense of presence and co-presence.

On the antipode, the reasons that may deter educators from utilising virtual worlds are related to:

1. the technological architecture of these platforms (e.g. downtime, frequency of client versioning updates),
2. the in-world competences and the steep learning curve that learners have to undergo and overcome (e.g. development of familiarity with the manipulation of the avatar, navigation within the world, objects' creation/manipulation),
3. the issues that may arise from the co-presence and/or co-existence of users (especially in virtual worlds for socialising),
4. the return on investment (both in terms of effort to develop activities, and financial cost to run the service), and
5. the persistence of the environment (users-avatars with irreducible interest in using the virtual world).

All the aforementioned issues not only influence the educators' decision to embed virtual worlds in their teaching agenda, but may, also, affect learners' experience (e.g. frustration, dissatisfaction, disappointment).

2.5.2.4 Framework for the Evaluation of Serious Games & Simulations

The framework developed by de Freitas & Oliver (2006) provides educators with instructions on how to critically examine the educational potential of their existing applications (referring explicitly to games and simulations), and offers

designers guidelines on how to identify the elements that should be integrated prior to developing or that should be present when utilising new ones (Figure 2.11). In addition, as shown from the evaluation that the authors and their colleagues have performed (de Freitas *et al.*, 2009; 2010), educators may even opt to utilise this framework (retrospectively) to analyse their educational practices.

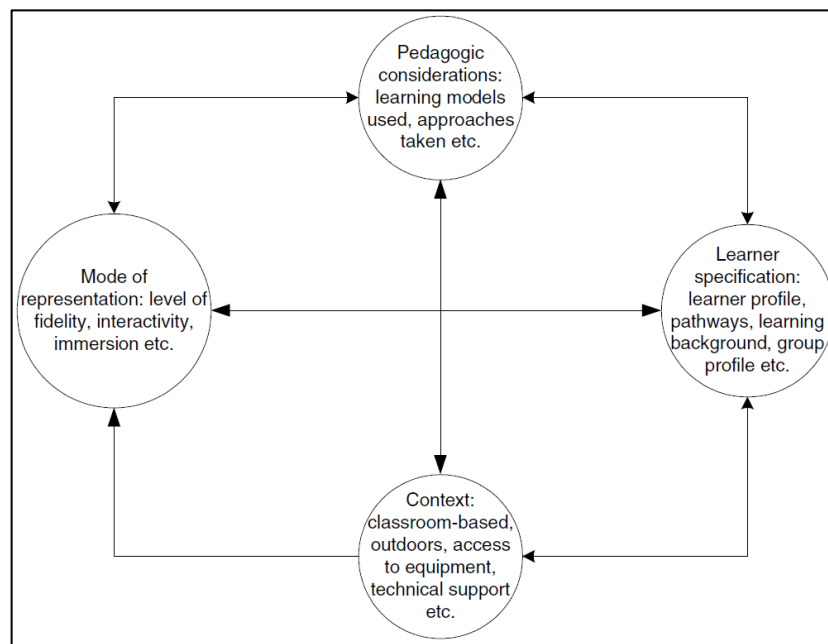


Figure 2.11 Framework for evaluating games- and simulation-based educational practices (de Freitas & Oliver, 2006).

The first category includes all the parameters related to the ‘*Context*’ in which the learning activity occurs (i.e. place, style, subject area/discipline, tutors’ background, supporting resources/tools, available technical support), as well as the approach that will define how the knowledge transfer will be achieved. The second category defines the ‘*Representational Elements*’ that may affect motivation and engagement (i.e. level of required interactivity, fidelity and immersion, the breakdown of the game’s format and model). In addition, emphasis is placed on the process of briefing and debriefing—prior to and after the conduct of the learning intervention—as the authors distinguish between being immersed and critically reflecting outside the virtual environment.

The next category examines the effectiveness and efficiency of the ‘*Pedagogical Affordances*’:

1. design of the formal curricula,
2. identification of the informal learning objectives,
3. identification of the learning approach already in use or of others, in order to improve the learning practice,
4. identification of the links between the learning process and the attained outcomes.

It also examines the tools—existing or new ones—that are required for the attainment of the learning outcomes, as well as the design of e-assessment techniques.

The last category refers to the ‘*Learners’ Profile*’ (i.e. age, background, learning preferences and styles), role (i.e. working individually and/or in groups, approaches to support CL), and competences to support their needs.

2.5.2.5 Framework for Presence & Telepresence

Steuer (1992) examined various media technologies (including VR products) and concluded that it is the environment’s vividness and interactivity that affect users’ presence⁹ and telepresence¹⁰ which, in turn, affect:

1. the sensory stimuli that individuals receive,
2. the ways they interact within it and
3. their experience.

Further elaborating on the aforementioned categories, the author defines vividness as ‘the ability of a technology to produce a sensorially rich mediated environment’ (i.e. the way that information is presented to the individual’s

⁹ The sense of being in an environment (natural perception)

¹⁰ The experience of presence in an environment (mediated perception)

senses), and interactivity as ‘the degree to which users of a medium can influence the form or the content of the mediated environment’ (i.e. the extent to which users can actively alter or modify the contextual representation of the environment in real time).

The factors that contribute to vividness are the sensory breadth (i.e. the number of sensory dimensions simultaneously presented), and the sensory depth (i.e. the resolution within each of these perceptual channels) (Figure 2.12).

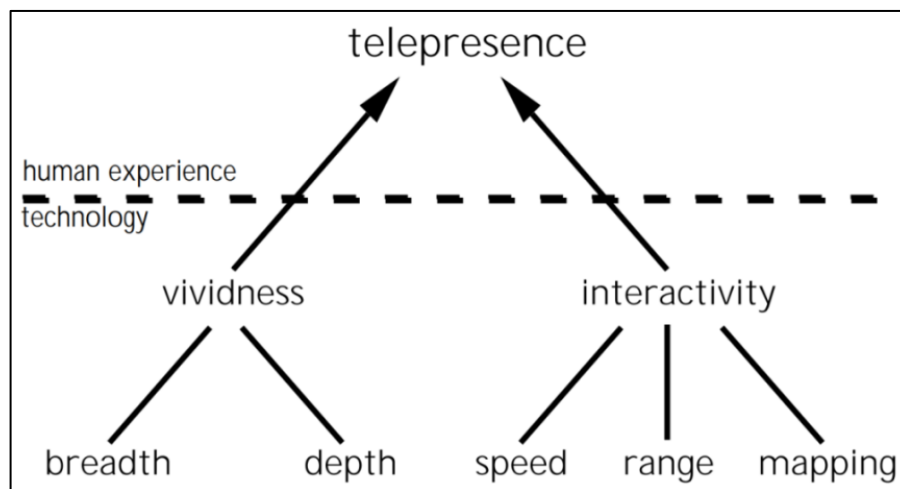


Figure 2.12 Technological variables influencing telepresence (Steuer, 1992).

The most influential factors that affect interactivity are:

1. the speed of interaction (i.e. the response time at which the users’ input is processed into the environment in real time),
2. the range of interactivity (i.e. the attributes of the environment and the possible variations that can be altered or manipulated by the users), and
3. the mapping control of the system (i.e. the environment’s ability to instantly identify and process the users’ input requests).

In addition to the presented technology-oriented dimensions, the co-existence of users is yet another factor which affects the sense of telepresence to an equal degree.

Therefore, it can be claimed that the more modifiable parameters a virtual world offers—along with its ability to simultaneously accommodate multiple users and all the different types of interactions that occur—the more they are expected to greatly affect the individuals’ consciousness and lead to the perception of the (tele)presence.

2.5.2.6 Framework for Mediated Environments

Childs (2010), based on Steuer’s (1992) work, investigated learners’ experience in virtual worlds with the focus on the impact that the sense of presence has on motivation and engagement. The elements that were taken into account were:

1. the various types of actions and interactions that learners perform within virtual worlds,
2. the knowledge and skills that are—or need to be—developed, and
3. the different degrees of presence that learners experience.

The aforementioned elements (and their correlations) led to the development of a set of relevant and appropriate activities that learners can perform during each stage of presence, and he utilised them to form the framework for mediated environments.

The stages and the activities are briefly presented below.

1. ‘**Preparatory**’: practical information, related to the first-time use of the virtual world, is provided to learners (e.g. provision of login credentials, instructions on how to log in/deal with errors or crashes).
2. ‘**Conscious technical skills**’: practical instructions, related to the use of the virtual world, are delivered to students (in the form of handouts):
 - ‘Interacting with the world’: motion, manoeuvring, way-finding, changing the camera positions, entering mouselook (first-person view).
 - ‘Interacting with others’: use of the public/private chat or the minimap.

- ‘Interacting with the avatar’: changing and saving the avatar’s appearance outfit, adding animation effects.
 - ‘Finding and searching’: creating/storing landmarks (in the inventory), teleportation to other locations.
3. ‘**Acclimatising**’: the transition process of practicing and acquiring the aforementioned technical skills through playing¹¹, prior to engaging with the actual learning tasks.
 4. ‘**Unconscious technical skills**’: learners have acquired, mastered and internalised the necessary knowledge/skills and can start engaging with curriculum activities that require such expertise (e.g. exploration, interaction with in-world media).
 5. ‘**Developing a body image**’: learners have developed the required knowledge to personalise their avatars’ appearance (social co-presence). Activities related to situative learning (e.g. class discussions, formation of groups) can be performed at this stage.
 6. ‘**Developing a body schema**’: learners consider their avatars’ to be an extension of themselves (embodiment), whilst the sensory impressions of the world have an emotional and cognitive impact. As a result, the in-world experiences are perceived in a more direct/personal way and, therefore, cognitivist or experiential learning activities can be facilitated.
 7. ‘**Acculturation**’ (applicable mainly to social virtual worlds): learners engage with the society of the virtual world, and participate in the community-driven sociocultural activities.

¹¹ No particular set of tasks is suggested for this stage. Learners will discover and experiment with these elements by themselves.

Another aspect that the author investigated was learners' reactions to virtual worlds. In the developed typology (presented below), learners' perception and opinion—regarding the use of such spaces—are taxonomised, described and correlated in accordance to the levels of presence and engagement.

1. '**Positive**': learners experience high levels of sense of presence, consider the learning experience to be of high value, perceive the environment as realistic enough, and are flexible to perform adjustments.
2. '**Need for realism**': learners hold a positive attitude towards the overall learning experience and develop the sense of presence, yet might be reluctant as to the non-real aspects of the environment.
3. '**Not embodied**': learners have no sense of connection with the avatar/world, they consider the learning experience to be of low value and the world as a non-realistic or poorly designed place.
4. '**Virtual is inauthentic**': learners maintain the attitude and belief that the virtual world cannot replace or replicate the authenticity of the physical environment, and insist that the educational activities should be explicitly performed in the real context.
5. '**Don't like games in education**': learners hold the preconception that virtual worlds are equivalent to digital games or maintain a generic antipathy towards 3-D environments. As a result, the learning value is belittled, whereas the use of virtual worlds (for educational practices) might be considered to even be inappropriate.
6. '**Don't like the culture**': the harassing attitude or misbehaviour that other users might present, negatively affect the levels of engagement, lower the value of the learning activity, and lead learners to consider it to be inappropriate or even upsetting.

2.5.3 Frameworks & Taxonomies for Blended & Hybrid Virtual Learning

2.5.3.1 *Framework for Designing Blended-Reality Educational Activities*

Bower, Lee & Dalgarno (2017) argue that most of the literature reports related to the Blended-Reality learning model, discuss empirical projects mainly focused on the development of software, yet disregard the affordances that are required in order to conduct educational activities in such setups. To investigate this gap, the authors identified the features that should be present in such activities and examined the impact that the different types of interactions have on the learning process and outcome.

According to Bower *et al.* (2017), a Blended-Reality setup requires (at least) a physical and a virtual environment ‘connected’ in real-time, through the use of audiovisual technology. In this scenario, participants who are not physically co-located (present in the virtual world) receive projected information (in the form of streamed video) from the physical space (where the rest of the cohort is), and vice versa. As to the communication channels, participants in the physical space interact with each other in person (verbally), whereas those in the virtual world do so through the use of text/voice chat and gestures. Based on their experiments, a framework was developed in which the pedagogical, technological and logistical factors—which support and constrain learners’ interactions—are grouped and discussed (Table 2.5).

Table 2.5 Factors supporting and restricting face-to-face and remote learners in the blended reality CL environment (Bower *et al.*, 2017).

	Factors supporting F2F learners	Factors supporting remote learners	Factors restricting F2F learners	Factors restricting remote learners
Pedagogical	<ul style="list-style-type: none"> - Instructor prompts for responses - Working in a group with F2F peers - Activities that encourage sharing between students - Heightened engagement - Active learning 	<ul style="list-style-type: none"> - Instructor prompts for responses - Opportunities to interact with each other <ul style="list-style-type: none"> - Being in groups together - Delegating roles and dividing work <ul style="list-style-type: none"> - Heightened engagement - Active learning - Recognising voices of friends - Willingness of shy students to contribute <ul style="list-style-type: none"> - Gestures - Verbal communication <ul style="list-style-type: none"> - Text chat 	<ul style="list-style-type: none"> - Lack of opportunities to interact and co-create with remote peers - High proportion of instructor-mediated communication <ul style="list-style-type: none"> - Repetition of instructions - May finish faster than remote students 	<ul style="list-style-type: none"> - Lack of opportunities to interact and co-create with F2F peers - Difficult to determine who was speaking <ul style="list-style-type: none"> - Repetition of instructions - Lack of cues - People talking over one another - Knowing when and how to communicate - Difficulty of capturing F2F participants' attention - People overwriting one another's notes
Technological	<ul style="list-style-type: none"> - Being able to speak to remote students - Being able to see remote student avatars - Being able to see avatar names - Being able to hear remote students - Being able to screen share 	<ul style="list-style-type: none"> - Notes areas for sharing text ideas - Visual presence in the form of avatar <ul style="list-style-type: none"> - Names of avatars - Minimal communication lag between remote students - Learning more accessible 	<ul style="list-style-type: none"> - Audio issues - Issues sharing screen - Students not knowing how to share the screen 	<ul style="list-style-type: none"> - Audio issues - Issues viewing shared screens - Unfamiliarity with how to gesture
Logistical	<ul style="list-style-type: none"> - Could communicate naturally with F2F peers 	<ul style="list-style-type: none"> - Could communicate one-on-one with remote students - Level playing field with remote peers - Having breakout room in the virtual space 	<ul style="list-style-type: none"> - Unable to communicate one-on-one with remote students - Cannot see people behind the avatars <ul style="list-style-type: none"> - Could be distracted by focus on remote participants 	<ul style="list-style-type: none"> - Unable to communicate one-on-one with F2F peers - Lack of troubleshooting support

The core findings of this study suggest that Blended-Reality, as a pedagogical approach, enhances learner engagement through the various interactions that occur among the physically co-located and remote learners. In addition, it positively contributes towards the development of the embodied presence, to the degree that the physical boundaries are diminished. Nevertheless, the technical issues that learners (from both environments) encounter, (partially) constrain the opportunities for interactions. At the same time, the technological affordances that are required to set up such interventions make the employment of this approach rather unrealistic for regular use. Lastly, as to the logistical factors, the added value of this approach is acknowledged, regardless of the issues that learners and instructors might experience. However, more effort should be made to increase the opportunities and the incentives for interactions between the peers who participate via the alternate mode.

2.5.3.2 Taxonomy for Designing Hybrid-Blended Learning Courses

Tashiro *et al.* (2015) acknowledge the conclusions deriving from studies that discuss the added value of the Hybrid-Blended learning approach, but, also argue that most of them lack sufficient evidence to support their claims or, in other words, to justify the reasons why this model improves learning. In addition, the authors have identified a gap regarding the lack of systematic attempts to provide frameworks and taxonomies on how to design Hybrid Learning courses. According to them, most studies related to this model present and discuss various points, such as:

1. the required realism of the virtual environment,
2. the knowledge retention and transfer process,
3. the conceptual performance and competences,

4. the impact of learners' misconceptions, but none of them considers all of them simultaneously.

As a result, identifying how this model *might* improve learning outcomes becomes an even more challenging task. Motivated by this shortcoming, the authors considered a wide range of elements (e.g. use and combination of different electronic mediums and communication capacities, examination of different course types, structures and educational disciplines and diverse degrees of educational scaffolding), and introduced a taxonomy that breaks down the different variations, under which Hybrid-Blended Learning courses can be developed and implemented (Table 2.6).

Table 2.6 Blended course taxonomy derived from the Rudak-Sidor taxonomy (Tashiro *et al.*, 2015).

		Course structure							
		Complete release		Time hierarchy		Topic hierarchy		Topic hierarchy with mastery	
Face-to-Face		G	U	G	U	G	U	G	U
Low ($\leq 35\%$)	C								
	NC								
Medium (36-70%)	C								
	NC								
High ($>70\%$)	C								
	NC								

C = Complementary, NC = Non-Complementary, G = Guided by Scaffolding, U = Unguided by Scaffolding.

The first parameter refers to the analogy of the F2F and the electronic instruction that students receive (e.g. balanced, low F2F/high online, or vice versa). Accordingly, the authors discuss the course structure and the different approaches that can be utilised to release the course material to learners (e.g. all the elements available from start till completion, on a timed schedule or based on the course topic/subject area). They also identify the conditions related to the mastery—or not—that students should develop prior to moving to the next

cluster. The last category refers to the degree of the educational scaffolding—which can be either guided or unguided—that learners receive, based on the course’s structure and needs.

In order to examine the robustness of their taxonomy and identify the different types of interactions that occur among the involved stakeholders (i.e. students, educators), a 3-D virtual world was developed so as to enable undergraduate students to undertake various simulated tasks. Moreover, this virtual world was utilised in conjunction with the F2F instruction and other custom-made electronic platforms (Learning Management Systems) and resources (social media, PowerPoint slides). As to the instructional approach, the Situated Learning model was employed under the principles of the Behaviourism and Cognitivism learning theories.

The core findings of this study suggest that in order to achieve the full potential of this educational approach, instructional designers should carefully examine their resources, tools and context. They should also identify the learning theories and models—which will consistently and appropriately blend the learning activities with the learning objectives, assessment and feedback—and ground them in the necessary scaffolding, so as to enable learners to retain and transfer the acquired knowledge.

2.5.3.3 Framework for Designing Hybrid Virtual Learning Contexts

One study akin to the nature of this research has been conducted by Esteves *et al.* (2011) who investigated the learners¹² and educators’ experience in the context of a HVL apprenticeship. Similar to the motivational roots of this work, the main reasons that triggered the authors’ interest were:

¹² undergraduate Computer Science & Technology students

1. the levels of dissatisfaction related to the students' performance, when undertaking programming courses which utilise the traditional methodologies/tools, and
2. the learners' difficulty in understanding abstract programming concepts.

Nevertheless, besides the similarities of the two studies, certain significant differentiations do exist. For instance, even though their student cohort was also simultaneously co-present in both environments (i.e. university laboratory/virtual world), the presence of the educator-researcher was mainly restricted within the virtual world. As a side note, it should be mentioned that a fixed number of on-site visits (once a month) were performed by the educator, so as to offer students direct guidance/support and monitor their progression. In addition, participants were also given an introductory lecture and a brief demonstration a priori to the use of the virtual world.

Another differentiation can be identified in the focus of their instructional design approach. More precisely, the authors investigated:

1. the capabilities that 3-D virtual worlds have, and
2. the affordances that are required (from the educator's perspective) to design and develop educational activities related to teaching programming.

Even though the topics of interactivity, motivation and engagement are discussed, the reported findings originate primarily from the interactions that the stakeholders (i.e. educator, learners) had within the virtual world. Nevertheless, they disregard partially or even completely the ones occurring within the physical classroom. The elements of this framework, briefly discussed below, originate mainly from the issues that the authors encountered, the solutions that were utilised to resolve them, as well as any other noteworthy observation they made during the course of their experiment (Table 2.7).

Table 2.7 Framework for teaching/learning computer programming inside Second Life (Esteves *et al.*, 2011).

Elements	Procedures
Communication	Public channel—for general explanations. Private channel—for private explanations.
Project	The project should be complex enough that the cooperation from all members of the group will be necessary. It must have a strong visual behaviour and should be adapted to the level of knowledge that students have.
Methodology	Project-based learning. Use of an outside platform (e.g. LMS) as a repository of learning materials.
Classroom (workspace)	Support interaction with the virtual world user community. Identify classroom areas for each group to work. Provide sample objects with simple programs for students to use as a reference.
Lectures	The teacher should be physically present in the first class to explain the SL interface. Teacher should prepare beforehand short phrases, ready to copy and paste on demand.

The first element reports the difficulties that the educator faced while communicating with students. More precisely, the absence of physical co-presence and/or VoIP communication among the involved stakeholders led to the employment of the in-world chat tool (public chat), as the main medium to facilitate verbal interaction. However, issues like intertwined conversations or the difficulty to follow up students' requests, made this approach non-viable. As a result, the employment of alternative techniques, such as the use of the private chat channel (one-on-one student support) and the preparation of premade answers (based on the frequently asked questions), had a less negative impact on learners' experience and interaction with the educator.

The second element refers to the educational methodology and approach that was utilised to design and conduct the educational intervention. More precisely, the authors suggest that the visualisation of project (i.e. the use of the 3-D element to observe the behavioural changes of the objects based on the given code) enables learners to receive obvious feedback—as regards the correctness of their code—and improves their reaction to compilation and execution errors—unlike the non-visualised programming techniques. In addition, project-based activities are more likely to maintain the learners' interest, as they enable them

to explore their solutions both individually (self-reflection) and collaboratively (group-reflection). Moreover, two observations can be noted:

1. the participants maintained an overall positive attitude whilst working in the virtual world, and
2. they also exhibited an increased amount of effort and commitment—besides the assigned practical sessions—to complete their project and develop more attractive and interactive artefacts (compared to their fellow students).

These two observations offer a great indication of the increased levels of motivation and engagement that the authors noticed.

The last element describes the affordances that are required to design the learning interventions in such scenarios, as well as the increased responsibilities that accompany the educators' role. Unlike the traditional teaching-learning context, in HVL scenarios, educators are expected to become instructional designers, facilitators, supporters, motivators, instructors and even 'colleagues' with their students. Moreover, supporting students' interaction with other peers (peer-learning/peer-tutoring) or users of the virtual world while offering small tutorials or example artefacts, can positively impact on the learners' experience and, therefore, motivation and engagement. Lastly, the teacher's physical presence—especially during the first class—can greatly affect the learners' first impression and reaction regarding this medium and alternative programming approach. Nonetheless, the lack of familiarity or prior experience with such environments can lead to the development of preconceptions and negative attitudes that may constrain the educators' attempts to motivate and engage their learners.

2.5.4 Summary

The presented frameworks and taxonomies discuss aspects related to the current educational use of virtual worlds, the affordances that are required to design and conduct educational activities—based on the unique features, elements and characteristics that these environments offer—and the factors that affect the sense of presence, learners’ motivation and engagement. In addition, the combination of different technologies, setups and educational approaches provide an overview of the very diverse ways that educators perceive the idea of this blended educational model.

As a concluding remark, virtual worlds can be employed to conduct educational activities both in distance and hybrid/blended/mixed learning contexts. The main characteristics that render these environments into appropriate educational tools are:

1. the inherent features that virtual worlds offer (e.g. 3-D element, programming and modelling tools, avatars, realistic context, interconnectivity),
2. the complex network of interactions (both between the users themselves and with the world),
3. the opportunity to integrate various multimedia tools, and
4. the high degree of personalisation, which enables educators and learners to optimise the learning environment based on their personal preferences and needs.

Lastly, the sense of presence (embodiment) is linked with all the aforementioned elements and contributes to achieving higher levels of motivation and engagement.

Additionally, emphasis is also placed on the importance of grounding the educational activities and the course design (e.g. structure, objectives, material, and scaffolding) in accordance to the established learning theories and models—so as to ensure that knowledge acquisition, construction, retention and transfer will occur efficiently and effectively. In addition, the increased responsibilities that educators are to assume (e.g. development of additional resources and tools, preparation of the learning environments) should not be disregarded.

Nevertheless, even if all the aforementioned affordances are met:

1. the demanding technological specifications that these environments require to operate smoothly and reliably,
2. the steep learning curve that learners have to overcome,
3. the issues that may experience from the co-existence with others (applicable to open/social environments),
4. the lack of familiarity or prior experiences with such contexts, and
5. the negative attitude or preconceptions that learners might have towards the use of virtual worlds for learning practices, they all greatly affect students' experience and, therefore, motivation and engagement.

2.6 Practical Framework: Virtual Worlds & (Instructional) Design

2.6.1 Introduction

Unlike Massively Multi-Player Online Role-playing Games—which have scripted goals, targets and objectives—the content of virtual worlds like Second Life[®], OpenSim or Open Wonderland[©] is explicitly developed by the users themselves (Minocha & Reeves, 2010). This level of flexibility and degree of freedom, in conjunction with the 3-D modelling and programming tools that these environments offer, attracted the educationalists' interest to explore and

utilise them for educational and research practices (Callaghan *et al.*, 2009). However, as Kirkley & Kirkley (2005) suggest, ‘designing a learning environment is a complex task with a multitude of variables and outcomes to consider’ (Section 2.6.2).

Therefore, in this section, a brief overview of the different approaches that educational technologists have employed—to shape the virtual worlds’ content, increase the incentives for interaction and, hence, engagement—are examined and correlated towards the design approach that has been employed to contextualise the present study (Sections 2.6.3 & 3.3).

2.6.2 Design Principles

As Minocha & Reeves (2010) suggest, choosing a virtual world provides the conceptual foundation of the *place* that will accommodate the educational activities. However, in order to motivate learners, engage their attention and enable them to experience the knowledge, the place (per se) needs to be designed. Indeed, the impact of the ‘architectural design’—as in the physical learning spaces so in virtual worlds—plays a crucial role in learners’ experience (Clark & Maher, 2001). Under this consideration, the architectural models of 3-D learning spaces are classified in two broad categories (Jennings & Collins, 2007; Prasolova-Førland, Sourin & Sourina, 2006):

1. real-life-like buildings and spaces and
2. imaginary or fantasy locations and places.

In the same vein, others (Harrison & Dourish, 1996; Dourish, 2006) discuss the ‘sense of place’ and how ‘*place*’ differentiates from ‘*space*’.

Nevertheless, the architectural elements that affect the learning experience or the impact of the instructional designers’ choices and decisions (e.g. design structure or aesthetics of the virtual environment) motivation and

engagement, are aspects that have not been extensively investigated. Motivated by this shortcoming, Minocha & Reeves (2010) examined the aforementioned topics and identified a set of points (as presented below) that contribute towards the development of the '*sense of space*'.

- **Interpretation of learning spaces in virtual worlds**
 - *Spaces for indoor/outdoor activities:* auditoriums and lecture amphitheatres for formal teaching, or gardens and parks for tutorials and orientation.
 - *Spaces with real-world-like settings:* classrooms with offices, chairs and presentation boards for learning activities and socialising.
 - *Open spaces/sandboxes:* these enable learners (avatars) not only to move freely around the space and express themselves (creativity), but also practice scripting or 3-D modelling skills, not to mention that they facilitate peer-tutoring/-learning interaction.
 - *Activity-focused spaces:* with task-oriented scenarios exclusively designed for learning activities (e.g. laboratories, project workspaces).
 - *The entire island is a learning space/learning can happen anywhere:* (applicable to social/connected virtual worlds) the affordances of the virtual world are exploited to facilitate informal or exploratory learning (e.g. virtual tours) and socialising with other users.
- **Relationship between the pedagogy and the design of learning spaces**
 - *Pedagogy and design of spaces influence one another:* educators should have a clear understanding of the learning theories/models that can be applied or supported by these environments and, therefore, develop their learning goals/objectives according to their principles.

- **Visual realism in learning spaces**
 - *Visual realism for 3-D simulations and visualisations:* encouragement of learners to develop and shape their own learning environment; development and exploration of concepts that are difficult or even impossible to be investigated in the real-world setting in a low effort or inexpensive way; the learning scenery can be (flexibly) altered to match the subject under examination.
 - *Realism for familiarity and comfort:* learners have certain reference points on which to ground, and to which they connect their existing cognitive schemas according to the virtual world's norms.
 - *Visual realism or non-realism is learning activity-dependent and context-dependent:* educators should determine the required levels of realism in accordance to the needs of the learning topic/subject.
- **Designs of learning spaces within an island**
 - *Combining formal learning areas with social spaces to encourage informal learning:* blending of virtual classrooms, libraries, study areas or exhibition centres (for students to display their work) with socialising areas (e.g. pubs, bars, beaches) to support informal learning practices in both individualised and collaborative setting.
 - *Spaces for asynchronous learning:* students can access the virtual world/learning content at any time (i.e. outside the scheduled class time) and work at their own pace.
 - *Designing spaces for socialising, collaborating and community building:* use of flexible meeting places/communal spaces, in conjunction with formal learning spaces, to encourage and enhance the possibilities for social interaction, as well as to develop the sense of community.

- *Designing spaces to promote the authority of the educator and the social norms:* use of different space arrangement/positioning of avatars (e.g. seating allocation) to visualise the relationship that exists between the involved stakeholders (i.e. educators, learners).
- *Formal and informal seating arrangements to suit the activity:* emphasis should be placed on creativity (e.g. design and development of unusual objects with unexpected behaviours), whilst designing the objects/space, to invoke fun and playfulness and, therefore, increase engagement.
- *Designing to provide affordance:* the objects within the learning space should have a self-explanatory aim and a clear purpose of existence.
- *Co-designing learning spaces with students:* the active involvement of learners in developing the virtual world's space facilitates interaction with others (e.g. social learning, teamwork), encourages exploration, and fosters creativity as well as community building.
- *Ambience and aesthetics of the learning space:* visual aesthetics influence the way that learners perceive their learning environment, and can potentially increase the levels of engagement.
- ***Design of learning spaces to avoid interruptions:*** (applicable to social/connected virtual worlds) division of the virtual space and use of access control techniques to prevent unauthorised users from interrupting/disrupting the learning activities.

Even though traditional instructional approaches—such as seminars and lectures—can be undertaken in virtual worlds, Minocha & Reeves (2010) oppose this idea and suggest that instructional designers should opt for activities that facilitate active and informal learning, foster learners' creativity and underpin socialising and collaborating.

On top of that, other factors that influence learners' engagement are:

1. the educators' and learners' skills and motivation invested in the designed educational activities,
2. the nature of the educational activities (i.e. compulsory vs option) and
3. their impact on learners' academic progression (i.e. assessed or not), or
4. the educational approach that is used for the delivery of the programme (e.g. distance, F2F, blended).

In any case, it could be concluded that '*educators can create the learning spaces, but it is the students that create the places through their usage of that space*' (Minocha & Reeves, 2010).

2.6.3 Design Practices

2.6.3.1 Exemplification

Miliszewska & Tan (2007) (cited from Bessière *et al.*, 2009), suggest that 'learning by examples is an excellent way for novices to overcome their difficulties'. Therefore, providing learners with sample objects or scripts, not only enables them to familiarise with the virtual world and its tools, but it also exemplifies the potential and capabilities of such environments, as well as encourages participants to further develop the virtual space in a way that reflects their personality and identity (Bessière *et al.*, 2009).

2.6.3.2 Conceptual Orienteering

There is an extensive literature on the importance of providing learners with areas of interest for exploration and familiarisation—such as orientation spaces with pre-tutorial learning activities—so as to enable them to develop the required technological skills, familiarise with the virtual interface and understand how to interact in the world (Bower *et al.*, 2017; Konstantinidis *et al.*, 2010; Minocha & Reeves 2010; Shen & Eder, 2009; Vrellis *et al.*, 2010).

Bessière *et al.* (2009), identified a set of elements that instructional designers should consider—whilst designing orientation activities—so as to enable learners to develop familiarity with the world, explore and acquire the necessary skills and prepare for the formal learning activities. More precisely, the orientation area/activities should have:

- **Structure:** with clear, challenging and attainable goals, so that learners can progressively familiarise with it, and move to more complex interactions through meaningful tasks.
- **Purpose:** with multiple objectives to enable learners to develop different skills both related to the (use of the) virtual world and the (future) formal learning task.
- **Fun:** achieved by exploiting the affordances of the virtual world to develop playful activities that cannot be performed in the traditional setting.
- **Social (nature):** using cooperative or competitive tasks to teach students how to interact with each other, encourage social behaviour and boost their intrinsic motivation.
- **Unique Features:** that exist only in virtual worlds—instead of replicating traditional practices—to enable learners to perceive the potential of these environments and further explore their capabilities.
- **Compelling/Enticing (nature):** so that learners can understand the learning opportunities and the real value of working in a virtual world, as well as explore the potential benefits themselves, beyond the initial attraction that may trigger their interest.

2.6.3.3 *Gamification & Edutainment*

The techniques utilised by instructional designers to blend game-like elements with educational content/activities were discussed in Section 2.3.6, whilst

Section 2.5.2.4 elaborated on the procedures used to identify the core elements/characteristics of such applications and the methods to examine their pedagogical value. This subsection reports in detail on an indicative sample of the different design approaches that are used to conduct gamified or edutainment activities, as well as to guide the experiment for the needs of this study.

In the approach that Konstantinidis *et al.* (2010) followed to enhance Collaborative GBL, there was a use of the Jigsaw (cooperation by design) and Fishbowl (formation of concentric circles for in-depth discussions and presentations) techniques. In both approaches the aim was:

1. to facilitate interaction among students (both in the virtual and in the physical environment),
2. to encourage collaboration and active involvement of all members in the problem-solving process, and, therefore,
3. to increase motivation and engagement.

Callaghan *et al.* (2009) used in-world quizzes, whilst Bredl *et al.* (2015) adventure games (quests), to assess the learners' understanding as well as consolidate their knowledge. Karakus *et al.* (2016) observed their learners' behaviour and attitude towards virtual worlds and concluded that the so-called digital natives perceive these environments as digital/virtual games. In addition, the authors report the difficulty that learners had to maintain their interest in the learning activities, as they were often observed performing irrelevant (to their task) actions, such as creating animations, competing in running races, or comparing the avatars' clothes and facial features. As a result, their advice is to gamify all the elements, tasks and activities that are performed in the world, so as to maintain the learners' attention and interest engaged and vivid.

Regarding the setup of the environment (Figure 2.13), space division might come handy, especially when it is structured to guide and lead learners around the virtual world's space. Some examples of the development plan that Karakus *et al.* (2016) utilised include the integration of:

1. an information house¹³ (using audiovisual material such as boards, posters, videos),
2. clothing areas¹² (with premade outfits for editing/modification of avatars' appearance),
3. spaces for exercise/practice¹² in order to increase the learners' confidence and familiarity with the world and their task,
4. a reward system with self-evaluation components (obstacles with questions) to boost the learners' motivation, satisfaction and satisfy their game-like expectations, and
5. socialisation/entertainment areas with featured game-related objects (e.g. swings, teeter-totters, campsites, dancing and music areas, fireplaces).



Figure 2.13 Snapshots of Information, Clothing, Exercise & Practice House (Karakus *et al.*, 2016).

¹³ mainly relevant to Section 2.6.3.2

2.6.3.4 Pedagogical Agents Tutoring

Employing PAs in a virtual world can cover various needs and serve different purposes. For instance they can increase learners' motivation, engagement and self-efficacy, or moderate their frustration by supporting the learning process (Baylor, 2011; Mendez, du Boulay & Luckin, 2005; Soliman & Guetl, 2010; Voerman & FitzGerald, 2000). In the same vein, others (e.g. Baylor & Ebbers, 2003; Baylor & Kim, 2005; Baylor, 2011) strongly recommend that PAs should have an explicit/clear role. They further advise designers to follow the principles of the 'split-persona' (i.e. splitting the agent's roles/functionalities in different personas), so as to offer learners a balanced instructional experience (Figure 2.14).

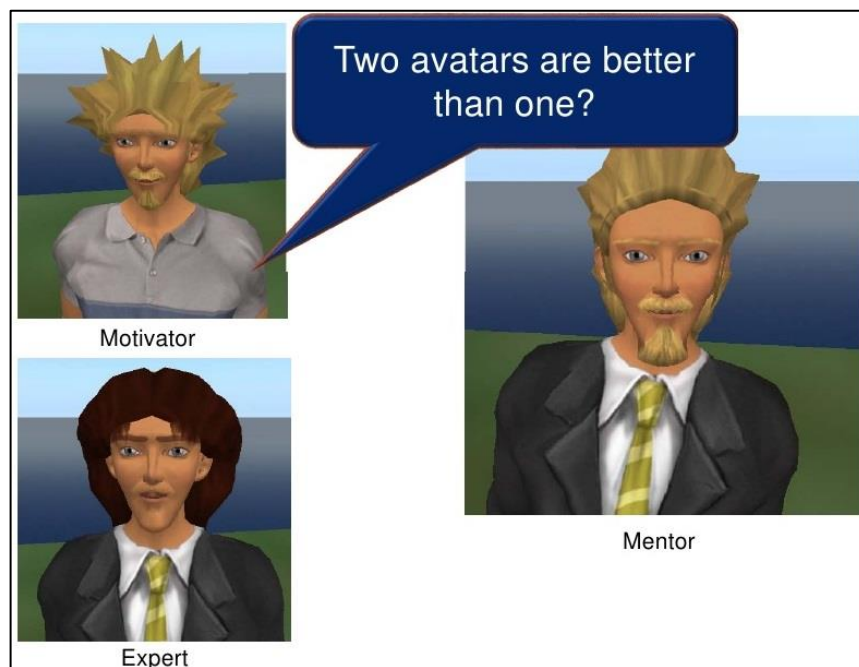


Figure 2.14 Split-persona effect: separating agent functionality (Baylor & Ebbers 2003).
Figure source: Kapp (2018).

In Section 2.3.7, the conditions that instructional designers should consider, prior to designing PAs, were presented and discussed. However, as the present section is dedicated exclusively to the design elements of these entities, the focus will be placed exclusively on the function/role of the PAs and their design features.

PAs' personality (i.e. role and function) can take many forms such as the one of a motivator, an expert, a mentor, a director, an information provider/retriever and so on (Baylor & Kim, 2005; Heidig & Clarebout, 2011; Macal & North, 2005; Mendez *et al.*, 2009). Nevertheless, after considering the experiential nature and limited capabilities of AI, as well as the suggestions of relevant research, it can be concluded that even if PAs' functionality and adaptability is limited, their impact on learners' perception, interaction and influence is not degraded (Baylor, 2011; 2009; Baylor & Kim, 2009; Kim *et al.*, 2007; Ryu & Baylor 2005). However, their appearance, attractiveness and credibility are still considered to be critical factors.

As regards the design features of PAs, Heidig & Clarebout (2011) propose a three-level approach, which can be utilised to identify and map their elements and characteristics:

- **Global level:** decisions related to appearance such as human/non-human, cartoon, animal, object, and motion condition (static/animated).
- **Medium level:** decisions related to technical aspects such as:
 - the degree of lifelikeness/realism (visual presence),
 - role (motivator, expert etc.),
 - behaviour (natural/unnatural),
 - animation (movement, emotions, expressions),
 - auditory output vs printed text and
 - speech style (personalised/formal).
- **Detail level:** decisions related to visual presence such as age, gender, clothing, weight, ethnicity and (if applicable) voice intonation, accentuation and speech rate.

2.6.4 Summary

The main advantage of community-developed virtual worlds is the opportunity given to users to shape their content in accordance to their needs and desires. The whole process of preparing the educational activities may seem simple, yet it is proven to be quite challenging, while the instructional designer's role cannot be disregarded. It is the instructional designer who will invest knowledge, time and effort to achieve the best possible educational result and influence the learning process and outcome.

The importance of following the principles of the established learning theories and models—whilst making the design decisions related to the nature of the space or the interventions—is once again highlighted. Under the same consideration, equally significant and noteworthy are some more factors such as:

1. the affordances and unique features of the virtual worlds,
2. the subject's nature,
3. the required levels of realism, as well as
4. the learners' involvement and profile.

In addition, emphasis is given on the importance of maintaining clear goals and objectives, while balancing between the educational and socialising activities, so as to maintain the learners' interest and motivation irreducible.

Lastly, as to the design practices, no instructional approach capable of equally covering all of the learners' needs could be identified in the available literature.

Nevertheless, a combination of different techniques, such as:

1. the provision of example content,
2. the use of structured induction to smoothly introduce learners to the world and its tools,
3. the use of gamified elements, and

4. the employment of PAs to perform different roles, can increase the incentives for interaction and, therefore, motivate learners to engage with the world and the learning task.

2.7 Summary & Implications

This chapter elaborated on a number of pedagogical approaches and techniques, on which the present study was grounded, and which determine:

- the ways in which people learn (Section 2.2)
- the relationship between the process of teaching and learning (Section 2.3)
- the instructional design theories that inform and guide the educators' approaches and decisions (Section 2.4)
- the strategies utilised by the instructional designers to develop and conduct educational activities within the virtual worlds (Section 2.5)
- the design techniques examined and recommended by the virtual worlds' educational specialists (Section 2.6)

Through this evaluation a set of desirable affordances was identified:

- increase on motivation and engagement through different interactions
- support of multiple scientific disciplines and learning styles
- accessibility and personalisation of the learning environment
- facilitation of collaborative work practices
- sense of presence (embodiment)

Under the same consideration, a series of shortcomings and limitations were reported:

- steep learning curve
- demanding technological specifications and technical issues
- distraction of students' attention to and focus on the learning task

- learners' negative attitude or preconceptions towards this educational approach
- increased responsibilities for the educators/effort for the instructional designers

To conclude, what should be highlighted is the purpose of the present study and the literature gap it aims to cover considering that:

- the relevant literature reviewed mainly treats on distance learning,
- there is a lack of studies/framework/taxonomies that concurrently examine multiple learning theories, models and (instructional) design approaches, but only do so in isolation to one another.

Therefore, this study aims to cover the aforementioned gap—especially considering the lack of literature in the field of HVL per se—and provide educators and instructional designers with a solid theoretical and practical background, so as to offer learners highly interactive, engaging and motivating educational activities.

Chapter 3: Application of Research to Practice

3.1 Introduction

The existence of the HVL curriculum at the University of Bedfordshire offered a great opportunity to examine a set of instructional design decisions and also, their impact on interactions and engagement. Following the suggestions from the literature (Davis, 2012; Pellas, 2014) to combine multiple learning theories and models with the proposed (instructional) design techniques, a combination of four different experiments was proposed and each one of them was tested against different student cohorts (Section 3.2) so as to broaden the opportunities to collect diverse data and provide strong conclusions. Section 3.3 describes the development plan of the PhD experiments, branded under the *DELUSIVE* project name.

3.2 Institutional Context

For the needs of this study, an institutionally hosted OpenSim¹⁴ virtual world—resourced from the University of Bedfordshire and supported by the in-house technical support team—was employed.

The OpenSim technology offers high levels of control, compared to other commercial platforms (e.g. Second Life¹⁵, ReactionGrid¹⁶, DreamLand¹⁷), thanks to its open source nature. More precisely, the maintenance of an institutionally hosted environment enables the server administrator to fully control the

¹⁴ http://opensimulator.org/wiki/Main_Page

¹⁵ <https://secondlife.com/>

¹⁶ <https://reactiongrid.com/>

¹⁷ <http://www.dreamlandmetaverse.com/>

functionality of the platform including customised content and scripts policy use, maintenance of backups, and restricted accessibility to unauthorised users. Moreover, the supported (in-world) scripting language, the embedded 3D element, the capability of the simulator to incorporate 3D content that originates from third-party software and the natively provided physics engine, offer fertile ground for the accomplishment of various programming tasks and project simulations. Lastly, as with every sandbox-like 3D virtual world, users are provided with vacant land and the freedom to create and script anything they would like using the provided in-world 3D modeling tools and the scripting language.

The available laboratory equipment¹⁸—provided by the School of Computer Science & Technology—was utilised in the context of the weekly practical sessions whereas, students could also access the virtual world, outside the university network, using their personal computers.

Although the context of the units (abbreviated below as Unit A, B and C) that were utilised to conduct the following experiments is under the Computer Science field, the knowledge acquisition and the learning outcomes are different, as presented below.

3.2.1 Unit A: Event-Driven Programming (Undergraduate)

This is a four-week course where the Linden Scripting Language (LSL) is introduced to underpin the understanding of Event Driven Programming (Ferg, 2006). Weekly lectures consist of the theoretical concepts plus material adapted from the Second Life® LSL Wiki. In the (3-hours) practical sessions, students write scripts with simple functionality. These are deployed in-world and tested by the students' avatars. Typical examples include objects that change colour or

¹⁸ desktop computers with high-end specifications

produce messages when touched. The implementation of object-to-object interaction explores the various uses of communication channels. Students had the opportunity to decide whether they would work in groups of two or individually, but in either case, at the end of this assignment all students were expected to perform a five-minute individual presentation of their work followed by the submission of a report.

3.2.2 Unit B & C: Project Management (Undergraduate & Postgraduate)

These are, respectively, a twenty-four-week (undergraduate level) unit, and a twelve-week (postgraduate level) one on Project Management. Students are required to build an educational showcase or a project simulation as part of a PRINCE2® managed group project. A two-hours lecture, prior to the first contact with the virtual world, was offered to students to help them understand the capabilities of these environments and the nature of their task. In addition, the learning objectives and anticipated outcomes were also explained. In either case, students were free to address questions—related to the 3-D modelling or scripting language—to the academic in charge or the laboratory demonstrators during the (2-hours) practical sessions.

3.3 The ‘DELUSIVE’ Project Development Plan

In order to distinguish the relationship between the experiments, that were performed every year (four years in total) in the context of each unit (three units in total), the following abbreviations are used: E_{1A}, E_{1B}, E_{1C}...E_{4A}, E_{4B}, E_{4C} (Table 3.1).

Table 3.1 Overview of the DELUSIVE project experiments.

Exemplification (Pre-Pilot Study)	Conceptual Orienteering (PhD Year 1)	Gamification (PhD Year 2)	Pedagogical Agent Tutoring (PhD Year 3)
E1A	E2A	E3A	E4A
Nov 2013—Jan 2014 4 weeks/12 hours	Nov 2014—Jan 2015 4 weeks/12 hours	Nov 2015-Jan 2017 4 weeks/12 hours	Nov 2016—Jan 2017 4 weeks/12 hours
E1B	E2B	E3B	E4B
Jan—Mar 2014 8 weeks/16 hours	Jan—Mar 2015 6 weeks/12 hours	Jan—Mar 2016 6 weeks/12 hours	Jan—Feb 2017 5 weeks/10 hours
E1C	E2C	E3C	E4C
Apr—Jun 2014 8 weeks/16 hours	Apr—Jun 2015 6 weeks/12 hours	May—Jun 2016 4 weeks/8 hours	Jun—Jul 2017 5 weeks/10 hours

Students, who participated in E_{1A}-E_{4A}, were expected to acquire strong and solid knowledge related to the structure and functionality of the Event-Driven Programming embedded in Graphical User Interface (GUI) (individual assignment). In the rest sub-experiments (i.e. E_{1B}/E_{1C}...E_{4B}/E_{4C}), the emphasis of the learning outcome was on the problem management (group project), and less on the knowledge acquisition related to the 3-D development or the programming language per se. A brief presentation of the units' structure is provided below.

Figure 3.1 illustrates the narrative and logic which led the decisions to blend the learning theories and models with the elements of the in-world instructional design approach as presented and described in the following Sections (3.3.1-3.3.4).

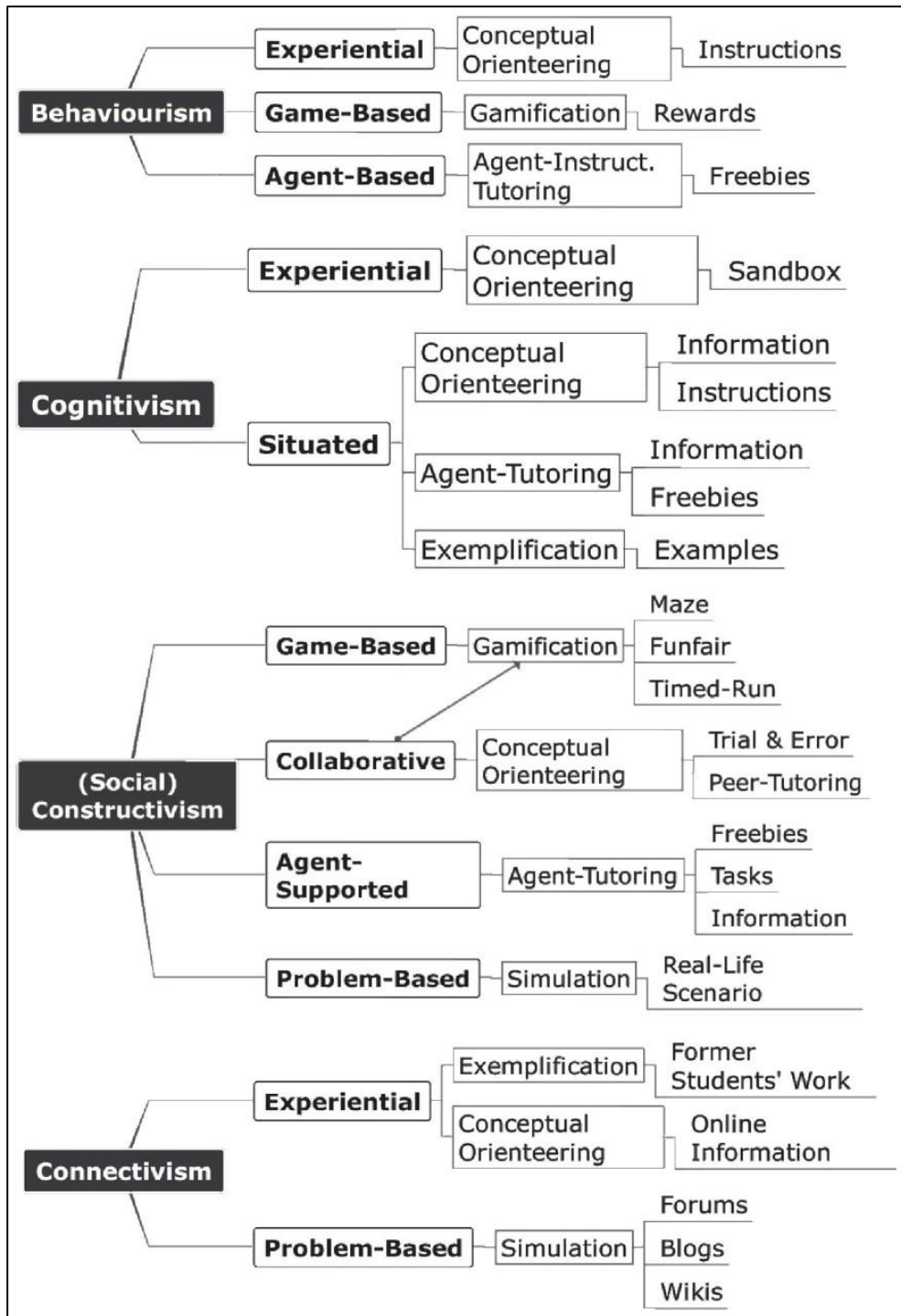


Figure 3.1 The relationships between the learning theories & models towards the instructional design approach used in this study.

3.3.1 Pre-Pilot Study: The ‘Abandoned-Land’ (Experiment 1)



Figure 3.2 Snapshot of the ‘Abandoned-Land’ experiment.

The work presented in this section (3.3.1) has been published in Christopoulos *et al.* (2014; 2015; 2016; 2018) and is provided here to ‘set the scene’ for the further experiments (Sections 3.3.2-3.3.4) conducted as part of this study.

Exemplification is defined as ‘the ability to critically assess the use of examples in scientific communication’ (Oliveira & Brown, 2016). The importance and effectiveness of exemplification to support conceptual understanding, provide supportive details about abstract concepts and engage learners with the phenomena they study has been highlighted by the aforementioned authors. Furthermore, as they consider exemplification an emotion-related process, they argue that the high degree of vividness, when providing examples, is an integral part of this process. Moreover, Zillman & Brosius (2000) mention that providing humans with examples enables them to associate the new features with past experiences and, thus, helps them to develop lasting cognitive and emotional experiences.

In this experiment, the most well developed student work (Figure 3.3) from a prior cohort was selected and utilised as example showcases for the newcomers, aiming to identify how such content can increase the opportunities for interaction both with the content of the world and with other students (e.g. discussion, criticism). Lastly, only one 'island' (simulator) was available by this time.



Figure 3.3 Example showcases & overview of the available content in the 'Abandoned-Land' experiment.

3.3.2 First PhD Year: The ‘Induction-Land’ (Experiment 2)



Figure 3.4 Snapshot of the ‘Induction-Land’ experiment.

As discussed in Section 2.6.3.2, providing students with enough time to familiarise themselves with the world and its tools is of vital importance (Christopoulos, 2013; Jarmon *et al.*, 2009; Savin-Baden *et al.*, 2010). However, the strict university time frames make that hard or even impossible. Considering that this is a time-consuming process, it is questionable whether or not instructional designers can facilitate, or even, speed it up.

Therefore, the aim of this experiment was to examine whether or not this process can help students to acquire all the knowledge and skills required to cope with the world, by increasing the incentives for interaction, and, therefore, engagement. In this area, students could educate themselves about the virtual world and its tools, freely experiment at the available sandbox area—which contained technical information related to object creation and manipulation—without ‘messing up’ their workspaces and socialise in a relaxed atmosphere at the surrounded meeting points (mini parks) (Figure 3.4).

The 'school-like' building was developed containing instructional information and practical exercises related to:

1. the navigation tools (Figure 3.5),



Figure 3.5 Information about the navigation tools & the in-world settings.

2. the avatars' editing appearance process, with freely available premade outfit sets (Figure 3.6),

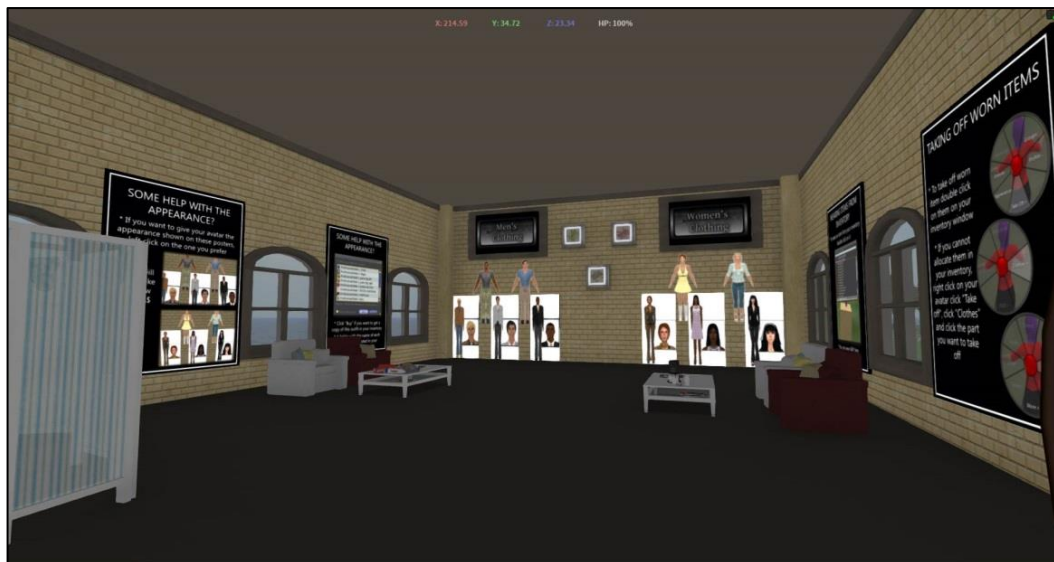


Figure 3.6 Information about the avatar editing appearance.

3. the use of the communication channels, with relevant infrastructure to hold formal meetings or informal conversations (Figure 3.7 lower side),

4. the use and development avatar gestures/animations (Figure 3.7 upper side), and
5. other functions of the virtual world (e.g. entering mouselook, accessing inventory).

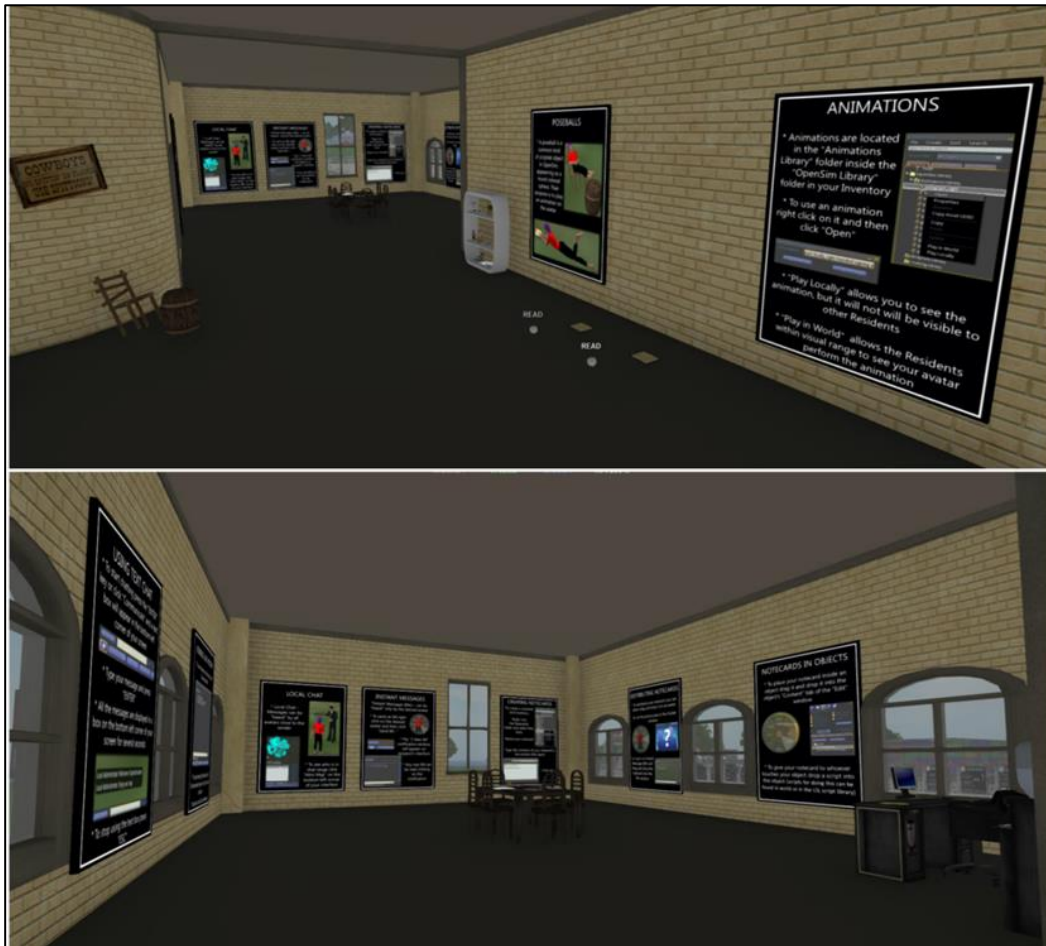


Figure 3.7 Information about the animation & communication tools.

In order to focus explicitly on one parameter, i.e. the impact of the orientation content on learners' interactions, motivation and engagement, the example showcases that have been developed by former students were removed.

3.3.3 Second PhD Year: The 'Leisure-Land' (Experiment 3)



Figure 3.8 Snapshot of the 'Leisure-Land' experiment.

The employment of the leisure games aims at evoking strong childhood memories and further enhancing the already playful nature of the virtual world. As a result, interacting with the games would presumably increase the opportunities for interaction, not only with the content of the world but also with other students.

The objective of this experiment (Figure 3.8) was to investigate the impact of such content on the educational process (knowledge revision), as well as to motivate learners to engage with the world (leisure) and the learning activities (virtual rewards). In either case, as this content was fairly massive, students could also derive a benefit from getting ideas for their own projects. The content of the previous experiments was wiped out, whilst additional technical work was conducted to further increase the stability of the server. Lastly, the available virtual space (island) was expanded from one to three (interconnected). The following content was available to students as part of this experiment:

- **Mini lake:** Row boat (animated), life jackets and sea mattresses with poseballs to animate avatars in different positions, and a variety of tropical fishes under water. The coast was set up to resemble a meeting point with interactive (animated) objects (Figure 3.9).



Figure 3.9 The mini lake.

- **Amusement park:** Ferris wheel, train ride, teacups ride, whip ride and shooting targets (e.g. ducks, darts). For realism purposes there was also a ‘tickets’ office for role-play (Figure 3.10).



Figure 3.10 The amusement & leisure park.

- **Café:** The seaside café was another meeting point. A replication of a real café with chairs and stands for the students to rest and chat during their breaks from work (Figure 3.11)



Figure 3.11 The OpenBedfordia café.

- **Brick-Maze** (left side of Figure 3.12): A small maze made with virtual 'Lego-like' bricks. The obstacles (walls) would open only after providing the correct answer, whilst a penalty (time-delay prior to making the next attempt) was applied whenever an incorrect answer was given. In addition,

an Instant Message (IM) with a hint was sent to the participants' avatars guiding them towards the theoretical material. Various dead-end points have been placed in between to make the process more realistic and challenging. For every correct answer, participants would also get an IM with a password digit which could be used at the end of the maze to claim a reward. Both the questions and the rewards would change on a weekly basis. Their content originated from the theoretical course material of each unit.

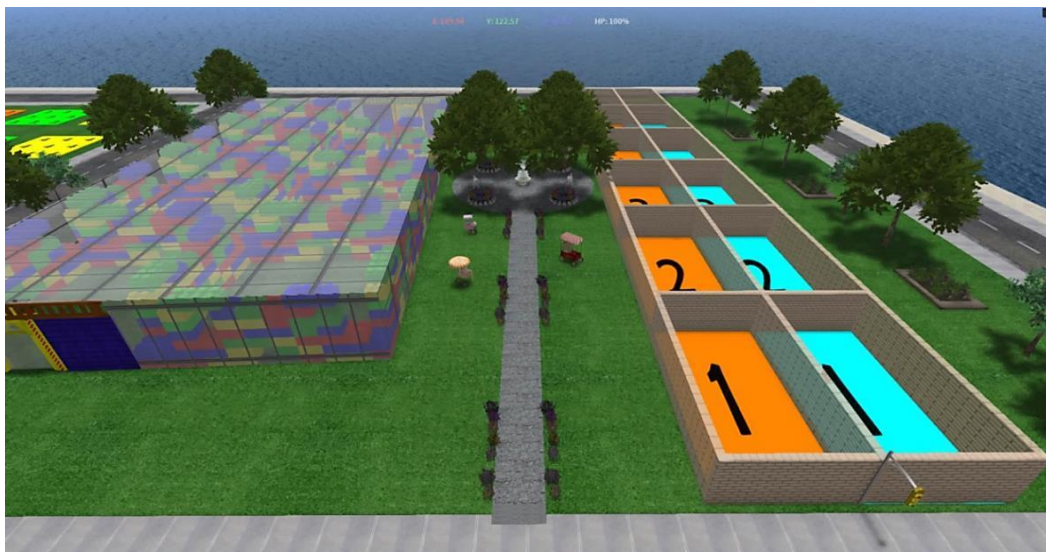


Figure 3.12 The Brick-Maze & the Knowledge Pentathlon.

- The **Knowledge Pentathlon** (right side of Figure 3.12): A short and timed multiplayer 'racing-knowledge' game. The minimum number of required players was two (opponents) or more (collaborators vs opponents). Five obstacles-walls, consisting of questions stemming, once again, from the theoretical part of each unit with increased difficulty were utilised, whilst the penalty timer was also applied. The content of the questions would also change on a weekly basis.

3.3.4 Third PhD Year: The 'Robot-Land' (Experiment 4)



Figure 3.13 Snapshot of the NPCs used in the 'Robot-Land' experiment.

Baylor & Kim (2005) suggest that PAs can take various forms such as that of an 'expert', a 'motivator', or a 'mentor'. In this experiment, two conversational entities with contradictory behaviours and characteristics and one Non-Player Character (NPC) were utilised to attract students' interest and attention in different ways (Figure 3.13).

The purpose of the final experiment was to examine the impact that different PAs have on the educational process, by offering support or mentoring as well as guidance and help with decision-making. In addition, light was expected to be shed on the limited literature, related to learners' attitude as regards this educational approach, and the aspects that contribute towards the attractiveness, or not, of the PAs. Lastly, students were intentionally not informed about the presence and roles of the NPCs, so as to allow them to act naturally and discover their features as part of the exploration process.

The NPCs that were utilised in this experiment were:

Jella Delta (Figure 3.14) had a human-like form, resembling the role of the instructor or educator, and was a conversational agent (chatbot) with knowledge-intensive and domain-specific question answering capabilities. Its role was to facilitate the learning process and support students by providing useful and meaningful answers to queries related to the virtual world and its tools.



Figure 3.14 The facilitator tutor-NPC.

The functionality and instructional capabilities (Figures 3.15-3.16) of this NPC can be classified into four major categories:

1. **Generic:** information about the OpenSim platform, the LSL and the secondary features of the virtual world¹⁹, as well as counselling related to the troubleshooting procedures of frequently reported issues²⁰.
2. **Avatars:** information about the communication²¹ and the navigation²² tools of the virtual world, as well as the avatar appearance editing process²³.

¹⁹ personal profile, friend requests, groups, multimedia, weather settings

²⁰ graphics, latency

²¹ IMs, notecards, calling cards, gestures, animations, poseballs

²² movement keys, camera manipulation, entering Mouselook, teleportation and landmarks

²³ clothing and accessories

3. **Scripting**: information about the in-world programming language²⁴ and the most frequently used functions²⁵, in accordance to the assignment needs.

4. **Primitives**: information about the object (primitives) manipulation processes²⁶ and the in-world physics²⁷.



Figure 3.15 Example conversation with the tutor-NPC (1).



Figure 3.16 Example conversation with the tutor-NPC (2).

²⁴ libraries, operators

²⁵ sensors, loops, dialog menus

²⁶ parameters, textures, meshes, grating editing permissions to other users

²⁷ motion, movement, rotation, transparency, glow

Nevertheless, due to the limited capabilities of the OpenSim technology to support complex AI algorithms, the accuracy rate of providing a correct answer—as calculated during the testing process—was roughly 66.66%. In an ideal scenario, the user input would consist of short sentences or phrases, where at least one key-word would be matched and correlated against the answers' pool (brain) of the NPC.

Queen Kong (Figure 3.17) was also a chatbot, though of a nonhuman type (ape), as an example of the contradictory content that virtual worlds can accommodate. Its role was to disorientate students by providing incorrect or 'nonsense' answers to their queries in a 'ludicrous' way.



Figure 3.17 The obstructor disorientation-NPC.

Gizmo Gear (Figure 3.18) had a robot-like form, operating as a vendor (task-specific/domain-specific information giver). Unlike the other NPCs, who also had moving capabilities, this NPC was immobilised, becoming interactive upon students' call. Its role was to provide students with informational notecards (digital text-based notes), assign or suggest tasks and offer freebies (premade 3-D objects and scripts)



Figure 3.18 The vendor NPC.

In addition to the NPCs, a mini park, with both animated (e.g. chairs, benches, fountain) and non-interactive (e.g. trees, flowers, well) objects, was offered to students for socialisation purposes (Figure 3.19)



Figure 3.19 Meeting point for socialisation.

3.4 Chapter Highlights

- In this chapter the institutional and instructional context of the study were discussed under the consideration of the following aspects:
 - The description and duration of the academic units which were utilising a HVL approach and offered fertile ground for the examination of the subject under investigation (Section 3.2).
 - The decisions that guided the approach to blend the discussed pedagogical literature (Chapter 2) with the in-world instructional design (Section 3.3).
 - The description of the development stages of the experiments that were conducted in the context of this study (Sections 3.3.1-3.3.4).
- The prime objective of the aforementioned experiments was to examine whether or not these processes could help learners—especially those who had negative preconceptions regarding the use of virtual worlds from the beginning—to acquire all the required knowledge and skills to cope with the learning activities, by increasing the incentives for interaction, and, therefore, engagement.
- For data validation purposes, each experiment was repeated three times, with different learning objectives and student cohorts.
- The context of each instructional approach was examined in isolation from the others so as to focus exclusively on one factor at a time.

Chapter 4: Research Methodology

4.1 Introduction

For the needs of this study, the Action Research methodology which Esteves *et al.* (2011) describe as ‘*a set of research methodologies that involve an intervention or change on part of the researcher, while the research occurs*’, was utilised. In accordance to the guidelines of this approach and, also, to reduce bias in the data interpretation process, a mixed-methods research design approach was employed (Section 4.3.1-4.3.2). Using multiple research methods, when studying human behaviours, has two considerable advantages (Cohen *et al.*, 2011):

- **Perspective:** Mixed methods allow researchers to triangulate and cross-examine their primary data, and, thus, have a wider and more diverse viewpoint of the subject under investigation.
- **Limitations:** Triangulation also minimises the limitations that each research method may separately have.

In doing so, the accuracy of the collected data increases, whilst their validity and diversity is enhanced. Moreover, it enables the researcher to develop a deeper insight of the studied phenomena and hence develop more reliable and substantial conclusions. This, eventually, justifies the reason why pedagogical observations (Section 4.3.4.2) were used to monitor learners’ actions and behaviours, in conjunction with the surveys (Section 4.3.4.1), which aimed at recording their thoughts and tendencies. The collected data were, subsequently, analysed (Section 4.3.5) and correlated (Section 4.3.6) using the recommended techniques. Lastly, the reasons that led to the selection of this particular sample and the related limitations are discussed in Section 4.3.3.

4.2 Action Research

Action or Practitioner Research is described as an effective tool for those who strive for change and have desire for improvement (McNiff, 2002). In fact, this is the main principle of this approach i.e. the identification of problems—as perceived by the educators themselves—and the motivational will to improve or change the current condition, grounded on data that have been generated from applied research (Kemmis & McTaggart, 1992; Kemmis, 1997; Ferrance, 2000). As Kemmis & McTaggart (1992) suggest, ‘*to do action research is to plan, act, observe and reflect more systematically, and more rigorously than one usually does in everyday life*’. The aforementioned actions are, in a sense, the four-steps that the Action Research cycle includes (Figure 4.1).

An extended version of the Action Research cycle has been developed by Cohen *et al.* (2011), discussing the preface preparation required prior to the conduct of the Action Research plan, the stages of which are presented below:

- **Stage 1:** Identification and evaluation of the problematic area so as to formulate the initial proposal.
- **Stage 2:** Preliminary discussion between the involved stakeholders (e.g. educators, researchers, advisers) and development of a draft proposal regarding the enhancement of the curriculum (e.g. changes, limitations, capabilities).
- **Stage 3:** Review of the literature so as to raise awareness about similar objectives, procedures or encountered problems.
- **Stage 4:** Review of the initial proposal, based on the previous steps, and formation of a testable hypothesis with clear aims and objectives.

The aforementioned steps have been performed during the preparation process of this study, where the initial research proposal was developed and

submitted for consideration. From this point onward, the formal and initial *reconnaissance cycle* begins (Tripp, 1995):

- **Stage 1:** Matters related to:
 1. the allocation of the resources and the materials that will be used for the teaching and learning practices (Section 3.2),
 2. the deployment of staff,
 3. the choice of the research methods (Sections 4.3.1-4.3.2),
 4. the evaluation techniques that will be employed during the repeated cycles of the study (Section 4.3.4), and
 5. the sampling selection, are planned (Section 4.3.3).
- **Stage 2:** At this stage, the implementation of the project begins. More precisely, the conditions and the methods that will be employed for the data collection approach are defined and the data analysis approach is classified. As a side note, it should be mentioned that surveys (pre- and post- the controlled intervention), observations, multiple case-studies or longitudinal studies are amongst the various design approaches and methods that can be employed in the context of this methodology.
- **Stage 3:** Subsequently, the experimentation begins and the primary data are produced and collected. Part of this process also includes their analysis and interpretation (Sections 4.3.5-4.3.6).
- **Stage 4:** The final stage includes:
 - the discussion of the findings (Chapter 5),
 - the review of the research process, and
 - the reflection on the undertaken actions.

At this point the project is evaluated so as to identify the errors, mistakes and issues that arose along the way. Lastly, a summary of the conclusions is

drawn and the results are becoming publically available (Chapter 6). As a final note, it should be mentioned that the looping of the cyclical research process is never ‘actually’ completed. However, an end-point is reached when the reflection stage produces a significant amount of knowledge in accordance to the aims and objectives of the study (Chapter 7) (Zuber-Skerritt, 2002).

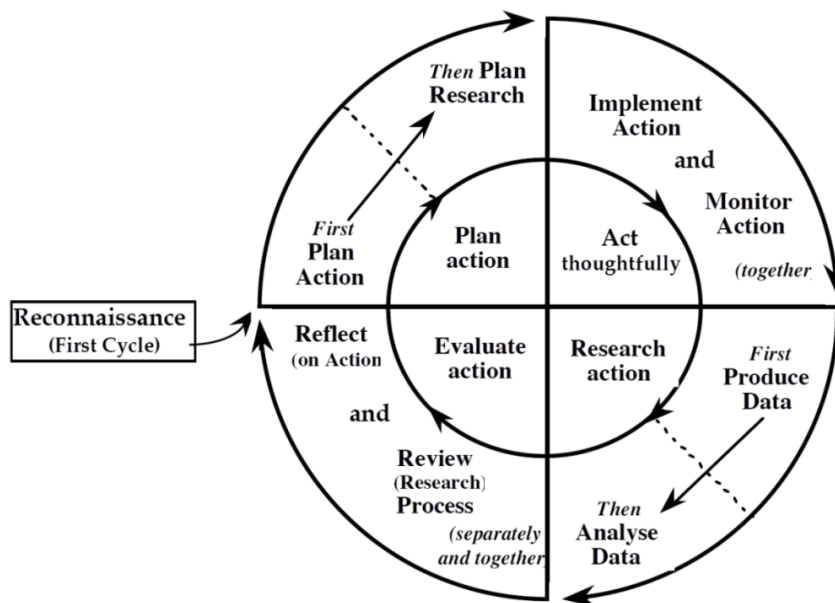


Figure 4.1 The full action research cycle (Tripp, 2003).

4.3 Research Method

4.3.1 Quantitative Research

According to Cohen *et al.* (2011), quantitative research—such as surveys—has numerous advantages. First of all, it is regarded as the most efficient method to gather the opinions of a large-scale sample, especially for the purposes of this study where not all students could take part in the observations for practical reasons. Moreover, the data gathered from the surveys could be used supplementary to those gathered from observations, since these would reveal students’ thoughts as to the use of the virtual world, and justify their actions and behaviours. In addition, the survey allows for a statistical analysis and

considerably accurate generalisations. Finally, surveys are thought to be participant-friendly, since participants are familiar with how to respond to them quickly and easily, thanks to their multiple-choice Likert scale style.

Surveys also present a set of limitations as, according to researchers (Hakkarainen *et al.*, 2001; Rosenfeld *et al.*, 1996), the main problem of student self-report data is that participants often have notions about socially desirable answers²⁸, thus leading them to respond in a manner that will make them to be viewed good or favorable by the researcher. Indeed, Social Desirability Bias or Social Desirability Responding is of special concern and has been correlated as a potential source of error variance (Hancock & Flowers, 2001). The proposed solution to eliminate the impact of this issue is the *anonymisation* of the surveys (*ibid*).

Additional bias might occur due to the novelty effect. As Hew & Cheung (2010) suggest, short term studies—especially the ones conducted in virtual worlds—are more inclined to suffer from this effect, as the nature of this technology might lead educators and learners to have a more pleasant or joyful experience compared to the traditional educational practices.

4.3.2 Qualitative Research

Research through qualitative research (in general) and the pedagogical observation method (in particular) has a great number of advantages. There are, however, unavoidably—as with most methods—certain disadvantages in the data collection process (Moyle, 2002; Wilkinson, 2000) which are deemed wise to report.

The main challenge was the ‘*selective attention of the observer*’. When two or more observers are examining the same sample, different outcomes are likely to

²⁸ over-reporting good behaviour or under-reporting bad/undesirable behaviour

be reached, due to the very unique way the human brain perceives what one sees, feels, and hears. To eradicate the negative impact of this issue, the researcher attempted to explicitly log students' actions, exactly the way they were taking place in real time (note-keeping), and consequently log them in a diary (Cohen *et al.*, 2011).

In addition, the '*reactivity*' of the sample can also run the risk of bias. According to Shaughnessy, Zechmeister & Zechmeister (2003), human behaviour might alter when someone is being observed. In terms of the observations per se, students may feel stressed or anxious while they are conducted, which can affect their overall behaviour, e.g. work harder, or perform worse, or even behave in ways that are thought to positively affect the researcher's work. This is why the laboratory observer maintained an overall low profile, roaming almost silently around the lab, keeping a '*safe distance*' from the students, and trying not to make his presence distracting for them. Finally, observations are recording only what happens in a given period of time, or what can be seen in a given interface, known as the '*problem of inference*'.

All in all, nevertheless, it should be mentioned that a great effort was made to eliminate the aforementioned disadvantages. As a result, it was the advantages of the qualitative method that were most predominant in the end. The greatest one lies on the principles of '*immediate awareness*' and '*direct cognition*', i.e. the opportunity given to the researcher to have a '*direct look*' at the actions taking place, without having to rely on second-hand accounts. Observation was chosen for this study based on three main criteria. First, as described in Cohen *et al.* (2011), comes the ability to collect unique primary data. Secondly, observation is a very flexible form of data collection that allows researchers to alter their focus, depending on the observed actions and

behaviours. Finally, the method of observation allows the researcher to gather any necessary data, while the participants unimpededly follow their own agenda and priorities.

4.3.3 Sampling

Convenience or purposive sampling is the most commonly used sampling selection method. As already mentioned, all methods have certain disadvantages, which are, however, overcome by the great number of advantages they present. The limitations of sampling include elements such as the variability and bias that cannot be measured or controlled, as well as the results that cannot be generalised beyond the sample's population (Acharya *et al.*, 2013).

Nevertheless, these limitations were mitigated, and the advantages of the sampling method were the ones most prominent in the end. Therefore, sampling allows the researcher to collect information from participants who:

1. are 'easily accessible',
2. meet certain practical criteria (e.g. geographical proximity), or
3. simply have the willingness to participate in the study (Dörnyei, 2007; Saumure & Given, 2008).

As a result, participation in this study was voluntary and all the enrolled—to the presented units (Section 3.2)—students were invited to participate. In other words, no filtering in terms of setting up 'standards' or specific criteria, such as age, gender, nationality, were made. Likewise, no particular selection, such as prior experience in similar platforms or generic interest in using or, thereof, not virtual worlds/games, was made either.

4.3.4 Data Collection

Although the data collection approach was planned at the beginning of the research, an anecdotal observation—which became apparent during the pilot study (Experiment 1)—led to the modification and alteration of the data collection approach. Students' attitude and behaviour towards the virtual world as an educational tool was overwhelmed by negative attitude and emotions originating from their biases and preconceptions that 'virtual worlds' are equivalent to 'virtual games'. Indeed, the teaching team in charge received negative feedback suggesting that such medium has 'no place' in the university classroom and should be, therefore, discontinued from the teaching curriculum. As it was unclear how such behaviour could affect interactions and engagement, the distribution of a preliminary survey, prior to the conduct of the PhD study (Experiments 2–4), was considered necessary. The observations' checklist and the statements of the conclusive survey were designed prior to the conduct of the pilot study and further modified based on its results.

The aim of the preliminary survey was to enable the researcher to develop a clear idea of the learners' beliefs and preconceptions—prior to using the virtual world—so as to correlate them with the findings deriving from the conclusive survey and the observations. The content of the observation checklist and the conclusive survey was developed in accordance to the constructivist theoretical approach—as it emphasises the impact of interactions on the learning process—and is the outcome of a joint effort to blend the relevant literature (Chen *et al.*, 2006; Huang *et al.*, 2010; Merikivi, 2013; Rjaibi & Rabai, 2012; Zaharias, 2006) and the author's prior research experience in matters related to educational practices in virtual worlds (Christopoulos, 2013).

To reduce the survey error (conclusive survey only) and ensure its clarity, the Respondent Debriefing Approach, as described by Hess & Singer (1995), and the Cognitive Interviewing Technique, as described by Willis (1999), were utilised. In both cases, former university students ($n = 10$)—who had utilised virtual worlds in their academic curriculum—were invited to undertake and provide feedback on the comprehension and interpretation of the survey elements.

Figure 4.2 illustrates the chronological order of the (adjusted) data collection process, as adopted post-completion of the pilot study.

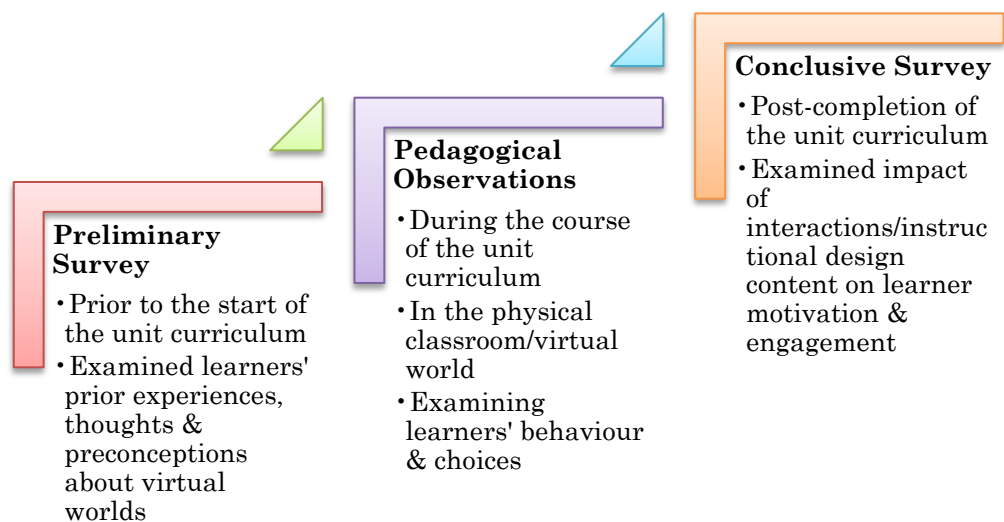


Figure 4.2 The data collection process in chronological order.

4.3.4.1 Surveys

The questionnaires aimed at eliciting information of how learners perceived their interactions—both with the content of the world (including the material developed by the researcher) and others—so as to establish intuitive ideas about their effects on motivation and engagement. In addition, they offered important indicators and insights on issues related to the learners' performance and the impact of virtual worlds on the educational practices (Table 4.1)

Table 4.1 Description of the surveys' elements.

Core categories	Examination key-points	Statements (Appendix A)
Sample	Sample's identity	G1, G2, G3
Experience	Prior experience & preconceptions	S1*–S3*
Personal opinion	Educational value of virtual worlds	S4*–S5*, Open-ended
Interactions with the content & other students (mutual elements)	Motivation, engagement, presence, learning experience	S1-S9, S15-S23, S31-S33
Interactions with the content (exclusive)	3-D modeling, programming, exploratory learning	S10-S14
Interactions with other students (exclusive)	Communication, collaboration, peer-tutoring & peer-learning	S24-S30

As to the design of these instruments, the preliminary survey (Appendix A) consisted of eight statements²⁹, of which three were covering personal details, three prior exposure and two preconceptions related to the use of virtual worlds for educational practices. As regard the conclusive survey (Appendix A), it consisted of 36 statements, of which three also covered personal details (Part 1), whilst the second part examined the learners' interactions with the content of the virtual world (14 statements/Part 2A) and other users (16 statements/Part 2B) on a five-point Likert Scale (Strongly Agree–Strongly Disagree). The third part (Part 3) was introduced during the 'Leisure-Land' experiment and subsequently adopted in the 'Robot-Land', in order to examine the frequency (one statement) and the impact of the particular instructional design content (i.e. educational/leisure games and PAs) on the learning process (two statements), once again using the same Likert Scale technique.

The Likert scale can be described as a participant-friendly method, since it is easily understood, while it offers a good range of responses and does not cause misapprehensions. In addition, participants are usually familiar with this scaling, which does not limit their answers to just either an affirmation or a denial of the statement (inclusion of neutral-opinion statement).

²⁹ Indicated in the corresponding table using asterisk (*) (Appendix A)

Lastly, in the open-ended question (Part 4), participants were asked to indicate the factors that would have helped them become more engaged with the virtual world.

4.3.4.2 Pedagogical Observations

In this study, the researcher undertook the role of observer, whilst the academic in charge along with the members of the technical support team were covering the learners' inquiries during the practical sessions. The pedagogical observations aimed at discovering the meaning, dynamics and processes involved in the various actions and interactions that learners performed in both environments (i.e. physical/virtual). The points that were examined, using an observation checklist, and subsequently logged in the diary are presented in Appendix B.

Table 4.2 Description of the observation checklist elements.

Core categories	Observation key-points	Focus points (Appendix B)
Communication	Verbal (in-class), textual & non-verbal (in-world) communication.	C1–C8 & V1–V9
Attitude	Interactions with the virtual world interface (related & unrelated to the project).	C9–C12 & V10–V15
Identity	Perception of the avatar identity (physical-world) & development of virtual identity.	C13–C16 & V16–V20
Occupation	Willingness to remain/use the virtual world.	CV1–CV6

4.3.5 Data Analysis

4.3.5.1 Quantitative Data

Questionnaires developed in accordance with the Likert scale principles are considered to be psychographic surveys and, thus parametric analysis might not be appropriate or even applicable (Gardner & Martin, 2007; Jamieson, 2004). Although this is widely acknowledged, the use of parametric tests—when their assumptions are met—to analyse Likert-type data is also perceived as a ‘commonly acceptable practice’ (Fagerland *et al.*, 2011; Norman, 2010; Pullin &

Haidar, 2003; Scheridan & Lyndall, 2001). Therefore, considering the above in conjunction with the nature of this study, the use of a mixed-method statistical analysis approach was deemed appropriate and practical.

To draw clear conclusions and make more reliable generalisations, the collected responses from each sub-experiment—as discussed in Sections 5.2-5.3—were merged into four main data sets; one for each experiment (i.e. $E_n = E_A + E_B + E_C$). In addition, in order to determine the strength (percentages) of the positive and negative responses that were given in each examination item (Hayes, 2008), the ‘*substantively scale*’ approach was adopted (de Vaus, 2001). As a result, the originally five-point observation scale was transformed into a three-point scale, whilst the collected responses were categorised under the ‘Agreement’, ‘Neutral’ and ‘Disagreement’ divisions. In doing so, the presentation of the frequencies becomes more robust and the trends of the samples more visible (*ibid*). In retrospect, it would suffice to say that, after examining the analysed data, the survey items should have been collected using a three-point observation scale in the first place. The rationale for this assertion is grounded on the fact that no additional information emerged or could be elicited after analysing and comparing the collected data using the different scaling approaches to analyse participants’ responses.

As regards the particular methods, a non-parametric test (see point Kruskal-Wallis *H* Test) was employed to examine the stochastic dominance of each instructional design approach (experiment) against the independent variables (examination items of the surveys). Moreover, a parametric test (see point Cochran-Armitage Trend Test) was employed to identify the impact that each type of interaction³⁰ had on the same sample’s trend. The samples’ mean values

³⁰ content of the world vs other users

(\bar{x}) have also been calculated and utilised as an indicator to measure and compare the central tendencies. Finally, the standard deviation values (S_x) and the most frequent response (Mode) for each statement can be found in the statistic tables (Sections 5.2-5.3), so that the data can be more clearly presented and perceived.

- **Kruskal-Wallis H Test & Conover-Iman**

The main reasons that led to selecting the Kruskal-Wallis H test were its non-parametric (distribution free) nature and the option it offers to perform multiple comparisons between many groups, especially when dealing with ranked data and ordinal-level dependent variables (Agresti, 2007; Mangiafico, 2016). The null hypothesis (H_0) assumes that the k samples belong to the same population and the probability α of a type-I error—occurring when a true H_0 is rejected—has been set to .05 (i.e. 95% confidence level).

In terms of statistical significance, the Conover-Iman *post-hoc* test was chosen to further reject the H_0 strictly because of its more powerful nature compared to the available alternatives (e.g. Dunn's test) (Conover & Iman, 1979; Conover, 1999).

- **Cochran-Armitage Trend Test & Freeman's theta**

To examine the existence of association between the ordinal (Likert scale points) and the nominal (examination items) variables, the Cochran-Armitage Trend Test (CA) was opted for. Unlike the chi-squared (χ^2) test, which ignores the categorical nature of the data, the CA test is more powerful when examining the association trend between the ordinal categories, as it accounts the ranking among the rows based on scores (Agresti, 2007; Mangiafico, 2016). The test can be used to examine different hypotheses/assumptions with or without applying continuity corrections (Armitage, 1955; Cochran, 1954). In this study, the

uncorrected approach was used to examine the two-sided H_0 .

In terms of statistical significance, the Freeman's coefficient of determination (Freeman's *theta*) is calculated to gauge the strength of the association between the nominal variables (Freeman, 1965; Mangiafico, 2016).

4.3.5.2 *Qualitative Data*

According to Strauss & Corbin (1998), the qualitative approaching of an investigational topic is the ideal option when the focus lies not only on the width of the phenomenon, but also on the details of that phenomenon. As reported in the pedagogical observations section (Section 4.3.4.2), an example of such details includes the motivation of the participants and their feelings, which are deemed necessary to be examined. In the same vein, Hammarberg, Kirkman & de Lacey (2016) emphasise the importance of allowing individuals to share their experiences, opinions and perspectives. The open-ended question of the survey was actually grounded on this perspective, aiming at recording and thus evaluating these experiences, opinions and perspectives.

Amongst the various methods that can be utilised to analyse qualitative data, such as the thematic analysis, the qualitative content analysis or the narrative analysis, the Grounded Theory—as described by Strauss & Corbin (1998)—was considered to be the most relevant and applicable approach after considering the nature and the context of this study.

The main reason that led to this decision is the exploratory nature of this method, as it is considered to be well-suited when it comes to the investigation of matters that have attracted limited or no research interest. This can be applied in the case of the hybrid interactions topic, treated in this study, as a completely new viewpoint needed to be drawn based on practically no available literature. Second comes the flexibility that this method gives to the researcher to

systematically generate a theory from the collected data (Strauss & Corbin, 1994). Indeed, as Holton (2007) suggests, 'Grounded Theory is about concepts that emerge from data, not the data per se'. In fact, this is the key principle of this approach; the formulation of conclusions that are not based on theoretical approaches, but grounded on the collected primary data (Engward, 2013). What should also be mentioned is the ability of this method to determine in a more robust and sustainable way 'what actually happens' in a given situation or context (Milliken, 2010). The rationale of the observations that took place in the context of this study is based on this last keypoint of the Grounded Theory and significantly explains why it was opted for.

Notwithstanding the foregoing, the Grounded Theory, as with all the other research methods, also has a number of limitations. The most widely raised concern or criticism refers to its epistemological roots and, more precisely, the embeddedness of the researcher in the data interpretation and theory construction process (Bryant & Charmaz, 2007). Indeed, the coding process produces large amounts of data, not to mention that there are no standardised rules or practices related to their grouping. Therefore, these issues become a major procedural shortcoming that has to be taken into account. To this end, the authors (*ibid*), mention amongst the lines that the researcher needs to be experienced and skillful in using Grounded Theory methods so as to avoid procedural errors related to the data interpretation.

However, the prior experience of the researcher in using the above mentioned approach (Christopoulos, 2013) as well as the wide adoption of the Grounded Theory in the field of educational research (Chong & Yeo, 2015), were regarded to be sufficient reasons to consider the employment of this approach, whilst maintaining its shortcomings to the lowest possible extent.

4.3.6 Data Triangulation

As Lin (1976) suggests, relying exclusively on one research method might eliminate the validity of the collected data (e.g. bias, distortion) and reduce the confidence of the researcher. Under this consideration, Cohen *et al.* (2011) suggest the triangulation of the primary data, especially when combining qualitative and quantitative methods, whilst examining human behaviours. Indeed, the added value of using triangular techniques to cross-examine the collected data from more than one standpoint, adds validity to the mapped information and is considered an effective way to acquire a holistic view of the educational outcomes (Campbell & Fiske, 1959; Gorad & Taylor, 2004; Mortimore *et al.*, 1988).

Although various techniques exist, *methodological triangulation* is proposed as the most relevant to educational studies (Cohen *et al.*, 2011). In this respect, two categories are identified, as developed and described by Denzin (1970): triangulation *within methods* (replication of a study), and triangulation *between methods* (use of more than one method to achieve a given objective). In the present study both techniques were utilised (i.e. replication of the core body of the experiments and examination of learners' interactions using different methods) to ensure both the validity and the reliability of the collected data and, therefore, conclusions.

Nonetheless, a portion of researchers holds different views in regard to the triangulation approach as they argue that multiple data sources do not necessarily add more validity or guarantee the objectivity of the research (Fielding & Fielding, 1986; Patton, 1980). In the same vein, Silverman (1985) claims that the idea behind triangulation is rather positivist, as it is presumed that the use of multiple instruments is superior to single data sources. However,

according to Cohen *et al.* (2011), the notion and validity of the aforementioned claims have been well-argued and critically discussed by Denzin (1997).

As a concluding remark, Table 4.3 presents the triangulation links between the surveys' statements and the observations' focus points.

Table 4.3 Primary data triangulation.

Triangulation Category	Surveys (Appendix A)	Observations (Appendix B)
Preconceptions	S1*-S5*	C7-C8, V6-V7
Personality	S4*-S5* S1-S33, open-ended	C5-C8, C10-12, V3-V4, V6-V7, V10-V15
Communication	S24-S30	C1-C8, V1-V9
Attitude/Feelings	S3-S4, S10-S14, S16, S18, S21-S27, S30	C5-C12, V3-V7, V10-V15
Student-Avatar identity	S2, S16	C13-C16, V9, V16-V20
Immersion	S1, S2, S15-S16	C9, C11, C13-C16, V16-V20, CV1-CV6
Engagement	S7-S14, S21-S23	C9-C12, V10-V15, CV1-CV6
Learning process	S3, S5-S9, S17, S19-S23	C1-C4, C9-C12, V1-V2, V10-V15
Instructional Design	S31-S33, open-ended	C5-C8, V15

4.4 Chapter Highlights

- The aim of this Chapter was to provide an overview of the research methodology and the approaches that were employed for the examination of the subject under investigation.
- Due to the complexity and changing nature of virtual worlds, as well as the active involvement of human subjects, the adoption of the Action Research approach (Section 4.2) was taken into consideration. The main reasons that led to this choice were:
 - the extensive employment of this methodology in educational studies, as it provides an efficient and effective way to carefully plan the stages of the study holistically, especially when introducing controlled changes,
 - the flexibility offered to the researcher to adjust, alter and modify the context of the study and the research tools in the light of the findings deriving from the former cycles.
- The data collection method (Section 4.3.1-4.3.2) included a combination of both qualitative and quantitative approaches, as highlighted in the main principles of Action Research. In addition, it offered the opportunity to cross-examine and triangulate the primary data, so as to increase the strength and the validity of the concluding remarks (Section 4.3.6).
- The sample of the study was selected for convenience purposes, as both the institution, in which the study was undertaken, and the researcher, share common insights in regard to this educational approach (Section 4.3.3).
- The data collection approach included the following instruments which are also presented in a chronological order (Section 4.3.4):

- A preliminary survey, distributed to participants a priori to the conduct of the controlled intervention (i.e. prior to the start of the unit curriculum), aiming at examining the learners' prior experiences, thoughts and preconceptions.
- The pedagogical observations, performed using an observation checklist and note-keeping, as the instrument to record and log learners' actions and interactions—both in the physical classroom and in the virtual world—during their weekly practical sessions.
- A conclusive survey, distributed to participants a posteriori to the conduct of the controlled intervention (i.e. post-completion of the unit curriculum), aiming at examining the impact of interactions—both with the content of the virtual world and with others—in the context of their practical sessions.
- The instruments for the data collection of the observations and the open-ended survey question were developed under the principles of the Grounded Theory approach and analysed using the corresponding coding paradigms (Section 4.3.5). Concerning the survey statements, the Likert scale method was employed for the development of the survey items.

Chapter 5: Data Presentation & Screening

5.1 Introduction

The surveys' statements were analysed and discussed under the principles of the Likert Scale methodology, as described in Kothari (2014) and Cohen *et al.* (2011). The statistical analysis of the survey data was performed using the *R Project* for Statistical Computing³¹ (the integrated mathematical formulas are provided in Appendix F).

As to the analysis approach of the data collected from the observations and the open-ended question of the conclusive survey, the coding processes of the Grounded Theory approach, as described by Strauss & Corbin (1998), were utilised to identify the core categories and distribute the collected data.

An overview with the details of the samples that participated in each (sub)experiment is provided in Appendix C.

5.2 Preliminary Survey

To investigate how and to what extent the learners' personal choices and preconceptions towards the use of virtual worlds in education enhance or constrain the educators' plans, the preliminary survey was introduced in E₂ and all the subsequent experiments. The structure of the questionnaire included the following sections:

- **Part 1:** statements about the samples' identity (i.e. gender, age, study level).

³¹ <https://www.r-project.org/>

- **Part 2:** statements regarding the learners' prior experiences in virtual worlds, as well as biases, preconceptions and opinions (comments) heard from others as to the use of virtual worlds for educational practices.
- **Part 3:** statements regarding the educational value of virtual worlds and the learners' willingness to engage in activities that involve the use of such a medium.
- **Part 1**

The sample of the preliminary survey predominantly consisted of male, undergraduate students, aged between 18 to 25 years old (Table 5.1).

Table 5.1 Demographic information.

	G1. Gender		G2. Academic Level		G3. Age Group			
	Male	Female	Undergraduate	Postgraduate	18-25	26-35	36-45	46 or older
E2 (<i>n</i> = 196)	85.2%	14.8%	78.6%	21.4%	55.1%	38.3%	6.6%	0.0%
E3 (<i>n</i> = 138)	90.6%	9.4%	89.9%	10.1%	78.3%	15.2%	4.3%	2.2%
E4 (<i>n</i> = 160)	91.3%	8.7%	85.0%	15.0%	68.1%	22.5%	6.9%	2.5%

- **Part 2**

Most of the participants had a relatively minimal (up to a month) or even non-existent prior experience in the use of virtual worlds like Second Life® or OpenSim, be it for leisure or educational purposes (Table 5.2). Nevertheless, those who claimed to have had prior encounters described their experiences as generally positive (Table 5.3).

Table 5.2 Examining prior experience.

S1*. My experience in virtual worlds like Second Life/OpenSim is:	None	≤ 1 week	≤ 1 month	> 1	> 6 months & ≤ 1 year	> 1 year
				month & ≤ 6 months		
E2 (<i>n</i> = 196)	54.1%	18.9%	10.2%	10.2%	5.1%	1.5%
E3 (<i>n</i> = 138)	58.7%	10.9%	8.7%	10.9%	5.1%	5.8%
E4 (<i>n</i> = 160)	56.3%	13.8%	8.1%	12.5%	3.1%	6.3%

Table 5.3 Describing prior experience.

S2*. I could generally describe my prior experience in these virtual worlds as:	Positive	Neutral	Negative	\bar{x}	Sx	Mo	KW
E2 (<i>n</i> = 90)	56.7%	38.9%	4.4%	2.52	0.58	Positive	
E3 (<i>n</i> = 57)	63.2%	31.6%	5.3%	2.58	0.60	Positive	0.83
E4 (<i>n</i> = 70)	67.1%	24.3%	8.6%	2.59	0.65	Positive	

• **Part 3**

Initially, the induction of virtual world tasks met with a hesitant and somewhat negative reception on behalf of the students (referring to the anecdotal observation made in E₁). As can be seen from Table 5.4, year after year there is an increase in positive comments and opinions that the following students have heard from the previous ones. At the same time, a decline can be noticed in the students' negative stance. It can, therefore, be speculated that the instructional design decisions in conjunction with the favourable comments by their former fellow students may have had a beneficial impact on that shift.

Table 5.4 Biases & preconceptions towards the use of virtual worlds.

S3*. The comments I have heard about the use of such a virtual world were generally:	Positive	Neutral	Negative	No comments	\bar{x}	Sx	Mo	KW
E2 (<i>n</i> = 196)	59.5%	32.7%	7.8%	21.9%	2.52	0.64	Positive	
E3 (<i>n</i> = 138)	63.5%	30.4%	6.1%	16.7%	2.57	0.61	Positive	0.87
E4 (<i>n</i> = 160)	73.3%	22.2%	4.4%	15.6%	2.69	0.55	Positive	

Despite, however, the positive stance and the lack of negative preconceptions that most of the participants reported in the above-mentioned statements, the widespread distribution of their responses—as regards the educational value of virtual worlds (Table 5.5) and their willingness to engage in educational activities which include the involvement of such environments (Table 5.6)—reveal a very clear indecision. As a result, drawing any clear conclusions in regard to these matters would rather be avoided.

Table 5.5 Use of virtual worlds for educational practices.

S4*. I am of the opinion that the use of a virtual world in an educational context has nothing to offer me.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E2 (<i>n</i> = 196)	25.0%	35.2%	39.8%	1.85	0.79	Disagree	
E3 (<i>n</i> = 138)	46.4%	23.2%	30.4%	2.16	0.86	Agree	0.39
E4 (<i>n</i> = 160)	21.3%	21.9%	56.9%	1.64	0.81	Disagree	

Table 5.6. Discontinuing the use of virtual worlds for educational practices.

S5*. I would prefer it if the use of a virtual world had not been part of the practical sessions I am enrolled in.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E2 (<i>n</i> = 196)	32.7%	28.6%	38.8%	1.94	0.85	Disagree	
E3 (<i>n</i> = 138)	24.6%	30.4%	44.9%	1.80	0.81	Disagree	0.36
E4 (<i>n</i> = 160)	21.3%	29.4%	49.4%	1.72	0.79	Disagree	

However, an interesting observation can be made by cross-examining the responses given in these statements, especially in the case of the cohort that participated in E₃. More precisely, even though almost half of the participants reported that they see no educational value in the Virtual-Learning approach, an almost equally high number of them welcomed the idea of being enrolled in classes that include the use of such technology.

Motivated by this contradiction, the following questions are raised and will be discussed further in the wider context of the data triangulation in Chapter 6.

1. Why did students find a small, or even no value whatsoever, in the use of a virtual world in an educational context, despite the fact that their stance and preconceptions were generally positive?
2. Why would students want to be enrolled into activities in a virtual world, despite the fact that they did not consider it to be a worthwhile experience?

5.3 Conclusive Survey

To examine the impact that the in-world interactions had on motivation and engagement, the conclusive survey was distributed to students post the completion of their project in the virtual world. The structure of this questionnaire included the following sections:

- **Part 1:** statements related to the samples' identity (i.e. gender, age, study level).
- **Part 2A:** statements related to the learners' interactions with the content of the world.
- **Part 2B:** statements related to the learners' interactions with other users.
- **Part 3:** questions and statements related to the content developed by the researcher³².
- **Part 4:** open-ended (optional) question related to the elements that could have helped learners to become more engaged with the virtual world.

To facilitate the reading process, a working example is provided (Table 5.7).

Table 5.7 Results of Statement-content & Statement-users (example).

...is a good working example.		Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	CA	KW
E1	content ³³	X%	Y%	Z%	mean	stdev	response	p-	
	users ³⁴	X%	Y%	Z%	mean	stdev	response	value	
E2	content	X%	Y%	Z%	mean	stdev	response	p-	p-value
	users	X%	Y%	Z%	mean	stdev	response	value	content
E3	content	X%	Y%	Z%	mean	stdev	response	p-	p-value
	users	X%	Y%	Z%	mean	stdev	response	value	users
E4	content	X%	Y%	Z%	mean	stdev	response	p-	
	users	X%	Y%	Z%	mean	stdev	response	value	

³² Applicable only to E₃ and E₄

³³ *Interacting with the content of the virtual world in the context of my practical sessions... is a good working example.*

³⁴ *Interacting with other users in the context of my practical sessions... is a good working example.*

- The element that each statement examined is presented at the first column of the tables along with the experiments' number and the total number of participants.
- To avoid repetition, the *main body* of the statements' description, which defines the **interaction type**, is abbreviated in the second column (see footnotes 19 and 20).
- The subsequent three columns provide the summary of the responses in the form of percentages.
- The mean scores along with the standard deviation and the most frequently selected response (for each interaction type) follow.
- Lastly, the p-values of the *CA* test—which examined the statistical significance between the interaction types for each experiment—and the *KW* test—which examined the stochastic dominance of both interaction types across the four experiments—are illustrated for reference purposes.

Structure-wise, the discussion starts with the reasons that led to the *decision* to examine each one of these items, grounded on the information derived from the review of the literature. What follows is a presentation of the participants' responses, in accordance with the *percentage values*. Moreover, as Section '*Part 2A versus Part 2B*' discusses comparatively the elements that have been examined in both interaction types (i.e. content/other users), the *trend* values and the results of the *CA* test are used to identify which *interaction type* had the most *influential impact*. Likewise, in order to provide a clear overview and understanding of which *experiment* had the most and/or the least *influential impact* on the subject under investigation, the mean values (trends) and the results of the *KW* test are used to discuss the four experiments in the '*Notes*' section. Finally, the take-away message and the influence that each

instructional design approach had towards these answers is provided in the ‘*Impact of the instructional design*’ bullet-point at the end of each statement.

- **Part 1**

As in the case of the preliminary survey, so in the conclusive one, the sample consisted mainly of male, undergraduate students, aged between 18-25 years old (Table 5.8).

Table 5.8. Demographic information.

	G1. Gender		G2. Academic Level		G3. Age Group			
	Male	Female	Undergraduate	Postgraduate	18-25	26-35	36-45	46 or older
E1 (<i>n</i> = 161)	77.6%	22.4%	60.2%	39.8%	66.5%	31.5%	2.0%	0.0%
E2 (<i>n</i> = 178)	85.4%	14.6%	70.2%	29.8%	78.1%	19.1%	1.7%	1.1%
E3 (<i>n</i> = 133)	89.5%	10.5%	86.5%	13.5%	85.7%	10.5%	3.0%	0.8%
E4 (<i>n</i> = 165)	87.9%	12.1%	89.1%	10.9%	72.7%	20.0%	4.8%	2.4%

- **Part 2A versus Part 2B**

In this section, the statements that were examined in both categories (interaction types) are cross-evaluated and discussed in pairs.

5.3.1 Statements 1 & 15

One of the main challenges that educators face—especially when it comes to e-Learning—is the identification of the elements that will attract and sustain the learners’ attention. In the case of VL, the network of interactions that was developed in the virtual world had positive effects on the learners’ willingness to engage with the platform and the educational activities. Nevertheless, by cross-examining the participants’ responses, what can be noted is a slightly greater—though non-statistically significant—influence on that aspect, in favour of the interactions that learners had with the content of the world (Table 5.9).

Notes:

- E₁ received the least positive responses and that is further reflected on the sample’s trend, as it is inconclusive for both interaction types.

- E₃ received the most positive responses and is the only experiment having a holistically positive trend.
- E₂ and E₄ received a relatively similar distribution of responses. Nevertheless, the interactions with the content of the world had a stronger influence on the learners' engagement (positive trend), compared to the less intense influence of the interactions with other users (inconclusive trend).

Table 5.9 Results of S1 & S15.

...is a good reason for me to use a virtual world.		Agreement	Neutral	Disagreement	\bar{x}	S _x	Mo	CA	KW
E1 (n = 161)	content	64.6%	19.9%	15.5%	2.49	0.75	Agree	0.15	
	users	58.4%	19.9%	21.7%	2.37	0.82	Agree		
E2 (n = 178)	content	69.7%	19.7%	10.7%	2.59	0.68	Agree	0.055	content
	users	60.7%	23.0%	16.3%	2.44	0.76	Agree		0.78
E3 (n = 133)	content	72.2%	15.0%	12.8%	2.6	0.71	Agree	0.48	users
	users	65.4%	22.6%	12.0%	2.53	0.70	Agree		0.76
E4 (n = 165)	content	70.3%	19.4%	10.3%	2.6	0.67	Agree	0.08	
	users	61.8%	23.0%	15.2%	2.47	0.75	Agree		

Impact of the instructional design:

- The example showcases provided learners with insights regarding the teaching team's expectations, boosted their intrinsic motivation to produce more sophisticated and well-developed artefacts, and, thus led them to engage with the virtual world. Compared to the rest of the experiments, however, the 'unstructured' setup of the 'abandoned' environment had the least positive effect.
- The addition of the game-like content further enriched and enhanced the already ludic nature of the virtual world. In fact, the use of educational and leisure games had the most positive influence on the learners' interactions and, subsequently, high levels of engagement were attained.
- Lastly, both the inclusion of the orientation area and the employment of the PAs smoothed the steep learning curve that such environments present and

eliminated the negative impact of the challenges that learners had to overcome. Moreover, the existence of such content increased the opportunities for fruitful and constructive interactions and, thus the students' willingness to invest time and effort in the development of their project.

5.3.2 Statements 2 & 16

Immersion and engagement, especially in distance learning scenarios, are the 'two sides of the same coin' as the former brings about the latter. Additionally, interactions are regarded as one of the main factors that contribute towards the development of the sense of in-world presence. Thus, by combining these points, a correlation between interactions and engagement might be seen. Participants did confirm this assumption and acknowledged the positive impact that interactions had on immersion and engagement (Table 5.10). It is also noteworthy that interactions with the content of the world³⁵ appear to have a marginally stronger impact—compared to the effect that the presence of other users had—without, however, illustrating a detectable statistical difference. Notwithstanding the foregoing, the trend of the samples in nearly all the experiments³⁶ is inconclusive. A possible explanation to this outcome can be attributed to the simultaneous co-presence and, thus interaction, that learners had in the physical classroom.

Notes:

- E₁ received the least positive responses, whilst the sample's trend for the interactions with the content has the lowest mean score (2.24) amongst *all* the statements of the conclusive survey (Part 2). On top of that, it is the only case in which the interactions that occurred between the students

³⁵ E₁ is an exception

³⁶ E₃ (Part A) is an exception

themselves had an imperceptibly greater impact on the levels of immersion.

- E₃ received the most positive responses in both categories, even though only the interactions with the content of the world yielded a positive trend.
- E₂ and E₄ received similar responses, although E₂ has more positive trend.

Table 5.10 Results of S2 & S16.

...made me feel I am actually present in the virtual world.		Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	CA	KW
E1 (n = 161)	content	51.6%	21.1%	27.3%	2.24	0.86	Agree	0.79	
	users	55.3%	16.1%	28.6%	2.27	0.88	Agree		
E2 (n = 178)	content	60.1%	25.3%	14.6%	2.46	0.74	Agree	0.77	content 0.83
	users	59.6%	24.2%	16.3%	2.43	0.76	Agree		
E3 (n = 133)	content	65.4%	22.6%	12.0%	2.53	0.70	Agree	0.35	users 0.83
	users	60.9%	23.3%	15.8%	2.45	0.75	Agree		
E4 (n = 165)	content	62.4%	20.0%	17.6%	2.45	0.78	Agree	0.77	
	users	59.4%	23.6%	17.0%	2.42	0.77	Agree		

Impact of the instructional design:

- Even though the exemplification material was employed as the means to develop the ‘community feeling’ and lead learners to experience the sense of belonging in a ‘living’ environment, its persistent status degraded the levels of immersion that learners experienced. Nonetheless, its impact on the interactions that occurred between the students themselves was slightly more positive, as it offered food for thought and discussion.
- The elements of the gamification intervention aimed at promoting different kinds of interaction, so as to immerse learners with the virtual world and the educational activities in a way similar to the one that virtual games immerse players. Although learners considered themselves to be immersed in the virtual world, the degree to which this content encouraged the interplay among peers was minimal. This result can be attributed to the reduced interest that some of them may have had in interacting with the games at a high frequency (see Statement 31).

- Transferring learning activities into a virtual world is a rather challenging task, especially when the prime objective includes programming and 3-D modelling. In the same vein, immersing learners in or engaging them with the platform requires robust knowledge and technical skills, so as to increase their attention span which will otherwise dwindle due to the need to research information and resources outside the world. In this regard, the decision to blend the learning spaces with instructional and informational content had a positive effect on the sense of presence, as it preserved the learners' attention and focus within the context of the virtual world.

5.3.3 Statements 3 & 17

Individual students' learning styles might stand as an obstacle towards the educators' initiatives to introduce alternative educational approaches. Reciprocally, the degree to which a virtual world can enhance the learning process and improve the learner experience depends greatly on students' personality and preferences. As participants reported, the vivid and realistic content of the virtual world had a positive impact on the learning process, hence leading them to experience the knowledge (Table 5.11). In a similar manner, the help and support received by their fellow learners also contributed towards this result, though to a lesser degree³⁷.

Notes:

- E₁ received the least positive responses and is the only case having an unclear trend for both interaction types.
- Participants in E₂ agreed that interacting with the content helped them to experience the knowledge, yet they maintained an inconclusive opinion towards the influence that the interactions with others had on that matter.

³⁷ E₃ is an exception

- E₃ and E₄ present a relatively similar responses' distribution, as well as positive trends for both categories.

Table 5.11. Results of S3 & S17.

...made me experience the knowledge.		Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	CA	KW
E1 (n = 161)	content	63.4%	18.0%	18.6%	2.45	0.79	Agree	0.40	
	users	57.8%	21.7%	20.5%	2.37	0.80	Agree		
E2 (n = 178)	content	68.0%	22.5%	9.6%	2.58	0.66	Agree	0.12	content
	users	61.2%	24.7%	14.0%	2.47	0.73	Agree		
E3 (n = 133)	content	68.4%	17.3%	14.3%	2.54	0.73	Agree	0.43	users
	users	72.2%	16.5%	11.3%	2.61	0.68	Agree		
E4 (n = 165)	content	67.9%	21.8%	10.3%	2.58	0.67	Agree	0.58	
	users	67.9%	17.6%	14.5%	2.53	0.74	Agree		

Impact of the instructional design:

- The example artefacts enabled learners to develop a better understanding of the affordances of the virtual world or its digital tools, which made the learning experience more intuitive. However, the absence of the showcase developers (former students), to further expand and discuss their ideas, impacted on the value of this content on the knowledge empowerment.
- On the other side, the dynamically changing components of the edutainment technique and the group-based nature of the gamification mechanisms added a leisure note to the learning space, turning the virtual world into a '*knowledge worker*'. Indeed, the presence of such content in a strictly educational virtual world, made the learning process more entertaining and enjoyable without, however, degrading the learning experience.
- The employment of different instructional approaches and techniques, such as the tutorial-like orientation system or the use of PAs, provided learners with a variety of ways to access the instructional material and the opportunity to develop their knowledge and skills at their own pace. As a result, the knowledge constructed in the virtual world became more valuable and the learning experience more meaningful.

5.3.4 Statements 4 & 18

The lively atmosphere of the virtual worlds provides fertile ground to those educators who wish to offer their learners joyful and amusing learning experiences. It is, therefore, of no surprise why the vast majority positively acknowledged this element and attributed its impact equally to both interactions. Nonetheless, a very minor—yet non-statistically significant³⁸—difference may be observed on the role that the playful nature of the virtual world played regarding the achieved levels of enjoyment (Table 5.12).

Notes:

- The trend test for E₁ yielded a statistically significant difference (p=0.0052) among the sample's responses. Subsequently, the *post-hoc* test confirmed this result and revealed that the interactions with the content of the world contributed considerably more to the enjoyment levels.
- E₂ received the most positive responses in both statements, whilst the sample's trend in terms of the interactions with the content of the world has the highest mean score (2.71) amongst *all* the statements of the conclusive survey (Part 2).
- E₃ and E₄ have a similar responses' distribution although the trend of E₃ is slightly more positive.

Table 5.12. Results of S4 & S18.

...was fun.		Agreement	Neutral	Disagreement	\bar{x}	S _x	Mo	CA	KW
E1 (n = 161)	content	75.8%	17.4%	6.8%	2.69	0.59	Agree	0.0052	
	users	62.7%	22.4%	14.9%	2.48	0.74	Agree		
E2 (n = 178)	content	77.5%	16.3%	6.2%	2.71	0.57	Agree	0.60	content
	users	78.1%	11.8%	10.1%	2.68	0.65	Agree		0.84
E3 (n = 133)	content	75.9%	17.3%	6.8%	2.69	0.59	Agree	0.91	users
	users	76.7%	15.0%	8.3%	2.68	0.62	Agree		0.78
E4 (n = 165)	content	74.5%	16.4%	9.1%	2.65	0.64	Agree	0.73	
	users	74.5%	13.9%	11.5%	2.63	0.68	Agree		

³⁸ E₁ is an exception

Impact of the instructional design:

- Getting inspiration and ideas for development from former students' work made the overall process less stressful and, thus more enjoyable. On the other hand, the input of the co-present students had a significantly less impact, as they were probably also 'struggling' to cope with the virtual world and deal with their own projects.
- The existence of the orientation area, where the most important features of the virtual environment were introduced and explained, boosted the learners' motivation to explore the in-world tools and their intention to make the most out of them. As a result, their confidence levels to deal with their task increased and made the work-fun balance more manageable.
- The gamified content provided learners with diverse opportunities to spend time away from their workspaces, reduced the stress levels and made the learning process more joyful. Indeed, playing or even competing with their fellow students mitigated the impact of the negative emotions (e.g. stress, anxiety) and made the learning experience more pleasant. Lastly, the opportunity to revise the theoretical material in a less 'dull' and more rewarding way could also have had some impact to that end (see Statement 33).
- As in the case of the orientation process, the PAs also positively contributed towards the achieved levels of enjoyment. Indeed, having a personal tutor or an adviser (vendor-NPC) eased the perceived burden of the learning process and made the learners' accommodation in the virtual world more pleasant. Additionally, engaging in conversations with a non-human 'jester', whose responses were rather 'ludicrous', could be nothing but fun.

5.3.5 Statements 5 & 19

Synchronous interaction has numerous benefits, be it in the case of other students or peers. Likewise, providing learners with the opportunity to have immediate awareness of their actions—especially when it comes to 3-D modelling and programming concepts—is of paramount importance. In the same vein, real-time interactivity is an integral part of virtual worlds and one of the major advantages that such environments offer. Participants acknowledged the usefulness of this feature and agreed that both kinds of interactions had an equal contribution to achieving their goals. Nevertheless, a slight edge—though non-statistically significant—can be seen on the impact that the real-time interaction with other users had on the awareness of their progression³⁹ (Table 5.13).

Notes:

- Participants in E₁ reported that observing the results of their work impacted slightly more on the awareness of their progression, compared to the impact of the feedback from other users.
- E₃ received the most positive responses in both statements. The sample's trend was positive, as well.
- E₂ and E₄ present a relatively similar responses' distribution, although a differentiation exists among the samples' trends in regard to the impact that the interactions with other users had (inconclusive for E₂ but positive for E₄).

³⁹ E₁ is an exception

Table 5.13. Results of statements S5 & S19.

...was real-time & that helped me have immediate awareness/feedback of my actions/work.		Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	CA	KW
E1 (n = 161)	content	58.4%	28.6%	13.0%	2.45	0.72	Agree	0.13	
	users	56.5%	19.3%	24.2%	2.32	0.84	Agree		
E2 (n = 178)	content	52.8%	28.7%	18.5%	2.34	0.77	Agree	0.10	content
	users	62.4%	22.5%	15.2%	2.47	0.75	Agree		
E3 (n = 133)	content	63.2%	24.8%	12.0%	2.51	0.70	Agree	0.72	users
	users	66.9%	20.3%	12.8%	2.54	0.71	Agree		
E4 (n = 165)	content	62.4%	21.8%	15.8%	2.47	0.75	Agree	0.55	
	users	66.1%	19.4%	14.5%	2.52	0.74	Agree		

Impact of the instructional design:

- The integration of the example showcases helped learners to develop a better understanding of the virtual world’s technical capabilities and offered them a measure to monitor and compare their progression. In addition, as this content covered a wide variety of development decisions and approaches that the former cohorts had made, opportunities for discussion and debate were also encouraged, though to a lesser extent.
- In the case of the edutainment experiment, learners had numerous opportunities for real-time interaction (both as individuals and in groups) and social participation (e.g. role-play, team work in the context of the learning adventures, competitions). In addition, it can be expected that indirect learning gains also occurred, as this content covered a wide range of 3-D modelling and programming concepts.
- Finally, the orientation area and the agents provided learners with guidance and instructions on how to use the in-world tools, while enabling them to practice and observe the results of their work in real-time. In addition, as both instructional approaches were designed with the aspect of social interactivity in mind, opportunities for discussion and knowledge sharing were also encouraged.

5.3.6 Statements 6 & 20

Computer Science courses usually have long introduction periods prior to getting students started with ‘exciting’ or ‘interesting’ tasks. Moreover, it is not uncommon for learners to overestimate their skills and capabilities under the belief that the lectures or the laboratory sessions are filled with familiar or easy-to-understand information. As a result, observing low numbers of engagement with the course material—at least during the early stages—is an issue that educators often face. An overview of students’ responses provides a reliable indication that the integration of a virtual world in the academic curriculum had a positive influence on easing the learning process. Nevertheless, the instructional interventions had diverse and varied effects on this outcome; a fact that cannot be disregarded (Table 5.14).

Notes:

- E_1 received the least positive responses, when compared to the results deriving from the rest of the experiments. That influenced the sample’s trend which is neutral in both cases.
- On the other hand, the responses in E_3 reflect a strong positive trend towards the influence that both interactions had on the examined element.
- Finally, the trends of the responses in the instructional experiments are blended and inverted. More precisely, participants in E_2 claimed that interacting with the content of the orientation area had a positive influence on the learning process, whilst, in the case of E_4 , this outcome is attributed to the interactions with other users. Respectively, the responses’ trend for the corresponding statements was neutral.

Table 5.14. Results of statements S6 & S20.

...made easier compared to studying.	learning for me just	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	CA	KW
E1 (n = 161)	content	61.5%	20.5%	18.0%	2.43	0.78	Agree	0.77	
	users	62.1%	21.7%	16.1%	2.46	0.76	Agree		
E2 (n = 178)	content	67.4%	17.4%	15.2%	2.52	0.75	Agree	0.61	content
	users	63.5%	21.3%	15.2%	2.48	0.75	Agree		0.69
E3 (n = 133)	content	75.2%	16.5%	8.3%	2.67	0.62	Agree	0.50	users
	users	72.2%	17.3%	10.5%	2.62	0.67	Agree		0.55
E4 (n = 165)	content	61.8%	23.6%	14.5%	2.47	0.74	Agree	0.49	
	users	66.7%	19.4%	13.9%	2.53	0.73	Agree		

Impact of the instructional design:

- Providing learners with task-oriented artefacts enabled them to better understand the description of their weekly tasks and the requirements of their final project. As a result, their studying approach became more methodological and focused on the development of the elements that were aligned with the expectations of the teaching team.
- The presence of a cognitive environment—such as the orientation area—or the instructional role of the PAs had an almost equal contribution towards the ease of learning. Indeed, as the knowledge acquisition process was transferred into the virtual world, the cycle of action, reflection and dialogue was initiated in a more diligent manner, especially when compared to the non-interactive and less intuitive manner of the lecture notes, books or other 2-D e-learning material.
- Lastly, aligned with the main principles of the GBL approach, the blending of the learning material with the game-like content yielded the expected positive results. Indeed, the introduction of such elements restructured the usual learning approach—which is heavily reading-oriented and individualised—enriched the learning process, increased the opportunities for CL and, therefore, made the overall experience less demanding.

5.3.7 Statements 7 & 21

Educators may utilise alternative—or at least not so traditional—learning approaches in order to make teaching more appealing and alluring for learners. When it comes to digital learning, the options increase but so does the difficulty to identify the interface or the context that will compile different elements efficiently enough to meet the students’ different learning needs and styles. Recent virtual worlds stress on the concept of social networking interaction and user-contributed creativity, thus providing a fertile ground for delivering the course material in a more practical and effective way. The majority of participants acknowledged the positive influence that the virtual environment had on the attractiveness of the learning material, although some negligible differentiations among the trends of the samples are observed (Table 5.15).

Notes:

- E₁ received, once more, the least positive responses, which further influenced the sample’s trend (inconclusive) for both interaction types.
- Participants in E₂ agreed that interacting with other users increased the attractiveness of the learning material, although the same is not reflected on the influence that the virtual world had on this aspect (indecisive opinion). These results are in inverse proportion compared to E₄.
- Finally, respondents in E₃ acknowledged holistically the positive influence that the interactions had on the appeal of the learning material.

Table 5.15. Results of statements S7 & S21.

...made the learning material more attractive for me.		Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	CA	KW
E1 (n = 161)	content	65.2%	16.8%	18.0%	2.47	0.78	Agree	0.40	
	users	60.9%	18.0%	21.1%	2.40	0.82	Agree		
E2 (n = 178)	content	62.9%	20.8%	16.3%	2.47	0.76	Agree	0.52	content
	users	65.7%	20.2%	14.0%	2.52	0.73	Agree		0.48
E3 (n = 133)	content	72.2%	17.3%	10.5%	2.62	0.67	Agree	0.70	users
	users	72.2%	20.3%	7.5%	2.65	0.62	Agree		0.78
E4 (n = 165)	content	67.3%	18.2%	14.5%	2.53	0.74	Agree	0.60	
	users	63.0%	22.4%	14.5%	2.48	0.74	Agree		

Impact of the instructional design:

- Even though the example showcases were not part of the educational material per se, their presence added a realistic and vivid appearance to the rather ‘bland’ learning material that was delivered in the context of the lectures. In addition, exploring and using ‘tangible’ examples of how the theoretical foundation can be applied into practice, boosted the opportunities for discussion, increased the incentives for reflection and, thus, led learners to explore the potential of the in-world tools to the fullest.
- The instructional content, though an extension of the learning material, presented the available resources in a more interactive and meaningful manner. As a result, learners were encouraged to actively make sense of it in a more practical or hands-on way without disengaging from the world. Under this consideration, the positive influence that the orientation process had on social interactions is further grounded, and provides a strong indication that such techniques boosted the incentives for collaborative exploration and knowledge exchange. On the other hand, the NPCs offered learners a more personalised learning experience, which justifies the positive influence that the chat-bots or the vendor NPC had on the attractiveness of the learning material.

- Although there is no direct link between the distribution of the learning material and the gamification content, this experiment had the most influential impact on the examined subject. However, after accounting the creative and ludic nature of these crafts, this outcome can be attributed to the intuitive elements that this content had. Indeed, enabling learners to develop a better understanding and connect the key topics under investigation in a more interpretable manner, attributed a more ‘tasteful’ nature to the learning material and made the consolidation process more effective and attractive.

5.3.8 Statements 8 & 22

As in the case of any other educational subject related to Computer Science, the laboratory sessions are meant to help students better regulate the rate and speed at which they learn. However, the complex nature of virtual worlds and the students’ lack of prior experience may affect the pace or the escalation rate at which the learning material is organised and distributed. At the same time, different learners need different levels of challenge to keep their interest in attending classes. As a result of the above concerns, the students’ interest to attend the practical session may vary and can possibly change over the course of time. Participants agreed that breaking their routine, by doing something different or uncommon, made the procedures that take place during the practical sessions more attractive for them. With that in mind, the unique features and elements of the virtual world seem to have had a slightly greater effect on the attractiveness of the practical session, when compared to the impact that the interactions with other students had on that aspect. Nevertheless, the samples’ responses did not yield a statistically significant difference (Table 5.16).

Notes:

- E₁ received, once again, the lowest amount of positive responses, whilst the sample's trend for both statements is inconclusive.
- On the other hand, E₃ maintained its overall strong influence, as both interaction types collected the most positive responses, compared to the rest of the experiments.
- Responses in E₂ and E₄ are relatively similar, with a fairly positive trend, as in the case of the former observation statements.

Table 5.16. Results of statements S8 & S22.

...made the practical session more attractive to me.		Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	CA	KW
E1 (n = 161)	content	64.0%	19.9%	16.1%	2.48	0.76	Agree	0.77	
	users	62.7%	19.9%	17.4%	2.45	0.77	Agree		
E2 (n = 178)	content	65.7%	21.3%	12.9%	2.53	0.71	Agree	1	content
	users	69.1%	14.6%	16.3%	2.53	0.76	Agree		0.80
E3 (n = 133)	content	70.7%	19.5%	9.8%	2.61	0.66	Agree	0.77	users
	users	66.9%	24.8%	8.3%	2.59	0.64	Agree		0.97
E4 (n = 165)	content	67.3%	20.0%	12.7%	2.55	0.71	Agree	0.53	
	users	62.4%	24.8%	12.7%	2.50	0.71	Agree		

Impact of the instructional design:

- The example showcases made the challenges that learners would face along the way apparent. Thus, having such a knowledge-base from the very beginning, impacted positively on the attractiveness of the practical sessions in a twofold way. On the one hand, the slow-paced learners got the required motivational boost to attend the classes, so as to get help and support to fulfil and meet the assignment requirements. On the other hand, those who wanted to expand their knowledge and explore the maximum potential of the virtual world were also encouraged to attend them for the same reason.

- Learning activities in virtual worlds bring completely different knowledge and experiences to learners, compared to the more ‘traditional’ programming tools and utilities. At the same time, however, exposing students to different settings and perspectives increases the difficulty to assimilate the subject taught, makes the laboratory work more demanding and, possibly, less attractive for them. Therefore, the introduction of interactive features with a playful and fun nature made the virtual world a place where learners would like to be, which was further reflected on their willingness to attend the practical sessions.
- The lack of familiarity or prior experience with such environments leaves students in the lurch, as they have to deal with course material that is completely unknown to them. As a result, their attitude towards the virtual world might be affected in a negative way, which can in turn influence their willingness to attend the practical sessions. The integration of the instructional material, as part of the world’s content, made the introductory session to the virtual world an easy to understand task, with clear links and connections to the theoretical foundation, enabling learners to adjust the pace and path of their learning.

5.3.9 Statements 9 & 23

Increasing the numbers of attendance in practical sessions, considering the university policies (e.g. attendance recording), may not be that challenging. However, getting students to actively participate in and truly enjoy the sessions definitely is. In order to examine this aspect (Table 5.17) and validate the responses given in the former statements (S1-S8 and S15-S22), this statement was used as a cut-off/summary point, prior to diving into the exclusive—to each interaction type—statements.

Notes:

- The inconclusive trend for both interaction types in E₁ gives a clear indication of the least positive effect that the use of example content had on learners’ willingness to engage with the practical sessions.
- On the other hand, E₃ and E₄ had a relatively similar responses’ distribution⁴⁰ and an overall positive influence on making students more passionate to attend the practical sessions.
- Lastly, and most interestingly, participants in E₂ considered the interactions with other users to be more intense—as opposed to those occurring with the world—and that influenced their willingness to eagerly join the practical sessions.

Table 5.17. Results of statements S9 & S23.

...made participate the practical	me gladly in sessions.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	CA	KW
E1 (n = 161)	content	62.1%	21.1%	16.8%	2.45	0.77	Agree	0.56	
	users	58.4%	23.6%	18.0%	2.40	0.78	Agree		
E2 (n = 178)	content	61.2%	23.6%	15.2%	2.46	0.74	Agree	0.08	content
	users	69.1%	20.8%	10.1%	2.59	0.67	Agree		0.87
E3 (n = 133)	content	66.2%	25.6%	8.3%	2.58	0.64	Agree	0.77	users
	users	68.4%	23.3%	8.3%	2.60	0.64	Agree		0.87
E4 (n = 165)	content	67.3%	22.4%	10.3%	2.57	0.67	Agree	0.74	
	users	63.6%	27.3%	9.1%	2.55	0.66	Agree		

Impact of the instructional design:

- Providing learners with examples was perceived in a way similar to that of any other supportive material, regardless of the fact that a virtual world was being used. Although the presence of these example artefacts provided learners with several opportunities to examine and discuss the ideas or understanding that former students had developed, their non-evolving state and the inability to further elaborate on their thoughts with the creators of

⁴⁰ although E₃ had slightly more positive impact

this content degraded the value of this intervention.

- In consideration of the foregoing, the impact of the orientation area and the PAs on the learners' attitude towards the learning material was considerably stronger and notably more influential. Indeed, enabling learners to acquire the necessary knowledge and skills—while being in the virtual world—increased their self-assurance, boosted the incentives for communication and collaboration, and encouraged them to actively participate in the practical sessions so as to progress and achieve their goals.
- Finally, facilitating the learning process with the use of gamified elements had the most influential impact, as it brought the fun element into the practical session and made the learning process more enjoyable and less overwhelming.
- ***Part 2A Content Exclusive***

Note that the items that are examined in this section refer exclusively to the different types of interactions that learners could have with the elements and features of the virtual world.

5.3.10 Statement 10

Exploratory learning encourages learners to investigate new material with the purpose of discovering and developing relationships between existing knowledge and unfamiliar concepts. When this process takes place within a virtual world, the added benefits may include better understanding of the assignment requirements, familiarisation with the in-world tools and brainstorming of ideas. Participants agreed that exploring the available content—coming from either other learners or the instructional designer—was a pleasant process which most of them included in their agenda (Table 5.18).

Notes:

- E₁ has the lowest mean value, amongst all the experiments, followed by E₂ and E₄. In all the aforementioned cases the trend of the samples is inconclusive, an indication that the provided content offered limited or short-term opportunities for exploration.
- In contrast, responses in E₃ were more positive—as can also be seen from the sample’s trend—thanks to the massive nature of this content.

Table 5.18. Results of S10.

...pleased me, especially when I was exploring & sightseeing.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 (n = 161)	58.4%	25.5%	16.1%	2.42	0.76	Agree	
E2 (n = 178)	61.2%	21.3%	17.4%	2.44	0.77	Agree	0.76
E3 (n = 133)	66.9%	22.6%	10.5%	2.56	0.68	Agree	
E4 (n = 165)	61.8%	23.6%	14.5%	2.47	0.74	Agree	

Impact of the instructional design:

- Although the use of example content was expected to offer the most opportunities for sightseeing, the less intuitive or mediocre design of the showcases had the least positive influence on the learners’ interest to explore and navigate across the world.
- In the same vein, the abiding interior design of the orientation area or the discreet and minimalistic nature of the PAs, limited the opportunities for exploration almost exclusively to the content developed by other students.
- On the other hand, the large-scale mapping and the vivid textures of the game-oriented content, as well as the weekly alteration of the learning content that was used in the educational games, offered diverse incentives for exploration and maintained the learners’ interest relatively constant during the entire course of the experiment.

5.3.11 Statement 11

The core topic of the assignments involved the design and development of 3-D models as well as the animation—through the built-in programming language—of the final products. Participants’ responses related to the so-called ‘building’ and ‘scripting’ processes were overall positive and this further confirms the effectiveness of the virtual world to blend these elements in different ways. However, due to the twofold nature of this statement, there is no sufficient evidence to conclude whether or not any of these processes had a greater influence over the other towards the levels of enjoyment. Moreover, the portion of participants who hold a different opinion—presumably because of the difficulties they faced with understanding the mechanisms of the virtual world to complete the assignment—cannot be disregarded (Table 5.19).

Notes:

- Although this statement examined directly the learners’ opinion about the 3-D content design and the code development, some insights related to the influence that the instructional decisions had on these processes can be elicited.
- For instance, as respondents in E₁ maintained a clearly inconclusive viewpoint—compared to the borderline neutral-positive trend that the rest of the experiments have—it can be assumed that the instructional or the edutainment content had a slightly more positive effect on learners’ perception towards these processes.

Table 5.19. Results of S11.

...pleased me, especially when I was ‘building’ & ‘scripting’.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 (<i>n</i> = 161)	58.4%	24.8%	16.8%	2.42	0.76	Agree	0.82
E2 (<i>n</i> = 178)	62.4%	24.2%	13.5%	2.49	0.72	Agree	
E3 (<i>n</i> = 133)	64.7%	21.1%	14.3%	2.50	0.73	Agree	
E4 (<i>n</i> = 165)	64.8%	22.4%	12.7%	2.52	0.71	Agree	

Impact of the instructional design:

- Although the example showcases provided learners with great opportunities to develop their knowledge and improve their background understanding regarding the technical affordances of the virtual world, the fact that this content had been developed by amateur or inexperienced students should not be disregarded. Furthermore, comparing the flaws or inadequacies of former students' work to the professionally developed models and textures of which the gamification experiment consisted, makes the relatively stronger impact that the latter had on learners' attitude and motivation—towards the modelling and programming elements—justifiable.
- As regards the instructional experiments, the emphasis was given on providing learners with the required knowledge and techniques to design and develop more sophisticated and intriguing artefacts. In doing so, the 3-D modeling and programming process was expected to become more enjoyable and pleasant for them. Even though this was achieved to a reasonable extent, the diverse nature of the PAs as well as the 'freebies'⁴¹ that the vendor NPC was offering had a slightly greater impact on students' views towards the modelling and programming elements.

5.3.12 Statement 12

Unlike the traditional programming approaches, which require a sufficient amount of source code and a dedicated GUI to produce a 'tangible' outcome, virtual worlds inherently complement and enhance users' experience by offering a set of 3-D patterns and a large scripting library. Participants acknowledged the importance of having such resources available, as these enabled them to observe the functionality of their creations in a more vivid and robust manner,

⁴¹ 3D models, scripts or detailed information about procedures

thus making the programming concepts less difficult to master and the learning process more meaningful and interesting for them (Table 5.20).

Notes:

- Unlike the vagueness of the samples' trends in Statement 11, the participants' responses in the present item were clearer and definitely more positive⁴².
- Similar to the previous statement, the main reasoning for asking this question was to elicit the learners' perception towards their own work and creations. However, based on the mean scores, some speculations can be drawn regarding the influence of the available content on the learners' own experiences in each occasion.

Table 5.20. Results of S12.

...was interesting since I had the opportunity to see my creations 'alive'.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 (n = 161)	67.7%	20.5%	11.8%	2.56	0.70	Agree	0.72
E2 (n = 178)	64.0%	20.8%	15.2%	2.49	0.75	Agree	
E3 (n = 133)	72.9%	18.0%	9.0%	2.64	0.64	Agree	
E4 (n = 165)	70.9%	18.8%	10.3%	2.61	0.67	Agree	

Impact of the instructional design:

- Interacting with the example content or the games had some motivational or inspirational influence on learners' thoughts and creational ideas. Thus, despite the effort needed in order to achieve their goals, the final outcome has met with success and rewarding results.
- In the same vein, the detailed instructions and information that the PAs were offering, may have lengthened the preparation time, yet have had equally remarkable and positive results on the final outcome.

⁴² Exception to both is E₂ as participants maintained their 'neutral-like' attitude consistently in both observation items.

- Nonetheless, what comes to a great surprise is the rather weak impact that the orientation area had on helping learners to develop more sophisticated and creative artefacts. A possible explanation for this outcome can be attributed to the limited interaction time that the students dedicated to familiarise themselves properly and thoroughly.

5.3.13 Statement 13

In order to examine the in-world development process holistically, this item was used as the means to investigate the learners' perceptions and thoughts towards their artefacts as end products. Indeed, for most of them, testing and validating the functionality and interoperability of their own creations—so as to ascertain how well they met the requirements—was an amusing activity rather than a tiresome obligation (Table 5.21).

Notes:

- Cross-examining the participants' responses in this statement with those in Statement 11, a question is posed: Why did students enjoy using their virtual artefacts but did not enjoy creating them equally as much? A possible answer to this may lie in the difficulty that the learners had in dealing with this technology, due to the steep learning curve, as well as the rigorous or time-consuming development process to reach the desired outcomes.
- Moreover, regardless of the strength of the responses, participants in E₃ and E₄ maintained an overall positive and invariable attitude towards the cross-examined items (S11-S13). However, this was not the case for those who completed the survey in the context of E₁ and E₂, as their responses present some contradictory differentiations and an overall inconclusive trend.

Table 5.21. Results of S13.

...pleased me, especially when I was using the virtual objects I created.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 ($n = 161$)	62.7%	18.0%	19.3%	2.43	0.80	Agree	0.77
E2 ($n = 178$)	70.8%	18.5%	10.7%	2.60	0.68	Agree	
E3 ($n = 133$)	73.7%	18.0%	8.3%	2.65	0.63	Agree	
E4 ($n = 165$)	69.1%	18.2%	12.7%	2.56	0.71	Agree	

Impact of the instructional design:

- Even though the nature of the available content—during each intervention—affected the learners’ attitude and decisions towards the development process, their willingness to use their artefacts does not seem to have been affected much, if not at all, by this factor.
- Nonetheless, a notable difference between the experiments is identified, on the basis of which a speculation can be made. For instance, in the cases where the instructional designer had some active involvement in shaping the students’ learning experiences (E₂-E₄), the reported behaviour outcomes reflect a more accurate picture compared to the ‘less privileged’ students who participated in the exemplification experiment.

5.3.14 Statement 14

As mentioned in Statement 10, exploring the content of the virtual world was a pleasant process for various reasons. However, the decline in the number of positive responses provided in this statement, gives an indication that interacting with the objects developed by others was not one of them (Table 5.22).

Notes:

- The high distribution of the samples’ responses provides a strong indication of the relatively low influence that the third-party content had on learners’ contentment. In addition, it is the only statement—across the conclusive

survey (Part 2)—having neutral mean values in all the conducted experiments.

- As there is no evidence for E_1 and E_2 to support the assertion that the participants accounted the content provided by the researcher (for E_3 and E_4 see Part 3), it can only be speculated that there was some influence.

Table 5.22. Results of S14.

...pleased me, especially when I was using others' virtual objects	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 ($n = 161$)	51.6%	30.4%	18.0%	2.34	0.77	Agree	
E2 ($n = 178$)	50.6%	29.2%	20.2%	2.30	0.79	Agree	0.83
E3 ($n = 133$)	55.6%	30.1%	14.3%	2.41	0.73	Agree	
E4 ($n = 165$)	58.8%	26.7%	14.5%	2.44	0.74	Agree	

Impact of the instructional design:

- Interacting with the example content or the attributes of the orientation area could have had various benefits and advantages for learners (e.g. improvement in performance, better understanding of the required competences). However, for reasons that cannot be explored through the survey responses, it can only be assumed that the aforementioned content got limited attention, which affected the intensity of interactions that students had with it.
- ***Part 2B Users Exclusive***

Note that the items that are examined in this section refer exclusively to the different types of interactions that learners could have with each other.

5.3.15 Statement 24

The fact that not all the students were simultaneously co-present in the same laboratory (parallel sessions), so as to have in-person communication, could potentially make the employment of the in-world chat tool one of the main

communication alternatives. Indeed, the opportunity given to learners to communicate their ideas about their projects, or comment on their fellow students' work—without having to disengage from the virtual world and, thus interrupt their workflow—was generally welcomed by most participants (Table 5.23). However, the equally easy-to-access social media or cross-platform tools (e.g. Facebook[®], WhatsApp[®] or Viber[®])—which are predominantly used to cover communication needs—cannot be disregarded either.

Notes:

- The fact that E₂ and E₄ directly provided information related to the in-world communication tool does not seem to have had much influence on the learners' willingness to use it. Equally less intense was the use of the chat tool to communicate project-related matters in E₁.
- On the other hand, the strong signs of active participation and engagement with the world and its tools that the participants of E₃ have indicated so far, are also reflected on their interactions with other users, as can be seen from the positive trend of their responses.

Table 5.23. Results of S24.

...was interesting since I had the opportunity to chat with others about our projects.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 (<i>n</i> = 161)	60.2%	22.4%	17.4%	2.43	0.77	Agree	
E2 (<i>n</i> = 178)	57.9%	25.8%	16.3%	2.42	0.76	Agree	
E3 (<i>n</i> = 133)	63.9%	25.6%	10.5%	2.53	0.68	Agree	0.76
E4 (<i>n</i> = 165)	61.8%	23.6%	14.5%	2.47	0.74	Agree	

Impact of the instructional design:

- As there were many more factors⁴³—beyond the instructional content—that could influence the learners' intention to share information, the exact identification of the relationship between the utilised interventions and the

⁴³ e.g. privacy, inability to erase the chat logs, personal preferences to not disclose any information

use of the chat tool is difficult. On top of that, considering the unclear view of the findings presented above, drawing any direct conclusions should be avoided. Nevertheless, the statements that follow (e.g. S25, S28-29) will be used to counter this drawback and develop a better understanding of how learners perceived the in-world communication tools, and how each intervention influenced this outcome.

5.3.16 Statement 25

Experimentation is linked with the chance of failure or, in this case, the possibility to get undesired results. At the same time, code visualisation is a challenging process to go through, even after reaching a certain level of knowledge or a threshold of familiarity. Nevertheless, knowledge is gained through mistakes too and, thus sharing the most uncommon or unexpected results could have some indirect learning benefits. As seen from the positive responses, participants perceived their mistakes as an amusing or fun addition to the learning process and opted to further communicate them (Table 5.24).

Notes:

- As discussed in S24, participants in E₃ opted to use the chat tool more frequently, compared to those who participated in the rest of the experiments, to discuss matters related to their projects. The same applies to the present case, as those participants' responses were, once again, more positive and less distributed in contrast to the others.
- However, an interesting differentiation between the two examination points is witnessed in the case of E₂ and E₄. Even though students inclined less to discuss aspects of their own projects, they were considerably more prone to communicate and even make fun of the unexpected results they were getting during the development or the testing process.

- Lastly, the consistently low contribution that E₁ had on most interaction types also resonates in the current case.

Table 5.24. Results of S25.

...pleased me, especially when we were discussing and laughing with our mistakes.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 (n = 161)	58.4%	23.0%	18.6%	2.40	0.78	Agree	
E2 (n = 178)	65.7%	24.7%	9.6%	2.56	0.66	Agree	0.86
E3 (n = 133)	73.7%	18.0%	8.3%	2.65	0.63	Agree	
E4 (n = 165)	66.1%	20.6%	13.3%	2.53	0.72	Agree	

Impact of the instructional design:

- The available content during each intervention aimed to passively increase the learners' curiosity to explore the mechanisms of the virtual world, trigger their imagination and, thus increase the incentives for trial and error. Combining the above with the freedom and flexibility they had to experiment, making mistakes was to be expected. That said, sharing their knowledge or elaborating on the unexpected results with others was something which the presence of the chat tool encouraged and supported.

5.3.17 Statement 26

Students' willingness to collaborate with others may be affected by various factors (e.g. the nature of the assignment, one's personal preference to consciously work alone and undistracted or occasionally cooperate with others). Thus, examining whether or not their attitude towards collaborations was affected by the setup of the virtual world or the option offered to them to work in pairs/groups, was considered reasonable. Indeed, in the wider context of the social interactions among learners, teamwork was also affected, as they claimed to have become more open-minded towards collaborations (Table 5.25).

Notes:

- The collaborative atmosphere that was established in the context of the DGBL provided a strong foundation for additional collaborative activities to be performed, as indicated by the strongly positive responses.
- Interacting with the PAs also facilitated collaboration, though to a lesser extent. As the aim of this intervention was to trigger the learners' interest in 'discussing' the challenges they were facing with the NPCs or receiving technical advice from them, the borderline positive outcome is justifiable.
- Even though the reasoning behind the orientation area was similar to the one used for the PAs, its impact on collaboration was not the same. In fact, it had the lowest influence amongst all the experiments.

Table 5.25. Results of S26.

...made me more open & positive to collaborations.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 ($n = 161$)	57.1%	24.8%	18.0%	2.39	0.78	Agree	
E2 ($n = 178$)	56.2%	24.2%	19.7%	2.37	0.79	Agree	
E3 ($n = 133$)	72.9%	20.3%	6.8%	2.66	0.60	Agree	0.69
E4 ($n = 165$)	66.1%	21.2%	12.7%	2.53	0.71	Agree	

Impact of the instructional design:

- Despite the fact that the pre-existing content offered opportunities for team exploration and discovery, its influence on learners' attitude towards collaboration was not meritorious.
- Although the orientation area aimed at improving the learners' collaborative skills and abilities, its impact on facilitating this process was equally limited. An explanation to that can be attributed after considering the knowledge and skills the students developed as part of their interaction with this content. Indeed, as their self-awareness increased, their confidence to use the in-world tools was boosted and, thus they became less inclined to work with others on a constant basis.

- The alternative version of the instructional content had a slightly more positive influence. Though the conversational agents were designed to engage learners in a more personalised way, the major influence towards the aspect of collaboration is mainly attributed to the vendor NPC and the freebies it was offering. Indeed, after considering the daily limitation⁴⁴, an increase in the collaborative effort to collect and exchange these items might be seen.
- Lastly, the entertaining nature of the edutainment content made the learning environment a more interesting place to acquire knowledge, which also affected the learners' willingness to collaborate with others, be it for leisure purposes or work.

5.3.18 Statement 27

Accounting the diverse personalities that people have, working with others to achieve common goals can be a fairly tough process to go through. Therefore, determining whether the virtual environment encouraged learners to collaborate (S26) and, consequently, investigating the impact of this experience was considered practical. Collaboration, either constantly or sporadically, was acknowledged as a pleasant process, since it allowed students to achieve common goals (Table 5.26). Nevertheless, given that not all of them worked in groups, the number of neutral or negative responses becomes justifiable. In the former case, it can be assumed that the potentially short successful or unsuccessful collaborations affected their conclusive opinion, whilst, in the latter, it seems that the changes made in a virtual environment from groups of people with joint or different objectives might not always have positive results.

⁴⁴ one free item a day per student

Notes:

- The results of this statement are similar and (almost) aligned with those provided in Statement 26, a fact which confirms and supports the influence that each intervention had on collaboration and teamwork.
- More precisely, participants in E₃ and E₄ considered the outcome of their collaborative practices to be fruitful and the relationship with others valuable. On the other hand, even though a positive increase in participants' (E₁ and E₂) responses is observed, the inconclusive position of the samples remains.

Table 5.26. Results of S27.

...pleased me, especially when collaborating with others for a common goal.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 (<i>n</i> = 161)	60.2%	22.4%	17.4%	2.43	0.77	Agree	
E2 (<i>n</i> = 178)	64.0%	20.8%	15.2%	2.49	0.75	Agree	0.71
E3 (<i>n</i> = 133)	74.4%	17.3%	8.3%	2.66	0.63	Agree	
E4 (<i>n</i> = 165)	68.5%	19.4%	12.1%	2.56	0.70	Agree	

Impact of the instructional design:

- Collaboration can take many forms (e.g. discussion, hands-on activities). In addition, the instructional design techniques are aimed at encouraging students to explore the environment and socially connect with each other so as to achieve mutual goals.
- Amongst the conducted experiments, the edutainment offered the most opportunities for collaboration, be it for entertainment and collective effort to solve the questions or even for competition, as the objectives were more 'tangible' and clear.
- On the contrary, the pre-existing content offered considerably less opportunities for collaborative activities, as it restricted learners to mainly exploring and testing these artefacts.

- The students' joint effort to develop a mutual understanding and shared interpretation, whilst working on the development of their skills and knowledge under the guidance of the instructional content, was the most pronounced motivational achievement they could set for.

5.3.19 Statement 28

Witnessing students helping each other with the weekly tasks or the assignments is a frequently observed practice. However, as the underlying technology of the virtual world was something completely unknown for most of them, concerns towards their 'enthusiasm' to help others might be raised. As seen from the participants' responses (Table 5.27), the use of the virtual world not only encouraged the opportunities for collaboration but, also, boosted their willingness to help others understand the operation and functionality of the in-world tools (e.g. navigation, avatar modification, 3-D modelling and programming).

Notes:

- Though students' personality and learning style play the first and foremost role towards the extent to which activities like peer-tutoring are crowned with success, the influential impact that the educational interventions had in facilitating this process cannot be disregarded. That said, the responses towards this statement confirm and validate the overall picture known from the previous observation points, as the GBL approach maintained its superiority over the rest of the interventions. However, the relatively weak contribution of the example showcases to this point remained unchanged. Similarly, the effect that the educational material had on learners' intention to enlighten others with the knowledge and skills acquired, is once again observed to be at the positive/neutral borderline.

Table 5.27. Results of S28.

...made me teach others things I knew.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 (n = 161)	55.3%	26.7%	18.0%	2.37	0.77	Agree	
E2 (n = 178)	66.9%	19.7%	13.5%	2.53	0.72	Agree	0.68
E3 (n = 133)	72.9%	17.3%	9.8%	2.63	0.66	Agree	
E4 (n = 165)	66.1%	16.4%	17.6%	2.48	0.78	Agree	

Impact of the instructional design:

- Investigating the content of the virtual world’s unknown environment, in a joint collaborative effort to develop a core pattern regarding the assignment and its requirements, fostered opportunities for peer-to-peer tutoring. However, as this exploration was restricted and limited only to the available showcases and their structural elements, the extent to which this process could be facilitated was affected in a rather negative way.
- The instructional material had a stronger contribution towards the knowledge transferring process, as both the orientation area and the agents provided the means for research and practical work. On that basis, students could express their views and share their understanding with others without the direct involvement of the lecturer or assistants.
- The edutainment content set the foundation for many activities through which learners could co-discover knowledge and creatively connect themes and ideas. Thus, whilst playing and engaging actively in the various activities, the opportunity to share their knowledge and experiences with others also emerged and stimulated students’ interest in peer-teaching.

5.3.20 Statement 29

As already discussed (Statement 28), students tend to assume the role of the instructor-teacher when helping or working with others. Indeed, especially in practical-oriented fields, being taught by peers may be usually occurring subconsciously, yet has numerous and substantial intellectual benefits on

knowledge acquisition. Thus, aligned with the responses given in the former statement, students acknowledged the potential of peer-assisted learning and considered it as part of their routine interactions (Table 5.28). Regarding the neutral or negative responses, they can be interpreted in a two-fold way: 1) either students did not consider their interactions with others effective enough to learn, or 2) just because this is an indirect way of learning the acquired knowledge was not considered as actual ‘tutoring’.

Notes:

- In a similar manner to the physical classroom setting, where students develop their social and interpersonal skills, the in-world educational interventions aimed at offering additional opportunities for collaboration and passive learning. Indeed, as discussed in Statement 28, students acknowledged the opportunities they had to improve their academic competences by ‘teaching’ others what they already knew. Nevertheless, the way that learners distinguish and understand peer-tutoring or, in this case, peer-learning, heavily relies on their personality traits. Thus, the slightly differentiated trend values in the collected responses across the two statements are justified, and provide additional insights about the reach and influence that this interaction type had on their engagement.

Table 5.28. Results of S29.

...made me learn what others already knew.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 (n = 161)	60.2%	19.3%	20.5%	2.40	0.81	Agree	0.59
E2 (n = 178)	65.2%	17.4%	17.4%	2.48	0.78	Agree	
E3 (n = 133)	68.4%	21.8%	9.8%	2.59	0.66	Agree	
E4 (n = 165)	67.3%	18.8%	13.9%	2.53	0.73	Agree	

Impact of the instructional design:

- Based on the slight increase in the positive responses of E₁ and E₄ and, after considering that not all students had an equal desire to explore the pre-existing content in detail or interact with the agents on a frequent basis, signs of peer-learning influence might be observed.
- On the other hand, the structure of the orientation process and the ludic nature of the recreational areas, boosted learners' willingness to explore the content themselves and, thus lower levels of knowledge transfer are reported.

5.3.21 Statement 30

Unlike the traditional educational approaches, which are task-focused and offer limited opportunities to learners to perform actions non-directly related to their project, virtual worlds have the potential to combine work, leisure and even relaxation. For instance, exploration, chatting or modification of the avatars' appearance are but a few examples of short breaks that students can have without having to disengage from the learning environment. Participants acknowledged this opportunity and the included benefits as a positive aspect of this teaching-learning approach (Table 5.29). Nevertheless, not all of them were keen to blend the aforementioned elements, as also seen in the former statements (e.g. S10, S25).

Notes:

- The extensive and varied content of E₃ and E₂ provided students with the most noteworthy options to reduce the workload and spend time away from their workspaces, as opposed to the more task-oriented elements of the agents or the pre-existing content.

Table 5.29. Results of S30.

...pleased me, especially when we were having breaks from our work.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo	KW
E1 (n = 161)	52.8%	32.3%	14.9%	2.38	0.73	Agree	0.93
E2 (n = 178)	66.3%	21.9%	11.8%	2.54	0.70	Agree	
E3 (n = 133)	66.2%	24.1%	9.8%	2.56	0.67	Agree	
E4 (n = 165)	63.0%	23.0%	13.9%	2.49	0.73	Agree	

Impact of the instructional design:

- The presence of the edutainment content and the intrinsic passion for (digital) games that especially young people usually have, turned out to be the best possible way to combine learning and relaxation.
- Almost equal were the opportunities offered by the orientation building along with the mini park and the sandbox area. Be it the relevant section in the orientation area dedicated to editing the avatars' appearance/gestures, or the opportunity to meet with others and socialise, the outcome was in either case positive.
- Finally, the confined nature of the agents and the limited range for recreational and social activities that the exemplification content offered, sensibly enough reduced the opportunities for breaks. Indeed, after considering that this material was the one mainly linked with the assignment and the intended course of the study, such outcome is to be expected.
- ***Part 3 E3 & E4 Exclusive***

Note that the items that are examined in this section refer exclusively to E₃/E₄ and examine directly the interactions that the learners had with the content developed by the instructional designer.

5.3.22 Statement 31

Given that only a few students were observed interacting with the in-world games or the agents during the practical sessions (Section 5.4.6), posing a question about the frequency of use was deemed necessary. Though not all of them were equally attracted to these approaches, the vast majority opted to use part or all of this content, at least once, during the course of these units (Table 5.30). Moreover, studying these results comparatively, it can be assumed that the greater the substance of the content was, the more frequent and significant the opportunities for interaction were.

Table 5.30. Results of S31.

How many times have you used the content ⁴⁵ developed by the instructional designer?	Never	$\geq 2x$ during the entire course of this unit	= 1x/week	$\leq 1x/week$
E3 ($n = 133$)	22.6%	27.1%	22.6%	27.8%
E4 ($n = 165$)	31.5%	37.0%	20.0%	11.5%

5.3.23 Statement 32

As the instructional content had a manifold role (e.g. educational, recreational, inspirational, social), examining students' perception towards the extent to which these entities helped them to become more engaged with the virtual world and the learning activities, was considered to be enlightening and helpful (Table 5.31).

Notes:

- Participants' responses in terms of positive and negative answers reflect a strong uncertainty, especially in the case of E₄. This is further confirmed from the mean values which are observed within the neutral range.

⁴⁵ In the distributed surveys the word 'content' defined explicitly the instructional material that has been provided by the researcher (i.e. maze/racing game/amusement park/lake/café or the names of the NPCs, respectively).

Table 5.31. Results of S32.

This 'content' helped me become more engaged with the virtual world and the learning activities.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo
E3 ($n = 103$)	53.4%	25.2%	21.4%	2.32	0.81	Agree
E4 ($n = 113$)	41.6%	25.7%	32.7%	2.09	0.86	Agree

Impact of the instructional design:

- As also seen from the former responses, the presence of this content affected learners' engagement with the environment. It should be reminded that the students' primary objective was to fulfil the needs of their assignment. Therefore, considering that the games or the agents were 'add-ons' to the virtual world, the extent to which they impacted on students' attitude towards the learning activities remains rather questionable.

5.3.24 Statement 33

As the educational interventions also aimed at improving students' understanding and knowledge of the learning subject, the final statement examined their value in view of learning benefits and knowledge acquisition (Table 5.32).

Notes:

- Although both approaches had the pedagogical foundation to stimulate students' interest in learning and expose them to the subject matter in a more exciting way, the inconclusive records provide an indication that the shift from the long-term tradition of 'passive' learning is more challenging.

Table 5.32. Results of S33.

This 'content' made it easier for me to understand the learning subject.	Agreement	Neutral	Disagreement	\bar{x}	Sx	Mo
E3 ($n = 103$)	55.3%	20.4%	24.3%	2.31	0.84	Agree
E4 ($n = 113$)	45.1%	31.0%	23.9%	2.21	0.81	Agree

Impact of the instructional design:

- Regardless of the instructional design decisions, it is the learners' perception and interpretation towards the virtual world and the given interventions that influence the most the success of this material and its potential to establish meaningful outcomes, as it requires that they take an active role towards the learning process.
- As a final note, interaction with the game content or the PAs has the potential to influence and positively contribute towards the learning process and outcome, though the role of the lecturer or the input of other students cannot be sufficiently substituted.
- *Part 4*

5.3.25 Open-Ended Question

The last part of the conclusive survey provided participants with the opportunity to propose ways that, according to their opinion and based on their student-side experience, would have made them become more engaged with the virtual world. The open-ended question was introduced in E₂ and was used in all the subsequent experiments. As answering this question was not mandatory, only 172 out of the 476 students (36.1%) provided an answer. Participants' responses (Appendix D) were analysed under the principles of the Grounded Theory (Strauss & Corbin, 1998) and they were classified into six major categories grounded on their needs, experiences, opinions and perspectives, as discussed in Section 4.3.5.2. Similar or identical responses have been grouped or merged for presentation purposes.

- **Time limitations**

Participants claimed that the duration of their project was not sufficient enough to allow them to understand the philosophy of the virtual world, familiarise with its tools and programming language, acquire the necessary skills, and produce the desired outcome. Indeed, time limitation seems to be a common obstacle to student engagement, since induction and familiarisation processes are time-consuming, whilst the project is time-demanding, too. Thus, students asked for additional time to acquaint themselves with the virtual world prior to the beginning of the course.

- **Lack of pre-existing content**

Even though the freely available online content of example scripts and libraries for the LSL programming language was fairly massive, a portion of participants expressed their willingness to have more example scripts, objects, artefacts and animation samples available in-world. Despite the fact that there were several scripted objects in the orientation area, their aim was to provide students with basic information about the virtual world and its tools, as well as with examples of how to design and turn objects into interactive creations. That way students' creativity would be triggered, so as to design and develop their own objects and scripts, which was also within the scope of their assignment. Nevertheless, students seemed to be looking for examples of the artefacts they were asked to create as part of their assignment, which could only be achieved in the experiment where the PAs were utilised. Furthermore, having mini virtual games was also mentioned as a reason that could have increased the levels of engagement because of their interest to discover more about the way they are coded. Participants seemed to enjoy the in-world games to such an extent that they were asking for more. As the existing educational games were mostly

testing students' theoretical knowledge, one of them suggested that there could have been a game testing their scripting ability, in order to practice while playing the games. Another student, appreciating the interactivity of the virtual world, suggested that more interactive elements, games and mini-games be put into the virtual world. One more interesting point made by another student was that more content encouraging student socialisation should be added into the virtual world. Finally, another participant asked for the ability to copy existing objects created by others, so that they could spend more time on modifying the copied objects and creating scripts, rather than creating objects from scratch. However, that could not be applicable, since creating virtual objects from scratch was part of their assignment.

- **Technical issues**

The technical issues reported were related to the world's graphics, its programming language as well as some non-categorised matters.

1. The first category includes the answers concerning the quality of graphics. Specifically, for these students the engagement with the world could have probably increased if the frame rate speed, the texture resolution, the physics engine, and the user interface had been better. Furthermore, participants with 3-D modelling experience felt that the option of editing objects, while observing them in the first person, would have positively worked on their engagement, whilst for another portion the option of importing 3-D models would have helped them to produce a better outcome, and, therefore, feel more engaged.
2. Moreover, students stated that the experiential nature of the scripting language and the various bugs that occasionally occurred decreased their engagement; therefore, they suggested that its functions and operations

should be improved. On the other side, others stated that LSL was rather simple and abstract, preventing them from creating complex scripts that would make their objects multifunctional.

3. The rest of the reported issues were related to the back and front end of the virtual world. For instance, the server-side of the technology or the viewer, the architecture of which caused latency issues and crashing incidents that occasionally occurred. Others suggested that more options to customise avatars or voice input be added. Indeed, one of the features that this type of virtual worlds offers is the avatar modification and customisation. Nevertheless, it should be mentioned that this process is fairly time-consuming and demanding in order to achieve a desirable outcome. Finally, there was also a comment about the primitives' library within the system (limited number of available options). This response can be judged from the following perspectives:

- the gallery of the basic shapes (polygons) that users modify in order to shape them in a meaningful way, or
- the maximum allowed objects that students could use to produce their artefacts, as there were restrictions applied in the assignment description.

- **Assignment**

Special reference was also made to the project that students had to complete. Indeed, the nature of the assignment weighs as much as the design of the in-world activities that the instructional designers plan for their students, as each one of them complements the other. Students asked for more precise tasks, which would offer them less freedom, yet would indicate something specific to create, or, at least, introduce them to a plot based on which their development should be made. Another student stated that he might have been more

immersed in the virtual world if the scripting required had been less extensive. On the contrary, another student underlined that the '10-script-limitation' rule that applied for the cohorts of the Project Management students had been a negative factor to his engagement. A portion of students suggested that higher levels of engagement would have been achieved if the use of the virtual world had not been part of this assignment [which included other tasks to be done complementarily] or if the assignment focused exclusively on the virtual world without including other tasks. Others pointed out that a more challenging and competitive setting of the assignment would have been more engaging. However, even though the design of the in-world activities is part of this study, the assignment brief or setup is out of the scope, and, therefore, cannot be further elaborated on.

- **Instructions**

The lack of proper induction was the main issue that students mentioned in this category. More precisely, they referred to the instructions and information they would like to have access to, either regarding the virtual world or its impact on their learning development, as well as the scope of their project. Unlike participants in E₂, participants in the rest of the experiments designedly went through no induction process. As a result, students had to spend a considerable amount of time exploring the virtual world and its potentials in order to learn its mechanisms, principals and tools. Combining these responses with what other students mentioned about time limitations, a clear conclusion is drawn: students need to go through a proper induction process before starting working on their assignment, and they should also be given enough time to familiarise themselves with the virtual world. If students are deprived of any of these two, they are most likely to not feel engaged.

- **Student Personality**

The last category is mostly related to students' personality and preferences that could not be included in any of the other categories. Even though students were satisfied with the freedom they had to create anything they desired, they noted that the space limitations curbed their creativity and prevented them from being immersed. The students' background also affected their perception; one of them claimed that the nature of his scientific discipline is unrelated to the use of such software, whilst others stated that a virtual world more tailored and oriented to cover 3-D modelling and programming purposes would have had a better impact on their engagement. In the same vein, there were students who claimed that they would have preferred to not use a virtual world of this kind, but another technology or virtual world, instead. Finally, a student who felt isolated mentioned that his engagement decreased due to the lack of interaction with others.

5.4 Pedagogical Observations

To examine student in-world and in-class actions, interactions and feelings related to the use of the virtual world pedagogical observations were closely monitored. Students were observed during their practical sessions and the observed data were collected in a diary. These data were subsequently categorised into eight categories:

1. **Talking and making comments** (Section 5.4.1): includes information about in-class verbal communication among students themselves, as well as between students and the teaching team. Along the lines, some direct quotes from students' conversations are provided as footnotes to contextualise the context of the discussion.
2. **Attitude towards the use of the virtual world** (Section 5.4.2): includes

information about students' expressed emotions when using the virtual world, as well as their willingness to engage with it or not.

3. **Student identity and avatar identity** (Section 5.4.3): includes information about students' perception of the avatars.
4. **Talking, making comments and use of the chat tool** (Section 5.4.4): includes information about students' in-world verbal communication through the use of the chat tool.
5. **Nonverbal communication** (Section 5.4.5): includes information about the students' use of avatar gestures and emoticons in chat.
6. **Interactions with the virtual world** (Section 5.4.6): includes information about the students' interactions with objects and tools of the virtual world.
7. **Student identity and avatar identity** (Section 5.4.7): includes information about avatar modifications and the way students referred to their avatars in-world.
8. **Students' willingness to remain longer than expected** (Section 5.4.8): includes information about the students' willingness to remain engaged with the virtual world and their assignment, after the completion of the practical session.

The analysis of the observation that follows is based on the same logic as the analysis of the surveys. In accordance to the four experiments, each category includes the relevant information collected from each one of them. A summary with the frequencies of the observed actions can be found in Appendix E.

5.4.1 Talking & Making Comments (classroom)

- *Experiment 1*

Students were usually observed talking about the virtual world (including the secondary tools⁴⁶), its potential, and their projects whilst, references to matters unrelated to the aforementioned were very rare and infrequent. Technical questions, related to the programming language and the 3-D modeling tools were usually addressed to the teaching team. On that note, those who needed more time to familiarise themselves with the world and its tools were observed asking more frequently questions about the navigational and searching tools, and less about the 3-D modeling and programming. On the other hand, those who were more comfortable with the in-world tools were observed elaborating the outcome of their research so as to get further help, guidance and instructions.

At the early stages, students were observed being concerned about the transition of their ideas to in-world development and opted to discuss such matters both with the lecturers and with other students. On the other hand, as their projects were to conclude, students were observed exchanging information about the available software for video capturing or editing, and even providing help and guidance to others on how to use it. In fact, this was the most intense cross-team peer-tutoring that had ever been observed in these cohorts, as most students were usually interacting exclusively with their team members or close friends.

The positive comments that were recorded were mostly related to their achievements and progress⁴⁷ while the negative ones concerned, mainly, the

⁴⁶ such as the weather settings, the group function or the in-world personal profile

⁴⁷ 'I think it's a bit overcomplicated at first, but after a while it's smooth!'

technological drawbacks⁴⁸ of the virtual world and its architecture⁴⁹. Students' emotional experience was generally positive⁵⁰ and ecstatic⁵¹, though, some disadvantageous⁵² and doubtful thoughts were also expressed verbally. More precisely, those who were struggling to understand⁵³ the operation of the virtual world or disliked this educational approach⁵⁴ insisted that the use of such technology had nothing to offer them and that the teaching team should consider its discontinuance.

- ***Experiment 2***

The assignment's requirements were fairly often the highlight of students' conversations on the basis of which they also discussed matters related to the use of third party software (for 3-D modeling) or the information gathered from external resources related to scripting. Interestingly, even when the focus of their talks was not relevant to their work, generic matters related to the virtual world—such as the accessibility of the environment using portable devices (tablets) or the integration of this platform in other university units—occupied their attention. However, those individuals who 'traditionally' observed being detached from the classroom, talking about completely irrelevant matters to the academic subject, maintained such behaviour regardless the fact that an alternative educational approach was used. All in all, it can be assumed that even the integration of such technology cannot alter students' attitude or mindset towards their studies or, otherwise, engage them with the subject under investigation.

⁴⁸ 'Nothing works here. Eveyrthing I try is unresponsive'.

⁴⁹ 'Sir, is it possible to make a script that can crash the server? I have heard many stories from other students and I want to try it!'

⁵⁰ 'It's a lot of fun trying to learn more about this technology! A completely new experience!'

⁵¹ 'That was a rather weird session, but with lots of fun! Anyway, thanks for that, sir!'

⁵² 'This is the most stressful thing I have ever done in my life'

⁵³ 'What are we supposed to do here?', 'Why didn't we have any lectures related to the world?'

⁵⁴ 'I really don't know why we are doing this...it's so unreal and childish; we ain't 10 years old anymore'.

Students' negative preconceptions, especially during the first practical sessions, were quite strong⁵⁵. However, this attitude changed gradually over time as they were observed discussing positively the opportunity to experience a completely different way to do programming and get hints of the 3-D modeling development principles⁵⁶. Nonetheless, negative comments about the technology, mostly related to the quality of the graphics⁵⁷ or the functionality of the scripting language⁵⁸, were expressed quite often. Likewise, almost all the students were observed making some unfavourable comments related to their emotional experience, especially when the assignments' submission deadline was due⁵⁹. In fact, students' main complaint was the tight time-frame⁶⁰ that they were given to prepare and submit their assignment, as it prevented them from producing something 'meaningful'. In most cases, this outcome was further elaborated with a pointer to the lack of prior experience that most of them had which, in turn, led them to dedicate most of their time to understand the 'basics' instead of getting hands on the 'real' development. Others expressed a completely different opinion claiming that this specific programming language, though 'easy', is used exclusively in such environments and thus, investing time and effort to make something useful was considered to be time-wasting.

- ***Experiment 3***

Based on the conversations that students had, a set of links with the previous experiments is identified. The first issue of concern was the lack of pre-existing

⁵⁵ 'What's the reason for using it?' 'Why do I have to play that?'

⁵⁶ 'Sir, my team and I have spent almost two weeks, 24/7, online to do that... It finally started paying off!'

⁵⁷ 'The graphics resolution is too low... the ground is so pixelated, I can't work like this.', 'The graphics in this world are sooo bad!'

⁵⁸ 'Sir, my object has a free will and I can't stop it!', 'Everything bugs here and scripts don't work.'

⁵⁹ 'It isn't working, I have tried everything to fix this and it still bugs out! Help me!'

⁶⁰ 'Can we get an extension just for the virtual showcase? We are going to fail, otherwise'.

content developed by former cohorts⁶¹. As students reported, not having any source of examples to help them establish a starting point for their own projects made it difficult to understand the requirements of their assignment. Moreover, those who found it difficult to adapt with the virtual world and cope with its tools expressed their wish to have an orientation/induction session dedicated to this technology, prior to the start of their assignment⁶². What was also observed, though this time from the very beginning, was students' willingness to 'secure' their workspaces so as to prevent others from accessing them⁶³. Not surprisingly, the results of this action caused disappointment to those who wanted to explore the world's content but were unable to.

The topics that students usually discussed with each other were related to the requirements of their assignment⁶⁴, the in-world development tools⁶⁵, the avatars⁶⁶ and even the 'secondary' tools of the virtual world⁶⁷. The content developed by others was also the highlight of their talks, though considerably less were the mentions made regarding the content developed by the instructional designer.

Students' verbal interaction with the teaching team covered mostly matters related to the marking scheme, along with some requests for informal feedback. Equally frequent were the requests that students raised for the removal of objects⁶⁸—which others had accidentally created in their workspaces—or had malicious code and thus, affecting their workflow. Nevertheless, students, once

⁶¹ 'What is the virtual showcase?', 'How should it look like?', 'Can we have some examples?'

⁶² 'Are we going to have any demonstrations or lectures about it?'

⁶³ 'This is my virtual land, get out, out, out!', 'I am trying to create a door that will only open for me so others will not enter my house, can you help me?'

⁶⁴ 'What else we need to do to get a pass grade?', 'Simulation completed, ready to shoot the video!'

⁶⁵ 'How can I rotate my objects?', 'Is it possible to make a script that can talk to you?'

⁶⁶ 'I want to change his skin colour, too. How did you do it?', 'I want to be more muscular!', 'How can I change gender?'

⁶⁷ 'How can I teleport back?', 'Why you have day time and me midnight?'

⁶⁸ 'Someone is lagging the server, who owns that chat repeater script?! Sir, can you please remove it?'

again, sought help from the teaching team to resolve such issues.

In either case, conversations completely unrelated to the virtual world (e.g. documentation of their assignment, use of third party software) or even to the project per se (personal issues/matters) were also observed taking place, both with the teaching team and with each other.

The comments that students made were generally positive and more intense whenever they were finishing parts of their work or acquiring new ideas for development⁶⁹. Moreover, exploring or using the content, which was developed by the instructional designer, was also a good source of joy and enjoyment, as the 3-D element and the ludic nature of this content altered the traditional learning process. On the other hand, negative comments were mainly heard about the OpenSim technology⁷⁰ such as latency issues⁷¹, server crashes and graphics' quality or the inability of the viewer to import 3-D models that were incompatible with it.

Limiting the available number of scripts, which each team was allowed to use, led students to raise complaints. In fact, one of them even proposed to use his own virtual world so as to have 'unlimited' number of scripts to work with on his team's project. This idea was also welcomed by several students, who also expressed their willingness to have their 'own' virtual world, in order to work undistracted on their showcase. These proposals may have been rejected by the teaching team, however, they consist a significant indication of the great importance that a portion of students attached to the interactions with the content of the virtual world and with other students—as opposed to their main aim to fulfill the requirements of their assignment and gain good grades.

⁶⁹ 'I will put cannons on my ship to blow up your house!', 'Can we create guns so we can kill people? The Counter Strike Bedfordia!'

⁷⁰ 'I hate that...I don't like the virtual world...'

⁷¹ 'Crazy lag bro lol', 'Admin you need to fix it lol. We can't work with this lag!'

- ***Experiment 4***

The verbal interaction among the students was quite intense throughout the course of the practical sessions. At the initial stage, most of the comments or questions heard referred to the navigation tools, the avatars, and the objects' manipulation. Knowledge transfer among peers was present. Students tended to demonstrate their knowledge, discuss with their fellow students about the advice, suggestions, and information given by the teaching team, or even the knowledge they had acquired based on their personal research. Students did not hesitate to request their peers' help or feedback when needed and those requests were—more often than not—fulfilled. Nevertheless, student communication was not limited to issues related to the virtual world per se. They were exchanging information about available third-party software, useful in the context of the assignment, and even providing help and guidance to others on how to use it. In fact, it can even be said that this was the most intense cross-team peer-tutoring that students performed, as they were usually interacting almost exclusively with their team members.

However, not all student conversations were strictly focused on the virtual world or the assignment. Students were discussing, at random intervals, matters unrelated to the virtual world yet related to other university units, or even completely unrelated to the university environment. Conversations related to third-party software (e.g. Blender, Adobe® Photoshop®) or other components of their assignment also occurred. Other conversations covered matters related to research, design, and development planning, as well as the assignment of roles; elements which are also within the unit's scope (subexperiments B/C).

The verbal interaction between the students and the teaching team was almost as intense as the ones among students. At the first practical session of

each course, most of the comments or questions heard referred to the lab demonstrators regarding the general settings of the world, the navigation tools, the avatars, and the objects' manipulation. As the courses were progressing, most of the questions addressed to the teaching team were related to scripting and actually to advanced level programming. Moreover, students opted to discuss with the demonstrators issues regarding 3-D modeling (development/model importation), triggered by their concerns about the transition of their ideas to in-world development. Thus, brief conversations about third-party software, compatible with the virtual world were held, too. Approaching the end of each course, nearly all the groups wanted to perform an unofficial demonstration in order to get some 'last-minute' feedback. On the other hand, students who were struggling to deal even with the basic tools of the world wanted to find out more about the marking scheme and criteria—the 'passing' grade, in particular—of this assignment. An interesting question raised by several students concerned the 'future' of the sim and its content after the completion of their assignment, revealing that way an intrinsic need to continue having access to the virtual world and their property, by extension. Nevertheless, hardly ever did any of the students refer to a member of the teaching team about an issue completely unrelated to the context of the practical sessions.

Students enjoying the use of the virtual world made positive⁷² comments about their emotional experience mainly when talking to each other. Exclamation comments were heard during the students' first contact with the virtual world. Some of them were excited for having the opportunity to learn more about this technology, while others expressed their enthusiasm about

⁷² 'I will be a gamer for the first time in my life!', 'It's quite fun stuff don't you guys think so?'

having the opportunity to acquire knowledge while engaging in activities that they perceived as games⁷³. Other students made positive comments while interacting with others' avatars. Interestingly, by the end of the assignment, a student concluded that the use of a virtual world can open new horizons in product promotion (clothing, in particular).

On the other hand, negative⁷⁴ comments about the virtual world were not absent either. There were students who, from the very beginning, questioned the reason for using a virtual world in the academic context. Generally, the technical malfunctions and the world's architecture attracted students' negative attention and was a source of negative comments⁷⁵. Students reported that the OpenSim technology was limiting their creativity and made them feel very insecure as to continuing working on this platform. Others expressed their disappointment or actually complained about some technical bugs (e.g. objects' sharing privileges, non-functional scripts). Moreover, in cases when latencies or freezes were present, due to the massive content and number of active scripts that was considerably high, students expressed their concern about potential future server crashes. Aside from that, the lack of an induction process was also a matter that caused students' disappointment. Those students, though recognising the potentials of the virtual world, intensively and repeatedly expressed their insecurity regarding the lack of theoretical knowledge on its technology. The importance of providing students with an orientation process is undeniable, and, in some cases, even essential.

⁷³ 'Everyone deserves to have some fun at the end of the day!'

⁷⁴ 'A childish environment that should have never been part of the university.'

⁷⁵ 'There are other platforms with better graphics and programming capabilities than this one'

5.4.2 Attitude towards the Use of the Virtual World (classroom)

- *Experiment 1*

Students' attention was usually captured by matters related to the virtual world, though, not all of them and not always, were observed working actively on their project as they were, at various times, being away from their computers. However, this behaviour was recorded more intensively during the initial practical sessions, as the closer to the submission deadline they were getting to, the more engaged with the virtual world and focused on their assignment they were becoming.

Actions related to the virtual world included online search for 3-D models or scripts, YouTube videos with tutorials, demonstrations to the teaching team, and preparations for the video shooting of the virtual showcase. Along the way, they were observed working using both the in-world tools and a third-party software (e.g. Adobe® Photoshop®, Blender), so as to materialise the feedback or the acquired ideas.

Besides the minority, which intensively disliked the idea of using this platform, the rest seemed to enjoy their time and maintained an overall positive attitude as there was 'no more Java programming' (several students made this comment). Indeed, the way that students perceived the inclusion of a virtual world in the teaching curriculum varied as some of them opted to combine leisure with learning whereas, others, were more inclined to finish their task the soonest possible and leave. This is, indeed, a very characteristic example of how the cohorts (divided in two sides) perceived the virtual world (i.e. leisure-learning environment versus pure learning environment)

In any case, all the cohorts were clearly displeased with the server freezes and crashes, as these were the main incidents that generated negative feelings.

Another reason which caused frustration, especially at the early stages, was the difficulty that students had to understand how the virtual world's tools and functions operate. In fact, some students felt that not enough support or training had been provided by the teaching team. However, the nature of these assignments required students to dedicate time and effort to research information on this technology, manage their resources in the best possible way, and work under the guidance and support of the teaching team.

One way or another, nearly all of them managed to familiarise themselves with its mechanisms, roughly after being half-way through the completion of their project. In fact, from that point onwards, their progression became more visible and the substance of their artifacts more 'tangible'. As a result, their perception towards the world became more positive and so was their attitude.

- ***Experiment 2***

Students' attitude towards the virtual world and its tools was quite diverse and disparate in many ways. In general, those who decided to work in groups were observed helping and influencing each other whilst, those who worked alone, were notably less engaged and observed struggling for longer periods of time. The difficulty that most students faced to manipulate the virtual objects or to debug the non-functional scripts, caused disappointment and displeasure thus, affecting their engagement—at least with the world—in two rather opposite ways. On the one hand, a portion of students was observed spending more time to improve their knowledge and skills, sought help from others to cope with the requirements of their assignment and, at the end, achieved their goals. On the other hand, a few individuals were observed giving up almost completely and thus, the teaching team had to interfere so as to prevent the consequences of a potential failure.

Another issue that became apparent during the course of these observations regards the levels of engagement that students had with the world's technical tools. More precisely, students' interest was mainly attracted by the 3-D modeling capabilities of the virtual world and significantly less with the programming language which, as a matter of fact, was one of the main learning outcomes (especially in subexperiment A). Indeed, most of them were observed browsing websites with premade scripts—which consequently imported in-world with almost no alterations, enhancements or modifications applied—and only a few opted to develop their own. In addition, a few students were observed designing their 3-D models using third-party software and this is, actually, an example of almost complete lack of engagement with the world, while the focus was exclusively on achieving good results regarding their assignment.

Lastly, even though quite rarely were students observed being absent-minded, at certain points, their conscious decision not to work on their own task but, instead, help their fellow-students with other matters—not related to the virtual world—led most of them to be completely detached from it. Likewise, as part of their intermediate breaks, students were also observed performing actions completely irrelevant to the virtual world or their project per se (e.g. browse the news online, use of their phones, check their social media profiles).

- ***Experiment 3***

Students with prior experience were observed working on the assignment's requirements even from the first practical session. Likewise, those who were more comfortable or keen to explore the in-world tools on their own, were observed paying less or even no attention at all to the lecturer's demonstrations. On the other hand, the newcomers invested time to familiarise themselves, explore the world's leisure content, edit their avatars' appearance, research

information on the web, and even ‘play’ with others. Similarly, the less experienced students, were always observed interrupting their task to follow these instructions as they were being demonstrated. In either case, very rarely and only a few students were observed working strictly focused on their task, as the opportunities for small intermediate breaks were handful.

Actions outside the virtual world, yet related to the project, included occasional visits on websites to get ideas (e.g. examples of virtual content), support (e.g. tutorials related to 3-D modelling or scripting) or to find premade scripts. However, as it was also recorded in the former experiments, those with knowledge or experience in digital content development were more inclined to use third party software to design 3-D models (e.g. Blender/Maya[©]) or textures (e.g. Adobe[®] Photoshop[®]).

Moments, which students were completely detached from the virtual world, were also observed. In most occasions this disconnection was due to other commitments related to their project. However, this was not always the case, as some of them were observed performing actions completely irrelevant to their project or the university environment.

Acquiring new ideas for development, completing bits of work or seeing their scripts being functional were deemed as the main source of happiness and joy. Similar feelings were observed whenever they were making jokes or playing with their fellow students thanks to the theme of this experiment. On the other hand, the latency spikes and the server crashes, as well as students’ difficulty to understand the world’s tools, were the main source of frustration, disappointment, and displeasure. In addition, the inability of the viewer to import specific type of files and the last-minute work, which some students left to be done, caused increased levels of anxiety and stress.

- *Experiment 4*

For most of the time that the sessions lasted, students' attention was either on the lecturer's demonstration (whenever such occurred) or on their daily task/assignment. At the initial stage of each course of practical sessions, students' main task or goal was to learn more about the virtual world and familiarise themselves with its tools. As a result, they dedicated their time to exploring the world's content, researching the web and collecting information about the in-world tools and the programming language. As the classes were progressing, more often than not, students were working on various tasks in order to ensure that all the assignment requirements had been fulfilled. Students were observed shifting between the virtual world, the web browser searching for information related to the LSL and third-party programs. Switching interfaces was the main reason why students' attention and focus got distracted from the virtual world per se, though they kept being focused on their assignment. Indeed, most of them were productive and efficient, in terms of their work progression.

On the other hand, there were cases when students were not necessarily absent-minded, though working on matters unrelated to the unit, dealing with matters related to other assignments, or even performing actions non-related to the university (e.g. texting or watching videos online, checking Facebook). Thus, at times there were low or even no-existent levels of attention on their assignment, and this 'attention-deficiency' can be attributed to:

1. the very intense verbal interaction students had,
2. the students' reasonable need to explore the features and the tools of the virtual world (e.g. editing the avatars' appearance, exploring the sims etc.),
3. the students' need to interact with each other within it.

Regarding students' emotional experience, two basic categories could be identified:

1. those who were enthusiastic, keen to learn more about this technology, and happy to explore its capabilities and
2. those who were frustrated, disappointed and displeased with the world.

Students seemed to truly enjoy their time, be it during the moments of work, or the 'play-time'. The main source of pleasure and enjoyment was the verbal interaction that students had with each other. While exploring the in-world tools, the avatars attracted students' attention, as they offered them high levels of enjoyment and pleasure (especially during the appearance editing process) and triggered amusing conversations among them. Moreover, speaking loudly, making jokes or funny comments—while working on their project—was something that also observed as an indication of enjoyment and pleasure.

Technical issues, the nature of the assignment, or even the use of the virtual world in an academic context, worsened students' experience. Several students were displeased, or more precisely, disappointed about using a virtual environment for educational practices. Nonetheless, this attitude decreased as the sessions progressed. Another source of displeasure was the fast-paced nature of this project (time-wise), considering that they had to learn a programming language from scratch, as well as acquire the knowledge of how geometry works in 3-D environments. Even students who generally enjoyed the use of the virtual world experienced negative emotions, mainly frustration and anxiety, trying to meet the assignment's deadline. More apparent was the disappointment of those who were still struggling to deal with the world and its tools as the submission deadline was approaching. Those students kept questioning—with displeasure or even frustration—the virtual world's inclusion to the teaching curriculum.

Lastly, what was also highlighted by students as displeasing was the harassing behaviour that some of them had in the virtual world, not only during the practical sessions but also outside them.

5.4.3 Student Identity & Avatar Identity (classroom)

- ***Experiment 1***

Indirect and unintended references to avatars were mostly made during the first practical sessions whilst, a gradual decrease in the frequency was observed during the reach of the last ones. However, as students were usually observed using the first person⁷⁶ to communicate with others, it was not always clear, if they identified with their virtual figures or not. On the other hand, the most direct references to avatars—using the second⁷⁷ or third⁷⁸ person—were limited and so were the ones that addressed avatars as ‘objects’.

Despite the fact that not all the students identified with their avatars, the possessive attitude, which some of them maintained towards their virtual creations⁷⁹, provides an indication that they experienced the sense of in-world presence, even partially. Keeping that in mind, it can, therefore, be assumed that students considered themselves part of the virtual world and felt engaged with their task.

- ***Experiment 2***

References to avatars were very infrequent and rare even during the first observations. In most cases, students used the first⁸⁰ person to refer to their classmates—or their avatars—whilst, more direct references were almost non-existent. The brief conversations, which students had, were usually related to

⁷⁶ ‘Look at my hair!’, ‘How do I put my T-shirt back on?’

⁷⁷ ‘What are you doing? Don’t fly!’

⁷⁸ ‘She is ugly!’, ‘Look what he is doing!’

⁷⁹ ‘That’s the house I would like to have in real life’

⁸⁰ ‘Look at this box, I am inside it!’, ‘Oh boy! I am naked!’

the appearance editing process though some comments, revealing their admiration or surprise⁸¹ towards the outfit of their classmates' avatars, were logged occasionally. Negative comments were also heard as the aggressive attitude and behaviour that one student maintained towards the appearance of his avatar and other students was not welcomed. In fact, a couple of students took the initiative to escalate this issue with the teaching team which interfered and resolved the matter.

- ***Experiment 3***

Students would usually opt to edit their avatars' appearance—either using the in-world tools or by importing items—during their first contact with the virtual world, as they considered the default one 'ugly' and 'basic'. On that basis, questions related to this process or requests for demonstrations were frequently addressed to the teaching team. In the same vein, students who, either accidentally removed their avatars' clothing or purposefully stretched their avatars' characteristics to limits, were observed—and even confessed—feeling ashamed of that. In such cases, these students were observed seeking, once again, help from the teaching team to restore their avatars' appearance to the default state. In some cases, students were even observed asking others to control their avatars in order to help them complete the appearance editing process as they were struggling to.

Those who developed stronger bonds with the idea behind avatars expressed their wish for an option to buy and sell outfits, either developed by other students or the teaching team, using virtual currency. Another noteworthy case originates from a cohort of students who sought ways and options to have a health pool for their avatars, so as to turn the virtual world into a 'war zone'.

⁸¹ 'Check it out guys! It walks like a robot'

References to avatars were mostly made in the first or second person and mainly from those who had made, at least, some basic modifications. Moreover, the fictional characteristics that avatars bring together, inspired the more enthusiasts to use some well-known quotes (coming from relevant movies or books) whilst, imitating their avatars' in-world actions in the physical classroom. However, those who were less interested in this feature worriedly probed their fellow students' willingness to role-play or make detailed changes to their avatars' appearance, as they considered it a waste of time or unnecessary.

- ***Experiment 4***

References related to avatars were infrequent. The person (1st, 2nd, 3rd, singular or plural⁸²) that the students were using when referring to their avatars depended mainly on the situation, as well as on the level of embodiment they had developed with their avatars and the virtual world. More often than not, students opted to use the first person⁸³ when referring to their own avatars, less frequently the third, and rarely the second. Interestingly, only one reference to the avatar as an object⁸⁴ ('it') was observed. Moreover, very few students engaged in role-play⁸⁵ actions for a limited period of time in, an attempt to entertain themselves.

5.4.4 Talking, Making Comments & Use of the Chat Tool (world)

- ***Experiment 1***

Given that students were physically collocated, the lack of intense or frequent internal communication becomes justifiable. However, sporadically students

⁸² 'We want to animate our avatars to sleep on the bed, is it possible?'

⁸³ 'Lol I'm flying!', 'OMG I am stuck in the wall! How I can go out?'

⁸⁴ 'Something is wrong with it [avatar]', 'oh look how cool that Pooh bear is!'

⁸⁵ 'Don't you think I'm hot?', 'He became a dog and looks so real!'

were, actually, observed raising some requests for help or expressing their disappointment with some of the virtual world features. Likewise, when it was absolutely deemed necessary (e.g. lack of physical co-presence), students were also observed holding brief virtual meetings or short conversations. In any case, discussing matters completely irrelevant to their project was something that logged very rarely. The only exception to that was the conversations that some of them had related to their avatars and, more precisely, the changes they had made on their appearance. Nevertheless, avatars consist part of the virtual world's features and thus, opting to use the chat tool to discuss about them, can be perceived as a sign of engagement with the virtual world. Finally, extensive use of the chat tool was only observed when students performed programming tasks (such as sensor/listener scripts' testing).

Considering how often this communication medium was used, the frequency of social network slang language was high. This provides an indication that students did have previous experience with similar online chatting tools and thus, their reluctance not to use the in-world chat—in a high frequency—cannot be attributed to unfamiliarity but rather to personal preference for in-class communication.

- ***Experiment 2***

Students' maintained the chat window closed or minimised most of the times. Those who opted to use the in-world communication tool, mainly during the first observations, were observed greeting⁸⁶ their fellow-students or making comments about the avatars' appearance⁸⁷, as this process was more intense during their first contact with the world. Other than that, extensive use of this

⁸⁶ 'What's crackin?', 'Howdy guys?'

⁸⁷ 'Oh this is ugly!', 'Shame on you! Go get dressed'

tool was observed, once again, only when it was absolutely necessary (e.g. distance communication) or for programming purposes (such as script testing). The use of social media slang was also observed though the frequency was low.

Likewise the former experiment, students' unwillingness to communicate with others in-world is attributed mainly to the fact that they were physically co-located. Thus, even though—under specific circumstances—the chat-tool becomes handy, the benefits that the F2F communication offers cannot be overruled. In the same vein, students reported that they would rather use Skype[®] or any other VoIP tool—when physical co-presence could not be facilitated—due to the fact that verbal communication lifts many restrictions and bestows many privileges. In fact, the lack of an integrated VoIP tool was pointed out as a suggestion for implementation by most of them.

- ***Experiment 3***

Students were observed using the in-world chat tool quite infrequently, as their needs were usually covered through F2F communication or other online tools (e.g. Facebook[®], Skype[®], and WhatsApp[®]). Those individuals or groups who used the in-world communication channels opted to hold their conversations in English. However, a cohort of non-native English speakers was observed almost always using their mother tongue and thus, understanding the topic of their conversations was rather difficult. Likewise, even when the communication was in English, the topic might not always be related to university matters (e.g. personal issues). In such cases, the observer would discreetly maintain some distance from reading through the chat to ensure students' privacy.

Massive use of the chat-tool was mainly witnessed during students' first contact with the virtual world, as random letters or spontaneous words could be seen in the chat window due to their unfamiliarity with the environment. Those

who were more experienced with such platforms (e.g. virtual games) were observed greeting each other or even using command lines that simply did not and do not exist in the OpenSim technology. A noteworthy case of intense use of the chat tool was observed from a team, consisting of five members, only once. Even though all of them were physically co-located, literally right next to each other, they decided to use the chat tool to discuss matters related to their project, in order to avoid being loud in the physical classroom.

Concerning the exchange of private messages, only a very small portion of the same students was observed using this communication approach in regular basis. Nonetheless, even then, their conversations were brief⁸⁸ whilst, in most cases students were physically observed moving to each other so as to ease the communication process and speed up the time required to solve the inquiry. The most striking example of private chat communication was observed when a group of two—not physically co-located—students, spent an entire practical session to explore the content that had been developed by others whilst, making comments and notes related to their work.

The use of expressions or words usually found in social media was recorded quite often, considering the frequency of the exchanged messages. On the other hand, only a few were observed expressing their feelings while exploring the content of the world (happiness⁸⁹, admiration⁹⁰), making requests for objects' removal (frustration⁹¹), or during the server latencies (disappointment⁹²).

Finally, nearly all of the students used, at some point, the chat tool for programming purposes, though this action was usually involving the testing of

⁸⁸ 'How did you upload this image?', 'Can you help me troubleshoot this script?'

⁸⁹ 'oh this actually works! Cool though!'

⁹⁰ 'Have you seen the workspace of Team 9? They are networking students too!', 'Very nice work, we can pay them to do something for us too lol!'

⁹¹ 'Remove or fix your script, it spams the server and we lag, for God's sake!'

⁹² 'The server crashed... What a pity, I hope that I won't lose my stuff...'

their own scripts and less frequently the ones developed by other students or the instructional designer.

- ***Experiment 4***

When it comes to verbal interaction, F2F communication is the one mostly preferred. Nevertheless, in cases where this is not feasible (students not physically co-located), or low noise levels have to be maintained in the physical classroom, students tend to use the in-world chat tool to cover their needs. Using both the global chat and IMs, students were communicating not only with members from other teams but also with their own teammates. Indeed, at various times students were observed greeting each other, expressing their opinion, exchanging pieces of code or URLs related to scripting forums, asking questions and discussing other matters university-related (e.g. the assignment, virtual world, and tools). Very rarely did students discuss matters non-related to the class or the university context. After reviewing the chat logs, it can be reported that the frequency of the internet slang words was fairly high. Equally high was the use of the words revealing exclamation. The only negative comments made were related to the OpenSim technology—the functions that were not implemented, in particular—and the short freezes or latencies of the server.

5.4.5 Nonverbal Communication (world)

- ***Experiment 1***

Only a few students were observed using avatar gestures, though without having clear intention of achieving a specific outcome, as they did so while exploring the functionalities of the world. Likewise, only one student was observed having animated objects worn on his avatar as part of the demonstration needs of his assignment. Interestingly, a portion of students was

observed removing the animated typing move that avatars perform by default whilst, only a few were observed using emoticons.

- ***Experiment 2***

Despite the fact that part of the orientation area was dedicated to the non-verbal communication channels, the creation or use of avatar gestures and animations was very remote. In fact, even when students were observed using these features, the combination sequence was random and undetermined. To this end, none of them was observed wearing animated objects. Likewise, the presence of emoticons in the chat-tool was seen quite rarely.

As not all the students went through the orientation process, it can be assumed that they were unaware of these functions. This is further grounded after considering that this interaction type was usually performed unintentionally or, more precisely, while students exploring the menu options of the viewer used to access the virtual world. Moreover, taking into account students' physical co-presence, the conscious decision to not use non-verbal communication approaches becomes further justifiable.

- ***Experiment 3***

Students who discovered the gestures library, while exploring the in-world tools, were observed using most—if not all—of them for leisure/entertainment purposes. Interestingly, even those who were unaware of this feature got motivated by others and attempted to explore them at least once. Those who included the use of gestures in their project's demonstration work were observed enhancing the default ones or even developing their own custom-made combinations from the scratch. The use of poseballs or other animated wearables was also observed being adopted though less frequently and mostly by those students who performed intense role-play. Notwithstanding the above, the

time spent on these processes—with only one exception—was overall limited. In the same way, the use of emoticons was hardly ever observed.

- ***Experiment 4***

In-world nonverbal communication was scarce. Students with increased curiosity explored almost all the built-in secondary tools, including gestures. Students tested almost all animated moves of avatars from the gestures library to observe their function, without them covering any other particular need. Avatar gestures/animations were also used in order to ‘tease’ the lecturer’s avatar or other students, especially when they were away from their keyboards. In very few situations, students did the opt to develop their own gestures, aiming to amuse themselves and their classmates. The use of emoticons, on the other hand, was as intense as the use of the chat tool. Almost every time that the chat tool was used, the text was accompanied by emoticons fit for the purpose.

5.4.6 Interactions with the Virtual World (world)

- ***Experiment 1***

As most of the students had no prior experience in the use of such virtual worlds, the time spent during the early sessions was related to exploration and discovery. However, as the submission deadline was approaching, the time spent in-world was mainly dedicated to the development of their project with only a few in-between breaks performing actions not related to that (such as content exploration, editing the avatars’ appearance, interplay with others). The use of the secondary tools (e.g. notecards, avatar gestures, poseballs) was rather limited and opted in very rare cases. Lastly, most students were observed using their own or their team members’ virtual artefacts, but very rarely were they observed using artefacts developed by others.

Even though no restrictions applied from the teaching team in regard to experimentation with the programming language, students were rather reluctant to make use of complex scripts, due to the fear that such action would potentially cause technical issues to the physical server (e.g. freezes or crashes). On the other hand, a portion of specific individuals was observed almost constantly experimenting (on purpose) with potentially malicious code as they considered it to be ‘fun’. Nevertheless, such action was stretching the physical server to its limits and that led to extensive latencies or even crashes of the simulator. As a result, the frequent and extended downtime breaks, which were required for the sim restoration process, affected negatively learners’ experience and therefore, engagement.

- ***Experiment 2***

Students were usually observed using premade scripts, originating from online repositories, while only a few opted to create their own from scratch. Contrary to that, the time spent to design their own 3-D models was considerably more and that was also reflected on the quality of the produced artifacts. However, as not all the students opted to use the in-world development tools, it is questionable whether or not they truly believed that the use of a virtual world had an educational impact on their academic studies.

The opportunities for content exploration—especially during the initial practical sessions—were limited, as the only content available in-world was the one provided by the instructional designer. Nevertheless, over the time, students were observed visiting the workspaces of their classmates to get inspirational ideas for their own projects. However, this idea was not welcomed by everyone, as there were cases of individuals or groups who blocked the access points of their workspaces, so as to prevent others from ‘copying’ their work. This,

however, reduced the opportunities for interaction—both with the content of the world and with other students—despite the fact that the workspaces have been intentionally redesigned to enhance and increase the opportunities for interplay. This is, yet, another indication that learners' choices can oppose the decisions of the instructional designer and thus, eliminate the influence of the instructional interventions.

The impact of the orientation area was quite diverse and wide-ranging. To be more precise, the more mature students or those who were less comfortable with the idea of being in a virtual world were observed going through this process—usually in small groups—and spent a generous amount of time following the provided instructions. In the meantime, they were also observed discussing their understanding with their classmates and even opted to demonstrate their knowledge to the slow pace learners (peer-learning/peer-tutoring). On the other hand, those who perceived the virtual world as a 'playground', showed complete lack of interest to go through this process and even disregarded, almost completely, the existence of this area.

Nevertheless, those who decided to go through this process found it easier to work and collaborate with others whilst, those who ignored it partially or completely, were observed struggling. On top of that, the former were observed quite often addressing questions to the teaching team which could have, otherwise, been answered after having properly oriented themselves. Notwithstanding the foregoing, those who (initially) were less inclined to go through this process were observed (at a later point) visiting the orientation area, after being advised to do so by their fellow students.

- ***Experiment 3***

The most interesting observation during this experiment was the quick adaptability that most students had with the world and its tools. In fact, even those who initially joined with negative preconceptions or observed struggling with the world and its tools, shown an intense willingness to cope with the obstacles and overcome the difficulties. Part of this outcome, beyond individuals' personality, is also attributed to the willingness that the more advanced learners had to help and guide their classmates thus, making the whole process more enjoyable and less stressful.

During the early practical sessions students spent most of their time performing actions completely irrelevant to their projects, yet relevant to the virtual world (e.g. exploration of the leisure content, familiarisation with the tools, modification of avatars' appearance). However, a few notable exceptions exist. For instance, some of them were observed brainstorming ideas for development and implementation. Others preferred to isolate themselves, so as to work on their projects, instead of participating in any kind of socialisation activities. In any case, by the end of the second practical session and up until the completion of their projects, students' focus was mainly on the weekly task or on the objectives of their assignment.

Students opted to use the in-world tools to cover the development needs of their projects and paid equal attention to both 3-D modeling (minimalistic artefacts) and scripting (sophisticated code). However, some individuals or teams were observed spending more time on designing 3-D model and less on scripting, and vice versa. Finally, a few were observed exploring the secondary tools of the virtual world (e.g. landmarks, customisation of the weather settings) or the implementation of all concepts.

Sharing pieces of code or 3-D objects, in the wider context of the unofficial collaboration that students had, was an action that was observed frequently. Nevertheless, this resulted in having workspaces overloaded with duplicate items and affected negatively the stability of the physical server (latencies, freezes, crashes). On the other hand, others opted to ‘secure’ their workspaces, so as to ensure that their ideas will not be ‘stolen’. This, however, had negative impact on the exploration process that nearly all the students opted to perform while having short breaks.

Students were also observed visiting the leisure content quite often, even though not all of them opted to use it; at least, not as often as they were observed navigating around it. On the other hand, the educational games were treated less favourably. Interestingly, besides the emphasis that was given in regard to the planned weekly updates of this content (questions and rewards), so as to allow students revise their knowledge and gain some additional artefacts for their projects, very few students shown an interest towards the maze whilst, none of them (or the teams) was observed competing others in the racing game.

In any case, a large portion of students got inspired by the present instructional content and developed mini games or even replicated scenarios from the ‘real world’ with game-like elements.

- ***Experiment 4***

Content creation and exploration, use of the built-in tools, importation of 3-D models and textures from a third-party software, as well as testing the screen capturing procedures were the actions that monopolised students’ attention. More often than not, the majority of students were at their workspaces, working (relatively) focused on their task, with small intermediate breaks to explore the content of the world and interact with their fellow students. Students opted to

use mainly their own creations checking their functionality, but they were also glancing at their classmates' ones while wandering in-world. Interestingly, some of the teams opted to enable the group function—which allows members to edit primitives and scripts developed by others—without, however, such an action being observed. The aforementioned actions or students' attitude towards the world cannot be judged in a negative way. In fact, it can even be considered as a good sign, considering that students simply worked on their task.

An action non-related to the world, yet related to the project, that was frequently observed, was the 3-D objects development which some students performed using third-party software. In particular, students developed textures or models, which they consequently imported in-world to alter the avatars' appearance or as part of their project. They were also looking for pre-made scripts online, importing and testing their functionality in-world, without, however, making any changes. This is quite generic, though, as students would usually opt to use the web to collect information and expand their knowledge.

Students wandered around the world, from time to time, chasing their fellow students and performing 'childish'—one can say—actions. At this point a question is raised: Did the often disruptions of students' task (assignment), in order to have quick breaks and perform non-related actions, negatively affect their work progression? The answer to this question is indubitably no. Even though students were having frequent breaks to perform actions non-related to their work, this did not prevent them from (at least) 'ticking off' the assignment's checklist boxes. Nevertheless, what did, in fact, negatively affect students' engagement was the disruptive or inappropriate behaviour that some students had towards others, in an attempt to 'play with' or 'chase' them. Indeed, when someone is over-focused on the task or struggling to deal with it,

getting constantly disrupted by others can only have negative results, and this is where the teaching team should intervene.

Students' attitude towards the PAs was mixed. One of the three cohorts of students (E4C) was enthusiastic with them, especially at their first practical sessions. In particular, almost all of them had intense interactions with the vendor-NPC, reading through the information notecards, discussing the proposed suggestions for development, or even sharing the freebies that were randomly offered to them. Less intense, in terms of student numbers, but equally frequent was the interaction that students had with the tutor-NPC. Interestingly, one of them was even observed keeping digital copies of the in-world chat log of the NPC's answers to his questions. Lastly, less intense and very infrequent was students' interaction with the distractor-NPC, as they were not getting any meaningful answers to their queries.

Contrary to that, the other two cohorts of students had minimal interactions with the PAs. Only some of the students had very few interactions with all the NPCs, though only the tutor-NPC and the vendor-NPC were the ones who monopolised their interest and were acknowledged for their impact on the learning process. In any case, the lack of interaction between the students and the PAs is hard to be judged. Even though students were encouraged to read through the informational message about the world and the existing content—as uploaded in the university's e-Learning platform—it is beyond the teaching team's power to 'force' students to read through this message, let alone know whether or not they have done so. Even after assuming that students were actually aware of the existence and functionality of the NPCs, it is once again hard to know whether or not the agents and their help were attractive to or even desired by the students, compared to the on-spot responses and help that

students could get from the teaching team. However, and quite interestingly, various objects originating from the vendor-NPC could be seen in most workspaces, a clear indication that students had interaction with the aforementioned agent outside the observation hours.

Figure 5.1 illustrates a selective sample, originating from the server chat-logs, of the verbal interaction that students (names have been anonymised) had with the tutor-NPC.

```
[2017/11/12 16:43] Student A: who's Jella Delta?
[2017/11/12 16:43] Jella Delta: I am your personal assistant
[2017/11/12 16:43] Student A: lol
[2017/11/12 16:43] Student B: looks like a bot
[2017/11/12 16:44] Jella Delta: yeah, very funny
[2017/11/12 16:44] Jella Delta: I'm very much alive
[2017/11/12 16:44] Student A: what can she do?
[2017/11/12 16:44] Jella Delta: I can offer you educational advices about OpenSim
[2017/11/12 16:44] Student A: now that's funny!
[2017/11/12 16:44] Jella Delta: I'm glad you're enjoying yourself
[2017/11/12 16:45] Student B: are you talking to the bot for real?
[2017/11/12 16:45] Jella Delta: I'll tell you a secret: I'm not a bot
[2017/11/12 16:45] Student A: lol
[2017/11/12 16:45] Jella Delta: Yeah, very funny
[2017/11/12 16:45] Student B: that's hilarious we are talking with a bot!
[2017/11/12 16:45] Jella Delta: No kidding

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[2018/01/07 20:18] Student C: someone give me clothes I am naked!
[2018/01/07 20:18] Jella Delta: You can create your own clothing and accessories or import them from the web

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[2017/01/09 22:45] Student D: how you upload images here?
[2018/01/09 22:45] Jella Delta: You can upload textures by navigating to the Build menu and then click on Upload
[2018/01/09 22:45] Student D: i am trying to rotate it upside down but can't
[2018/01/09 22:46] Jella Delta: To rotate an object select it first and then hold the CTRL button down

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[2018/01/11 14:24] Student E: I need a haircut :D
[2018/01/11 14:24] Jella Delta: To edit your avatar right click on your body and choose the edit appearance option

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[2018/01/22 12:50] Student F: make sure that you keep copies in your inventories guys!
[2018/01/22 12:50] Jella Delta: Right-click on the object that you want to copy or take in your inventory
[2018/01/22 12:50] Student F: can I link them first?
[2018/01/22 12:51] Jella Delta: To link multiple prims hold down shift, select them, and use the CTRL + L combo

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[2017/02/18 17:18] Student G: make a group and invite us [student name]
[2017/02/18 17:18] Jella Delta: While in a group you can share your primitives and scripts with other members
[2017/02/18 17:18] Student G: thanks for the info Jella
[2017/02/18 17:18] Jella Delta: You're welcome

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[2018/02/25 15:04] Student H: give me a script please
[2018/02/25 15:04] Jella Delta: Have you visited my friend Gizmo?

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[2018/06/27 23:43] Student I: can you die here?
[2018/06/27 23:43] Jella Delta: Why you want to know?
[2018/06/27 23:43] Student I: i want to make a gun
[2018/06/27 23:43] Jella Delta: Can you think of a specific example?
[2018/06/27 23:44] Student I: a shotgun!
[2018/06/27 23:44] Jella Delta: I'm afraid I don't know anything about that.
```

Figure 5.1 Example conversations between the students and the tutor-NPC.

5.4.7 Student Identity & Avatar Identity (world)

- *Experiment 1*

Students seemed to be quite interested in editing their avatars' appearance as it was one of the very first actions that most of them engaged in during their first contact with the virtual world. However, not all of them dedicated equally much time or effort in this process, as seen from the intensity of the modifications or the frequency that this action was performed. On the one hand, students, in

most cases, would opt to edit their avatars' appearance up until the second practical session, though, a few of them were observed doing so up until the completion of their assignment. On the other hand, those who were less interested in the virtual world or did not consider this feature so important were observed maintaining their avatars' appearance completely unmodified for as long as they stayed in the virtual world.

Students' decisions towards the modifications made to their avatars also varied. On the one hand, those who considered the virtual world to be an extension of the physical classroom were observed 'mirroring' the characteristics of their real identity. On the other hand, those who perceived the virtual world as a 'game' environment opted to make more 'extreme' modifications which included role-play (e.g. opposite gender) or imaginative-play (e.g. fictional characters). Nevertheless, it should be mentioned that one student's avatar appearance and behaviour were rather inappropriate, but that was just an exception.

- ***Experiment 2***

Editing avatars' appearance was one of the very first actions that nearly all the students performed right after entering the virtual world for first time. However, those who considered this feature to be of minor or no importance maintained avatars' default look and shape up until the completion of their assignment. Even though this process was more intense during the first practical sessions, students who felt more attached with their avatars—and possibly the virtual world—were observed making additional changes during the whole course of the observations.

With only a few exceptions, students perceived avatars as the medium to mirror their real identity and opted to modify them accordingly. On the other

hand, those who decided to role-play were usually observed choosing the opposite gender or, less frequently, non-human figures (e.g. robots, aliens). A noteworthy observation regards the ‘provoking’ comments that a portion of students made towards those who had edited their avatars’ appearance extensively. In most cases, the responses of the former highlighted the increased levels of enjoyment that they were getting by exploiting the ‘fun-side’ of the virtual world or their intrinsic need to ‘look’ different. Such answers confirm the impact that avatars had on embodiment (i.e. engagement with the virtual world) but their influence on students’ engagement with the educational material remains questionable.

Those who went through the orientation process were observed editing their avatars’ appearance while being next to the dedicated for this process section. The rest opted to combine this process along with other activities (e.g. while exploring the virtual world). To this end, only a few students were observed adopting the look of the premade outfit sets that were freely offered to them from the instructional designer, as part of the orientation process. Finally, avatars, considering the infrequent use of the chat-tool, consisted one of the reasons for which students would opt to use it, mainly to comment unilaterally on others’ appearance.

- ***Experiment 3***

Students opted, once again, to replicate their real identity as their avatars were usually mirroring their physical characteristics (e.g. body shape, skin colour, hair style). Those with prior experience were observed taking over this process almost immediately (i.e. during their first contact with the virtual world) whereas, others preferred to do so after the lecturer’s demonstration. The more experienced or comfortable with the virtual world students undertook the role of

‘tutor’, influencing, guiding and helping others though, not all of them got attracted by this feature, as seen from the avatars that remained completely unmodified up until the end of the course of the study. Those who engaged into this process were usually located either at their workspaces or close to the recreational areas. Nevertheless, exceptionally, students were also observed moving to higher (sky) or lower (underwater) levels so as to edit their avatars’ appearance isolated from others.

Students were also observed performing some—not particularly intense—level of role-playing, e.g. altering their avatars’ gender or editing their avatars’ appearance to resemble their physical identity, yet with obvious changes (e.g. muscles, hair style and tattoos). Exception to the above were the student cohorts coming from the Games and Animation course, as they were observed making more intense and detailed modifications due to their generic interest in such technologies. As a matter of fact, in the role-playing spectrum, such students were observed having extra-short avatars (gnomes, dwarfs), super heroes (warriors, superman, batman), or fiction characters (robots, cartoons, creatures). A case worth mentioning, as it attracted several comments, was that of a female student whose appearance resembled one of the Kardashians (trending topic in the news). Finally, among all the cohorts, only one student was observed modifying his avatar’s appearance for the needs of the assignment, as the avatar was part of the project-demonstration. As a final note, the in-world references related to avatars were almost non-existent.

- ***Experiment 4***

Almost all students had avatars with an even slightly modified appearance. Nevertheless, the short periods of time that most of them spent during the practical sessions to edit their avatars’ appearance or, in other words, the

limited interest to perform such action during the practical sessions can be justified after considering that their main concern was to familiarise themselves with the world and its tools, and proceed with the development of their showcase infrastructure.

Nonetheless, some students had made very detailed modifications on their avatars' appearance, in terms of both quality and quantity (body and hair shape/colour, clothing and accessories), creating unique outfits for them or turning them into 'punks', 'rockers', 'robots' and even 'superheroes'. Interestingly, some of them had even used third-party software to import pre-made or self-made objects (e.g. clothing, costumes and weapons). This is, indeed, a good indication that students spent a considerable amount of their personal time, outside the practical session, to not only be in the virtual world but also work on their avatars' appearance. Furthermore, it provides an insight of the way they opt to invest their time while being inside and outside the university classroom. Other students, however, had completely unmodified avatars, as this was a feature out of their personal interest.

A few students, those who invested considerable time modifying their avatars, engaged in role-play activities during their practical sessions. More often than not, they referred to their avatars in the first person, revealing that they were experiencing embodiment. Apart from those occasions, the references to the avatars were infrequent.

5.4.8 Students' Willingness to Remain Longer than Expected

- ***Experiment 1***

Students were usually observed leaving the virtual world at the end of the practical session or, in some cases, just before its completion. Those who shown intense interest towards this educational approach were observed, from the

early stages, staying in-world more than the expected or even coming online prior to the starting time of the session. However, some individuals were observed constantly going online slightly delayed. At this point, it should be noted that most—if not all—of them were also usually online outside the laboratory hours as the virtual world was accessible outside the university network, too. Even though their actions were not observed during these hours, the results of their work could be clearly seen. On top of that, the server data logs provide strong evidence that students did spend a considerable amount of time in-world and, therefore, concur to the previous statement.

- ***Experiment 2***

In most cases students would follow the schedule that had been set for the practical session (i.e. entering and leaving the virtual world just on time). Only a few times were students observed remaining in-world for longer than the expected or going online beforehand, during the whole course of the observations. However, even when their avatars were online, students' attention was not always captured by matters related to the virtual world or task.

- ***Experiment 3***

Only a few times were students observed entering the virtual world prior to the starting point of the session or, likewise, remaining online for longer than the expected to complete their work in progress. When the assigned task was part of group work, students, who were responsible for the development of the virtual showcase, were entering the virtual world on time whereas their team members were joining them at random intervals to provide help, support and advice. In the same vein, the showcase developers were observed leaving the virtual world—even for short periods of time—to help their team members with other matters related to their project or to have short breaks away from work.

- ***Experiment 4***

More often than not, students were fairly punctual to the schedule, entering the virtual world at the starting point of the session and remaining in-world until the end. However, at various times they were away from their avatars, or even coming on and off the virtual world, according to the needs of their team. In other occasions, when not all students' online presence was mandatory, students went online to provide some hands-on support and additional feedback to their team members. That said, late log-ins and early log-outs were not rare occasions. Nevertheless, examining server logs and students' progress between the sessions, it can be safely stated that they invested part of their time outside the university classroom.

Interestingly, the completion of the course of the practical sessions was followed by mixed student feelings. Students, who overall struggled to deal with the virtual world or did not like this experience, were happy about coming to an end. However, others felt sorry for reaching this point, as the access to the virtual world was intended to be restricted after the submission of assignments.

5.5 Chapter Highlights

Overall, the participating groups expressed a positive agreement and shown a positive attitude in relation to the impact that the rich network of interactions—both with the content and with others—had on their motivation to engage with the world and the learning activities. Nevertheless, that should not lead to the invalid conclusion that this approach was perfectly appropriate or suitable for all of them.

Indeed, capturing students' attention and engaging them in the educational activities is the ultimate goal and—at the same time—the biggest challenge that educators face and have to overcome. Thus, expecting any particular medium to

fit the learning style and preferences of all learners is rather impossible or, at least, not feasible with the formatting that such virtual worlds have.

The most influential factors that affected learner engagement are:

- the alternative educational approach, which brought the technical and the social aspects together,
- learners' curiosity about how programming can be done differently in such environments, and
- learners' fascination to explore and work—either alone or along with others—on a new/alternative technological platform.

As regards the open-ended question, the additional elements that students reported as influential factors towards their engagement vary and so does their weight and importance. Covering all of them may not be an easy task to do, yet changes can be made to meet the learners' needs and increase their engagement with the virtual world and the educational activities, by extension.

Regarding the impact of the instructional design interventions:

- The relatively weak or discontinued influence that the exemplification content had on the intensity of interactions is justified after taking into account the nature and the aim of this content. Indeed, even just a glance at these resources was enough for learners to collect all the valuable information and obtain ideas about their own projects in a short period of time, without any need to refer to this content again in the future unless they wanted to. Nevertheless, this specific interaction instance illustrated the shared understanding of concepts that former students had, and provided current learners with concrete meanings and examples of important design and programming features. Accordingly, having as a baseline the approaches that others had used or the assumptions that they

had made, increased their motivation to take the context of their research a step forward, and encouraged the opportunities for communication, while attempting to understand specific phenomena or methods.

- On the other side, the procedural nature of the orientation area offered more opportunities for interaction with long-lasting and substantial effects. Indeed, the characteristics of this process enabled learners to ‘navigate’ through information spaces, connect the theoretical material delivered in the lectures with hands-on activities, and explore the world’s functions in a more vivid and flexible way. In addition, by emphasising the social elements of the virtual world, opportunities for productive interactions—between individuals or among small groups—were also encouraged. From this perspective, students could share or align their existing knowledge and ideas with each other and, thus create a new meaning and understanding of the available resources. To this end, the delivered information was materialised and transformed into knowledge objects and skillsets which could subsequently be applied in routine actions.
- The educational and leisure games narrative had the most influential role on learners’ interactions and added value as a learning tool. Thanks to the multimodal and dynamic features of this content, its impact was not merely restrained to the final outcome (i.e. leisure or entertainment), but, instead, provided substantial insights about the affordances and the limitations of the virtual world. In addition, the structural elements of these games covered different needs and desires, while, at the same time, offering learners diverse opportunities for productive engagement. For instance, the educational games aimed at knowledge-oriented activities and actions, whilst the leisure ones aimed at activities and actions related to exploration

and familiarisation with the virtual world and its tools. Thus, by highlighting the predominant type of interactions in a more entertaining and enjoyable way, student learning was enhanced, participation in group activities was encouraged, group discussions were facilitated and new knowledge emerged.

- The educational and technical support provided by the agents played an equally fundamental role on the type and frequency of interactions, though in a less diligent manner than that of the orientation process. In general, the different design elements of the NPCs—such as their roles or intellectual properties—offered a more personalised experience with diverse effects on learners’ motivation and achievements. Indeed, by creatively combining the available resources (i.e. knowledge-pool of the chat-bots) and the instructional artefacts (i.e. freebies or advices), learners were enabled to materialise their ideas, develop their concepts and even share the acquired knowledge with others. Nevertheless, the motivational influence of the conversational NPCs—on the social interaction processes—seems to be moderate, besides their dynamic character and intersubjective nature. On the other hand, the presence of an NPC with goal-oriented characteristics influenced more positively the levels of awareness and contributed towards the knowledge construction and advancement.

Chapter 6: Data Triangulation

6.1 Introduction

In Chapter 5, the collected data were presented and examined in detail. However, prior to reaching the final conclusions, the data have to be cross-examined and combined (see Table 4.3), in accordance to the methodological triangulation technique, as discussed in Section 4.3.6.

Therefore, in the following sections (Sections 6.2-6.8), the different actions and interactions that occur in the context of a HVL scenario are mapped and grouped in accordance to a number of points. The interpretation that follows is grounded on the notion of the transition from the real to the virtual and vice versa, the flow of interactions between the two environments, as well as its effect on student engagement.

More precisely, at the initial stage, a thorough understanding related to the psycho-emotional experience that learners had, is drawn (Section 6.2). Accordingly, the rationale behind the most and the least frequently discussed—in the physical classroom—topics, is identified (Section 6.3). The impact that avatars had on learners' embodiment and presence is then elaborated, whilst the discussion further immerses into the attitude that learners developed towards their virtual personas, while being in the virtual world. Phased into the virtual world, the various types of interactions that took place within the virtual environment—both with the content of the world and with other users—are mapped and classified in accordance to their impact on engagement. Consequently and conclusively, the complex network of interactions which was developed between the virtual and the real space, is used as the bridging medium

to elicit and highlight the level of engagement that learners reached while working on a task that included the use of a virtual world.

6.2 Virtual World but 'Real' Emotions

Learners experienced various feelings ranging from happiness and enjoyment to confusion, displeasure, and disappointment. Each one of these emotions affected their interactions and, therefore, engagement very diversely. Furthermore, the levels of engagement they had with the virtual world differed completely from the levels of engagement with the task (Sections 5.3.1, 5.3.4, 5.4.3, 5.4.7).

Learners' personal preferences and preconceptions, prior experiences, and adaptability to new technologies, directly influenced the way they perceived and adapted to the world (Section 5.2). Thus, some of them were more comfortable with using it, whilst others found difficulty even to navigate within it. In any case, only a few students intensely disliked this technology (Section 5.4.3).

The main incidents that generated negative feelings or dissatisfaction were the server latencies/crashes, and the difficulty learners had to manipulate virtual objects or non-functional scripts (Sections 5.4.2, 5.4.3). The former affected engagement in two opposite ways, as some of them opted to spend more time expanding their knowledge and improving their work, whilst others gave up (Sections 5.3.6, 5.4.7). On the other hand, the intermediate breaks to edit their avatars' appearance, explore the world, and 'play' with others, positively influenced their emotions and experience (Sections 5.3.21, 5.4.2, 5.4.3, 5.4.7, 5.4.8). Students' decision to work in groups or individually also impacted their engagement. More precisely, those who decided to work alone or completely isolated from others were less engaged with the virtual world. In addition, they were often observed struggling to deal with its tools. On the other hand, those who worked in groups were observed helping and influencing each other, and,

consequently, the teaching team would interfere only when deemed absolutely necessary (Sections 5.3.17-5.3.210, 5.4.2).

The design and development process of 3-D objects, using the in-world tools, attracted students' attention and resulted in higher levels of engagement (Sections 5.3.11-5.3.14, 5.4.7). On the other hand, the use of third-party software resulted in having an almost complete lack of engagement with the virtual environment, as students were focused exclusively on achieving good results (Section 5.4.7). Furthermore, higher levels of engagement were observed after reaching half way through the completion of their assignment. This can be justified in two ways:

1. either because they were more familiar and comfortable with the world and its tools, or
2. because of the need to complete and submit their assignment (Section 5.4.7).

In any case, learners were also observed being completely detached from the virtual world from time to time, as they were performing tasks related to other needs of their assignment, browsing the web, or discussing matters unrelated to the university (Sections 5.4.2, 5.4.3, 5.4.7).

6.3 The 'Trending' Topics

Content development and scripting were often the highlights of students' talks. However, the 'hard-to-use' (quoting students' comments) in-world 3-D modeling and scripting tools triggered discussions about the use of third party software, too. The negative comments heard were mainly referring to the technology per se (graphics, scripting language, latency/server crashes). On the other hand, students were observed being content with their achievements, or surprised when getting unexpected results (Sections 5.4.2, 5.4.3).

Students' emotional experience and comments were positive and enthusiastic, especially during exploration (Section 5.3.10, 5.4.1, 5.4.2., 5.4.6). Nevertheless, some students' willingness to 'secure' (i.e. prevent others from entering) their workspaces, caused disappointment to others. Furthermore, those who struggled with the in-world tools claimed that this technology is used exclusively in such environments, and, thus, no 'true' knowledge is gained (Sections 5.3.3, 5.3.4, 5.3.6-5.3.9, 5.3.11-5.3.13, 5.4.1, 5.4.2). On top of that, they reported that their experience was disadvantageous and doubtful, since it had nothing to offer them as a learning tool. However, students were willing to share with each other their knowledge and thoughts (peer-tutoring) when requests for feedback and suggestions were made (peer-learning). That eliminated the negative preconceptions and thoughts, as seen from the positive concluding remarks (Sections 5.2, 5.3.5, 5.3.6, 5.3.17-5.3.20).

Students' verbal interaction with the teaching team covered topics related to the marking scheme, informal feedback, suggestions for development and demonstrations related to the in-world tools. Especially during the early stages, requests for objects removal were made to the server administrator or the teaching team, as students' workflow was being negatively affected. Students were also observed discussing matters outside the scope of their project, though related to the virtual world. It is noteworthy that small portions of students was often detached from the classroom discussing matters irrelevant to the project or the virtual world (Sections 5.3.1, 5.3.5, 5.3.7-5.3.9, 5.4.1). Lastly, several students complained because of the limited number of scripts they were allowed to use per team (Sections 5.3.1, 5.3.2, 5.4.1).

6.4 Transition from ‘Real’ to ‘Virtual’ Identity

The default avatar appearance was considered ‘ugly’ and ‘basic’ (quoting students’ comments), leading most students to alter it almost immediately after entering the world for the first time. This action was taking place more intensely during the first sessions, though some students were working on it up until the completion of their projects. Some of the avatar-related interactions students had were:

1. exchange of ideas,
2. provision of feedback, or
3. even control of the others’ avatars.

Using mostly the in-world tools, students modified the avatars’ appearance (body shape, skin/hair colour and clothing) to resemble either their ‘real’ identity, or role-play (opposite gender, imaginary creatures, and robots). Nevertheless, a portion of them made slight or no modifications at all. Thus, it can be said that avatars were the medium for some learners to feel in world presence, whilst for others a factor of none importance (Sections 5.3.2, 5.4.7).

Due to the lack of knowledge, various questions or requests were raised, especially at the early stages (Section 5.4.1). Those who removed their avatars’ clothing or stretched their shape to the limit, for example, sought help to restore appearance to default. In fact, they even admitted feeling ashamed when taunted by their fellow students. Moreover, they expressed their wish for an option to buy and sell outfits using virtual currency. Others sought ways and options to have a ‘health pool’ for their avatars. All the above give a clear indication that students developed the sense of in-world presence, and considered themselves part of the world (Sections 5.3.2, 5.4.1, 5.4.4, 5.4.7).

Indirect and unintended references to avatars were made mainly during the first sessions, and more intensely from those who edited their avatars' appearance. Nevertheless, as they were using the first person to communicate with others in most occasions, it cannot be safely claimed whether or not they had identified themselves with their avatars. References to avatars using the second person were more direct and easier to detect, though rare. Even more infrequent were the references observed addressing avatars in the third person or even as an object. In most occasions, these references were expressing admiration and joy. Comments with a 'sexual' content were also observed, referring to those students who role-played, or those with 'attractive' avatars. In rare cases, expressions revealing anger or frustration could be heard, addressed to students with inappropriate avatars' appearance or behaviour. In the role-play spectrum, well-known quotes originating from movies or books were heard, while at the same time students were imitating the corresponding actions in the physical classroom. Lastly, students who had made no changes in their avatars' appearance worriedly commented on their fellow students' willingness to put effort on this process, as they considered it unnecessary (Sections 5.4.1, 5.4.4).

6.5 'Behind' the Avatar

Avatars affect users' virtual embodiment, which renders them one of the most important features that virtual worlds have to offer. Editing the avatars' appearance was among the first types of interaction students—especially those with prior experience—had. However, the more engaged they were becoming with the world, the keener they were to make more complex and detailed modifications on their avatars. From the teaching team's perspective, there were no restrictions, as long as the modifications were in an acceptable and appropriate way. Most of the learners decided to replicate their real identity, as

they considered the virtual world to be an extension of the physical university classroom. However, role-playing is also an option that virtual worlds offer and thus, especially those students coming from the Games and Animation course, made some intense and detailed modifications on their avatars. Finally, it is noteworthy that a few modified their avatars exclusively for the needs of their assignment (Sections 5.3.2, 5.4.7).

The in-world references to avatars were limited or almost non-existent. Nevertheless, the inappropriate behaviour of some students led others to make requests—or even warn them—to stop disturbing them. Even though avatars were named after students' real identity and chat logs were being maintained, not all of them were minding their language or behaviour (Sections 5.4.1, 5.4.6, 5.4.7).

6.6 'Real' Task in a Virtual World

Interactions played an important role in learner engagement, though not all of them were equally intense. Having pre-existing content was deemed to be extremely helpful for the student cohorts who participated in E1, whilst those from E2-E4 very often mentioned the lack of example showcases (Sections 5.3.25, 5.4.1). Students expressed the difficulty and disappointment to deal with the virtual world and its tools, at least initially (Section 5.4.1). Nevertheless, it should be mentioned that not all of them showed interest in visiting and going through the orientation process, as observed during E2 (Section 5.4.6). In addition, in E3 the leisure games attracted the attention and interest of students, whereas the educational ones left almost all of them completely uninterested. The impact of the PAs in E4 was also controversial as not all of them attracted learners' attention and interest at an equal level. That said, there were learners who occasionally opted to interact with the more useful

agents (i.e. vendor, supporter) but ignored almost completely the presence of the distractor agent, as it did not serve their needs (Sections, 5.3.22-5.3.24, 5.4.6).

The types of interactions that students had with the virtual world can be classified into four categories:

1. Content exploration
2. Use of the 3-D modeling and scripting tools
3. Avatar appearance modification
4. Communication with others

Avatars—as the elements that allow for cross-environment interactions and facilitate the transition from the real to the virtual and vice versa—have already been discussed in Section 6.5. Therefore, this section will elaborate on the remaining sub-categories:

1. **Content exploration**

The opportunities for exploration, especially during the first practical sessions, were limited (excluding E1). Over time, students were observed visiting others' workspaces—including the ones developed by former students—to get ideas for their own projects or to provide feedback, when requested. Nevertheless, students who blocked access to their workspaces—in an attempt to prevent others from copying their ideas—cannot be disregarded. This reduced the opportunities for interactions, hindering the enhancement of in-world interactivity (content/students), which was a primary aim when designing students' workspaces. Thus, despite the fact that the workspaces have been intentionally redesigned to enhance and increase the opportunities for interplay, learners' choices opposed to the plans of the instructional designer and eliminated the influence of the instructional interventions (Sections 5.3.10, 5.3.14, 5.4.6).

The impact of the orientation area on E2 was rather disappointing, at least initially. Students who explored this area and invested time in familiarising themselves with the world and its tools, found it easier to work and collaborate with others in the long run. However, the majority showed lack of interest to go through this process and disregarded, almost completely, its existence. As a result, they were observed struggling and often making questions which could have been answered if they had chosen to be properly oriented. Over time, students were observed visiting the orientation area, after being advised to do so by other students (Section 5.4.1, 5.4.2, 5.4.6). Considering learners' low interest in engaging with the orientation area, another indication related to the way that learners' personal choices may oppose towards the instructional design emerges.

The impact of the leisure and educational content was diverse. Students visited the leisure areas often enough. However, they were not always observed playing with the games. On the other hand, only a few used or even visited the maze, whilst none of them used the racing-knowledge game (Sections 5.3.22-5.3.24, 5.4.6). This becomes more interesting after considering that particular emphasis was given (by the teaching team) to the fact that students could revise their knowledge on a weekly basis and also get unique rewards for their projects. In any case, students got inspired by this content and developed (mini) games as part of their own assignment.

Regarding the impact of the PAs, the results are also very controversial. First, unlike the previous cases where the instructional content was massive, the minimalistic appearance of the NPCs made them look and feel as part, or thereof not, of the system responsible for controlling and ensuring the proper operation of the virtual world. Nonetheless, the appearance of the NPCs—especially the nonhuman creature—attracted students' attention as it was the

‘odd’ of the ecosystem. This agent received intense criticism for providing meaningless responses to ‘serious’ matters and therein, was interpreted as the ‘fun element’ of the world. The human-like agent was certainly more useful to address student queries, though only a small portion of them had intense interaction with this agent, probably due to the biases and preconceptions that have been developed from the behaviour of the aforementioned agent. Last but not least, the vendor-NPC was the one which truly added value to the learning process. Indeed, most of (if not all) the students would visit this agent fairly often to get advices, instructions or even ‘gifts’, as it befalls in nearly all the workspaces, (Sections 5.3.22-5.3.24, 5.4.6).

2. 3-D modeling & scripting tools

During the first practical sessions, with only few exceptions, students spent their time performing actions irrelevant to their projects, yet related to the virtual world. The quick adaptability that some of them had, and their willingness to help those who were struggling, speeded up this process making it more enjoyable and less stressful. In any case, most of them usually became fully familiar with the mechanisms of the world about halfway through the assignment. It is noteworthy, though, that only a few students were keen to explore the full potential of the programming language. This can be attributed to:

- their fear in causing technical issues to the server,
- their unfamiliarity with this language, or
- the fast-paced nature of these assignments.

On the other hand, much attention was placed on the designing process of 3-D objects. In short, students would spend most of their time designing their own 3-D objects, and, consequently, using or slightly editing premade scripts that

can be found on the web. It is worth mentioning that only a few of them used the more advanced tools of the world (e. g. poseballs, animations). Lastly, their willingness to share their code or objects resulted in having overloaded workspaces, something which negatively affected the stability of the physical server (Sections 5.4.1, 5.4.2, 5.4.6).

3. **Communication with others**

In the following paragraphs, an overview—in the form of summative discussion—of students' in-world communicational behaviour is presented, in accordance to and aligned with the data presented in Chapter 5.

Most learners, with only few exceptions, used the chat-tool infrequently and only when deemed absolutely necessary. This is because either they were physically co-located, or, when this was not possible, they would opt to use social media platforms or VoIP tools. In fact, the lack of embedded VoIP system was pointed out as a drawback of this technology. Considering how frequently the chat-tool was used, several were the times when internet slang language was observed. On top of that, students motivated by, and being used to virtual games, were even observed using command lines that do not exist in this world. The above instances indicate that students did have experience with similar online tools, yet they were reluctant to use the chat-tool because they did not prefer it (Sections 5.2, 5.3.15, 5.4.4).

In-world communication was more intense during the first practical sessions, as students were observed greeting each other, commenting on others' avatars or artefacts. On-the-spot help requests were also observed, though. When the subject was too complicated, students would opt to move closer (physically) to their fellow students and hold a F2F conversation (5.4.1, 5.4.4).

Though rarely, students' emotions or feelings were also imprinted in-world. This was not only observed but further confirmed from the server's chat logs. During exploration, phrases revealing excitement, happiness or admiration could be seen. On the other hand, students who were struggling with the in-world tools expressed their dissatisfaction. Furthermore, students with inappropriate behaviour received several 'warning' messages, delivering senders' irritation or frustration. Lastly, the server freezes or crashes caused intense disappointment to students, often discussed in the chat (Section 5.4.4).

Those who discovered the gestures' library were observed testing them at least once, and even motivated others to do so. Students who role-played or used their avatars as part of their assignment's needs, were even observed developing their own gestures combinations. Some of them also used poseballs (scripted objects) to animate their avatars. However, nearly all of them avoided the often or unnecessary use of the non-verbal communication channels.

Even though various emoticons were observed both in the public chat and in private messages, expressing students' feelings and emotions, the frequency was not as often as it is accustomed in the social media (Section 5.4.4).

6.7 The Attributes that Affect Engagement

The interactions students can have both with the virtual objects and with others make the use of a virtual world a worthwhile investment (Sections 5.3.1, 5.4.1). As stated in the conclusive survey, the in-world interactions made the practical session and the learning material more attractive and effective, compared to studying in the traditional sense (Sections 5.3.6-5.3.8). As the learning material was becoming more appealing, greater levels of engagement were reported (Sections 5.3.7, 5.4.2). This is also indicated by the fact that students enjoyed the sessions, as noted in the corresponding statements (Sections 5.3.10-5.3.14).

The elements that contributed the most to achieving the above are:

1. the interactivity of the environment (Section 5.3.5),
2. the freedom given to students to observe their creations ‘alive’ (Section 5.3.12), and
3. the ludic nature of the virtual world (Section 5.3.4).

What also facilitated the learning process and helped students experience the knowledge (Section 5.3.3) are the real-time awareness of the results of their work and the immediate feedback they could get from others (Sections 5.3.5, 5.4.1). Moreover, the continuous alteration of the students’ focus between the real and the virtual world does not seem to have affected their sense of in-world presence (Sections 5.3.2, 5.4.2).

In fact, this justifies the reasons why in-world interactions among students were less intense. Indeed, when students were physically co-located, their communication needs were covered in-class. However, in cases where this was not feasible, they would—at least initially—opt to use the in-world communication tools to cover them (Sections 5.4.1, 5.4.4, 5.4.5).

Interactions with the virtual world seem to have a substantially greater impact on learner engagement in four aspects:

1. **Content:** Interactions with the content, as an exclusive feature of virtual worlds, have some unique impacts and benefits on learning (Sections 5.3.10-5.3.14, 5.4.2). An increased level of willingness and enthusiasm to participate in practical sessions was reported (Section 5.3.8). Students also noted that their interactions with their fellow students had similar impact on their perception and attitude regarding the world (Sections 5.3.9, 5.4.1).
2. **Object creation:** The 3-D design and scripting were the core parts of these assignments. The reflection of students’ responses provides a clear

indication that this kind of activities can significantly increase student engagement with the learning material (Sections 5.3.7, 5.4.2).

3. **3-D**: The 3-D element turned coding into a stimulating activity, since students were able to design and observe 3-D objects performing actions (Sections 5.3.12, 5.4.6). Participants also stated that interacting with the content of the world helped them experience the learning material (Section 5.3.3) and have real-time awareness of the results of their work, since these were visualised in 3-D representations (Section 5.3.5).
4. **Artefacts**: Students enjoyed more using their own creations (Sections 5.3.13, 5.4.2). Exploring others' artefacts helped them get ideas for their own work, but not all of them would opt to use them (Sections 5.3.14, 5.4.6).

In-world interactions with other students did not seem to have influenced student engagement as extensively as the ones that occurred with the content. Nevertheless, their impact on some points was highlighted and is presented below:

1. **Collaboration**: Students became more open and positive to collaborations, since the use of this medium encouraged them to cooperate in order to acquire the necessary skills to work on and complete their assignment (Sections 5.3.17, 5.3.18). Moreover, in cases where students were not present in the classroom during the sessions, they would opt to enter the virtual world to collaborate with their team mates distantly (Section 5.4.4).
2. **Peer-learning/peer-tutoring**: Cross-examining the responses given in the statements regarding the 'learning from' and 'teaching' others, participants claimed that they felt more involved in the teaching-learning process (Sections 5.3.19, 5.3.20). However, this is more intense when it comes to 'teaching others' and less when 'being taught' from others. Peer-tutoring and

peer-learning had been intense not only in-class, but also in-world, as confirmed by the observational data (Sections 5.4.1, 5.4.4).

3. **Enjoyment:** The unexpected results and mistakes—especially those deriving from the programming language—resulted in amusing emotions and that made the process much more enjoyable (Sections 5.3.16, 5.4.4, 5.4.5).
4. **Rest breaks:** The opportunity to have small breaks and perform actions irrelevant to their project was something that was also acknowledged and highlighted as important (Section 5.3.21). Indeed, students often opted to take a break from their work on their project and enjoy their in-world time together performing leisure activities (Section 5.4.4, 5.4.6).

6.8 Engagement or Necessity?

Students would usually go online at the starting time of the practical session and leave right after its scheduled completion. Only rarely would they come online delayed but there were cases during which they were observed leaving the virtual world before the completion of the session. Those who showed interest in this educational approach would stay in-world more than expected, or come online even prior to the session's starting time. In cases where the assignment was part of a group work, those responsible for the development of the virtual showcase would usually enter the world at the starting point of the session. However, the need to help their team members on other matters was standing as an obstacle towards their undistracted engagement with the virtual world. As a side note, it should be mentioned that most students would remain online past the working hours of the practical sessions. Even though their actions were not observed during these hours, the results of their work could be seen during the weekly observations and the server logs (Sections 5.3.1, 5.4.8).

Chapter 7: Summary & Conclusions

7.1 Summary of Argument

In this study a new research direction is drawn while researchers and educators are provided with alternative focus points and directions. The initial hypothesis regarding the importance of examining interactions both in the virtual world and in the physical classroom, in conjunction with one another and not in isolation, has been validated and confirmed.

Learners' simultaneous physical and virtual co-location broadened the network of interactions, eliminated the drawbacks and the weaknesses of each educational approach and enhanced their strengths. In fact, this is the essence of employing the HVL approach. In other words, the interactions not only in-world—which have been extensively investigated—but also in-class, should be considered as factors that affect learners' attitude and motivation towards learning, and influence their engagement with the virtual world and the educational activities, by extension.

7.2 Summary of Contributions

RQ1. The synergy between learner engagement & hybrid interactions.

In the context of the HVL model, learners' in-world interactions are not equispaced with one another (Section 5.3). Indeed, those that occur with the content of the virtual world prevail over the ones that occur amongst the students themselves. This, however, becomes justifiable considering that the in-class interactions compensate for the corresponding diminished in-world ones (Section 5.4).

Cross-environment interplay brings some unique benefits on motivation and engagement that the exclusive use of a virtual world cannot offer. For instance, discussing aspects related to the virtual world or the project (Sections 5.3.5-5.3.6, 5.3.15, 5.4.1), helping, guiding and influencing each other (Sections 5.3.17-5.3.20), exploring together the available resources (Sections 5.4.6, 6.7) as part of the required research for the fulfilment of the assignment objectives, are all types of stimuli that increase learner engagement with the educational activities.

Nonetheless, the disadvantages that the physical co-presence also brings cannot be disregarded. For instance, performing actions or discussing matters non-related to the virtual world—or even to the subject under investigation—(Section 5.4.2) as well as working on different university tasks (Section 5.3.25, 5.4.8), limit the attention span, preclude the extended interaction with the virtual world and thus, critically affect the levels of engagement that learners can exhibit.

In the same vein, performing parallel actions also impacts on the levels of immersion that learners can reach (Sections 5.4.2, 5.4.8). In contrast to virtual games, where immersion is the key to engage users with the virtual world, when it comes to educational practices and, more precisely, in HVL setups, immersion does not seem to have much—if any—relevance. In both cases, in-world goals and targets are to be achieved. Students want to complete their assignment in order to get ‘real’ marks and gamers want to complete a set of tasks in order to get the feeling of completion or joy. However, using a virtual world—even with a game-like content—as an extension of the physical university does not lead students to achieve high levels of immersion, as the goal is to complete the task and achieve good grades. Counterintuitively, this lack of immersion might as

well be a plus. It may lead to a useful distance between the student and their in-world task, and might even foster critical thinking and reflection on their actions.

Lastly, the impact of avatars on engagement, as the bridging medium between the virtual and the physical world, is mixed. Even though embodiment influences the levels of engagement that users reach with the virtual world (Sections 5.4.7, 6.5), its impact on the learning process is rather limited (Sections 5.4.3, 6.5). Notwithstanding the foregoing, there are learners that consider their in-world representation by avatars that fit their taste as a prerequisite for engagement with the educational activities, whilst for others this feature is a factor of minor or no importance.

RQ2. Learners' personal choices & preconceptions.

Despite the fact that a virtual world can be utilised to cover different educational needs, when it comes to Computer Science courses, students will most likely be expected to perform activities that involve 3-D modelling, programming or both. Thus, an—at least—generic interest in or understanding of any commercial 3-D modelling tool and scripting language for Lua programming (graphics' design) will be a plus, as it will increase the learners' chances for meeting the requirements of their task and personal objectives.

Educators who are planning to use virtual worlds in their teaching agenda should be well-aware that a considerable amount of time has to be devoted for the preparation and the implementation of the educational interventions, in order to provide their learners with interactive and engaging learning experiences.

Moreover, when designing educational activities for HVL setups, it is essential to remember that factors that are associated with immersive

experiences (e.g. realism, sensory input/feedback, control, distraction) not necessarily correlate with factors that foster a situated learning experience (e.g. cross-environment interplay, motivational and emotional boost/support).

Furthermore, careful thought should be given to the duration of the (in-world) project, whilst additional educational tasks—non-related to the virtual world—should, ideally, be avoided (Section 5.3.25).

In addition, learners need time to make sense of new ideas and process information (Section 5.3.25). With that in mind, sufficient time should be dedicated to letting students engage with the available instructional content, familiarise themselves with the virtual world, understand the operation of its tools, and motivate them to communicate their knowledge and understanding with others throughout the lesson.

Lastly, the present study is in agreement with the literature as regards the role of educationalists who should be prepared to act as supporters and instructors.

Nonetheless, there is no guarantee that all the learners will engage with the educational material or enjoy the process. However, it is the educators' responsibility to 'teach' their students how to make the most of this alternative instructional approach and encourage them to engage with the provided interventions, as it will help them achieve better results—in terms of their assignment—and also work within the virtual world effortlessly.

RQ3. Guidance to instructional designers.

The role of an instructional designer is that of a 'game changer' in the teaching and learning process. Undoubtedly, not every learner will be attracted by the same design approach, as their personal preferences, choices, or preconceptions might come in contrast with the instructional design. Nevertheless, the higher

the levels of interactivity are, the higher the chances to attract learners' attention and engage them with the process will be.

Thus, instructional designers are advised to take the following points into account, when preparing educational interventions for situated learning experiences:

- The in-world content should have a dynamic scaffolding, with different levels of instruction, so as to ensure that it will fit the personality of different learners (learning style) and meet their perspectives. This should be done in accordance with the learners' educational level, background and former knowledge or experiences related to virtual worlds as examined in the case of the preliminary survey (Section 5.2).
- The instructional designers should account learners' simultaneous co-presence and provide different types of stimulus, so as to motivate them to develop and expand their knowledge, in both environments, through collaboration and mutual cooperation (Chapter 6).
- The instructional designers should ensure that learners undertake a proper induction to the virtual world and its tools. This will help them to understand quickly and deeply the world's mechanisms and, therefore, increase the success of the learning activities and the desired outcomes (see RQ3b).
- The instructional designers should provide learners with visual aids—such as examples and comparison measures—of the final product or the expected outcome. This will show learners the capabilities of the virtual world, help them to better understand the expectations of the teaching team and thus, boost their confidence towards their task and assignment (see RQ3a).

- The instructional designers should offer learners opportunities to disengage from the learning activities, but not the virtual world, through the use of leisure and (potentially) educational games. This will increase the perceived attractiveness of the environment, promote opportunities for socialisation and team-play and thus, maintain their interest towards the virtual world (see RQ3c).
- The instructional designers should ensure that learners get diverse opportunities for personalised tutoring through the utilisation of PAs. Although such content might have limited influence on engagement, the presence of these entities can potentially increase the interactivity of the virtual world (see RQ3d).
- Lastly, in collaboration with the educators, learners should be provided with clear information regarding the available in-world content and its potential, and should be further encouraged to use it, as it has been designed and developed in their favour.



Figure 7.1 The complete OpenBedfordia universe.

RQ3a. The impact of exemplification on learner engagement.

Students spent their time in-world performing actions related to 3-D content development and programming without, however, disregarding the option to explore the available content (Sections 5.3.10, 5.3.11, 5.4.6). These two actions seem to have been related to each other, as learners opted to interact with the pre-existing content, in order to find answers to their queries about the setup of their projects or whenever they were in need of inspiration to continue (Section 6.6).

Thus, providing learners with example showcases should be an integral part of the world's content, at least during the early stages of the intervention. Indeed, the existence of such content has many advantages, as it allows learners to have a comparison measurement against their aims and goals and, as well as provides them with ideas for development and experimentation. It also turns the virtual world into a more 'real' or 'alive' environment, which is conducive to the feeling of being part of a wider community.

RQ3b. The impact of conceptual orienteering on learner engagement.

Students really need to have some form of guidance related to the virtual world and its tools, especially at the early stage, be it through the use of an orientation area or any other similar method (Section 5.3.25). In order for this content to be effective, at least the basic aspects of the world should be covered, with the intention to motivate learners to further explore them by themselves.

However, the freedom that the virtual worlds offer and the human instinct to explore the unknown, make it hard to patronise such procedures. Thus, chances are that students will rather attempt to explore the world and its tools by themselves, instead of going through a specific process. Nevertheless, having an information 'fountain' available at any given point comes handy.

RQ3c. The impact of gamification/edutainment on learner engagement.

The impact that the educational and leisure games have on boosting the incentives for interaction and engagement can be positive (Section 5.3.23), though very diverse, especially after considering that the leisure games have potentially higher chances to attract learners' attention and interest, as opposed to the educational ones (Sections 5.4.6). On the other hand, the influence of this content on the learning process may be considered minimal (Section 5.3.22, 5.3.24).

Indeed, as not all learners are equally attracted by the gamified approach, the presence of such elements yields a wide variety of effects. Some may be inspired, others may perceive them purely as a way to break from their routine and entertain themselves, while others might even be disinterested. Either way, the existence of recreational content can help learners to familiarise themselves with the in-world tools, or even make them perceive the learning process in a more enjoyable way.

RQ3d. The impact of the PAs on learner engagement.

The inability of conversational agents to regulate emotional responses makes the employment of such concepts problematic (Sections 2.3.7). Indeed, using PAs to deliver a fully personalised or optimal experience—especially in virtual worlds like OpenSim—becomes even more challenging, due to the inadequate (so far) nature of the technology's architecture to support such entities.

In the relevant experiment, the learners' interest was attracted almost exclusively by the NPCs that could, at least, offer some kind of support towards their needs (e.g. free items, instructional notes/suggestions or guidelines). On the other hand, the PA who aimed at disorientating or, at most, entertaining them met with a complete lack of attention. Thus, in order for a degree of

desirable interaction with the NPCs to be achieved, the essence of the PAs should be either an essential part of the educational process or, at least, correlated and fully incorporated in the learners' task.

7.3 The DELUSIVE Taxonomy

This research attempted to fill the existing gap (Section 2.7) regarding the design of a taxonomy that provides a comprehensive view of the phenomena that relate to the use of virtual worlds in HVL contexts.

The *DELUSIVE* taxonomy (Figure 7.2) includes all kinds of interactions that take place in a HVL setup and affect learners' attitude, categorised in the following parameters:

1. the context in which the interactions take place, i.e. virtual world or physical classroom, and
2. the involved parts, i.e. students interacting with other students and students interacting with the virtual world.

Four categories of interactions derive from the combination of the context and the involved in the interactions parts:

1. student-to-student interactions in the virtual world,
2. student-to-world interactions in the virtual world,
3. student-to-student interactions in the physical classroom, and
4. student-to-world interactions in the physical classroom.

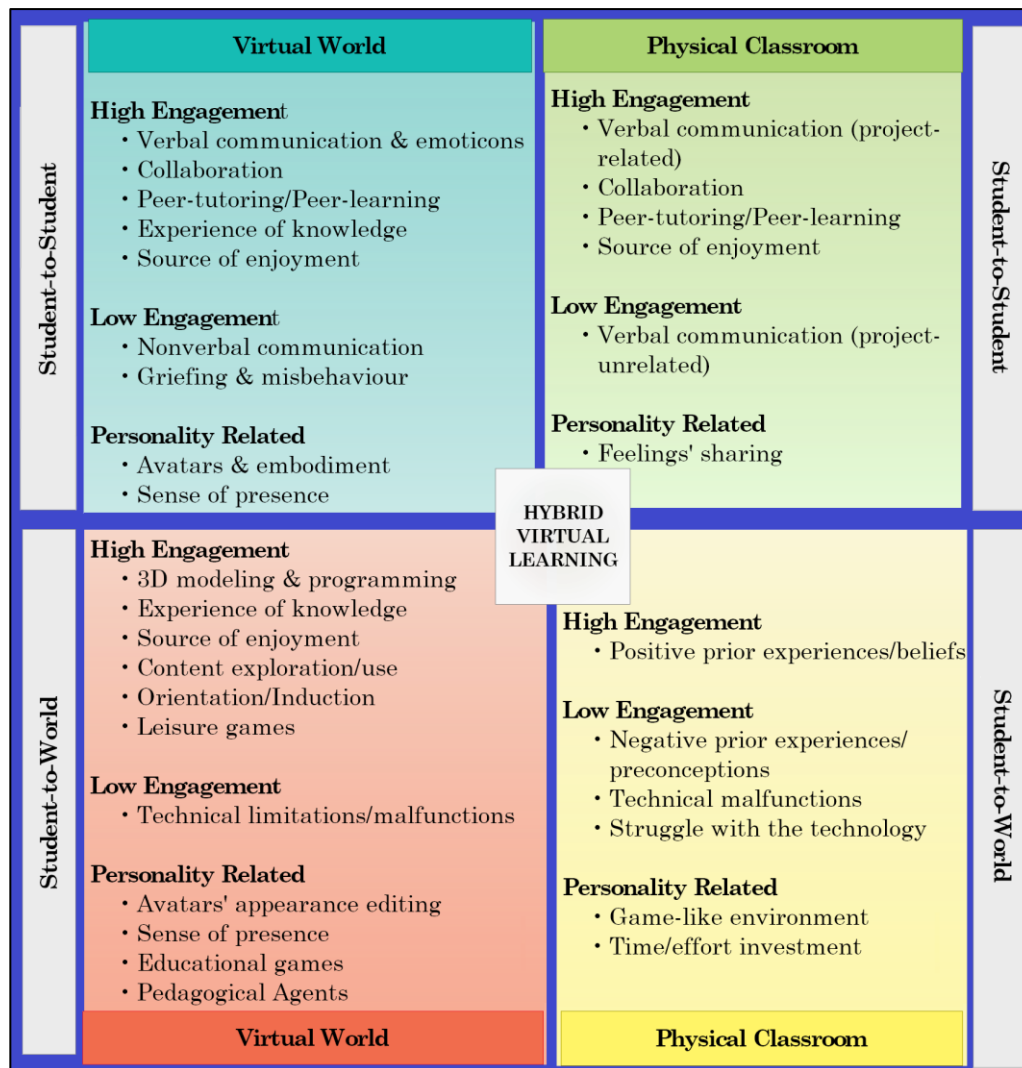


Figure 7.2 The DELUSIVE taxonomy.

7.4 Conclusion

Even though VL already counts for several decades of practice and has been widely investigated, the idea that underpins the HVL approach opened new educational horizons and, yet, remained a relatively unexplored field. Indeed, VL and HVL have different attributes and characteristics and thus, any conclusions drawn by research conducted in Distance/VL contexts cannot easily be transferred to HVL setups. The attributes contributing to HVL are illustrated in Figure 7.3.

It can, therefore, be concluded that cross-environment interactions play a crucial role in learner engagement—if designed appropriately—whereas learners’ personal choices and preconceptions towards the HVL approach, can certainly oppose against the educators’ plans and the instructional designers’ decisions.

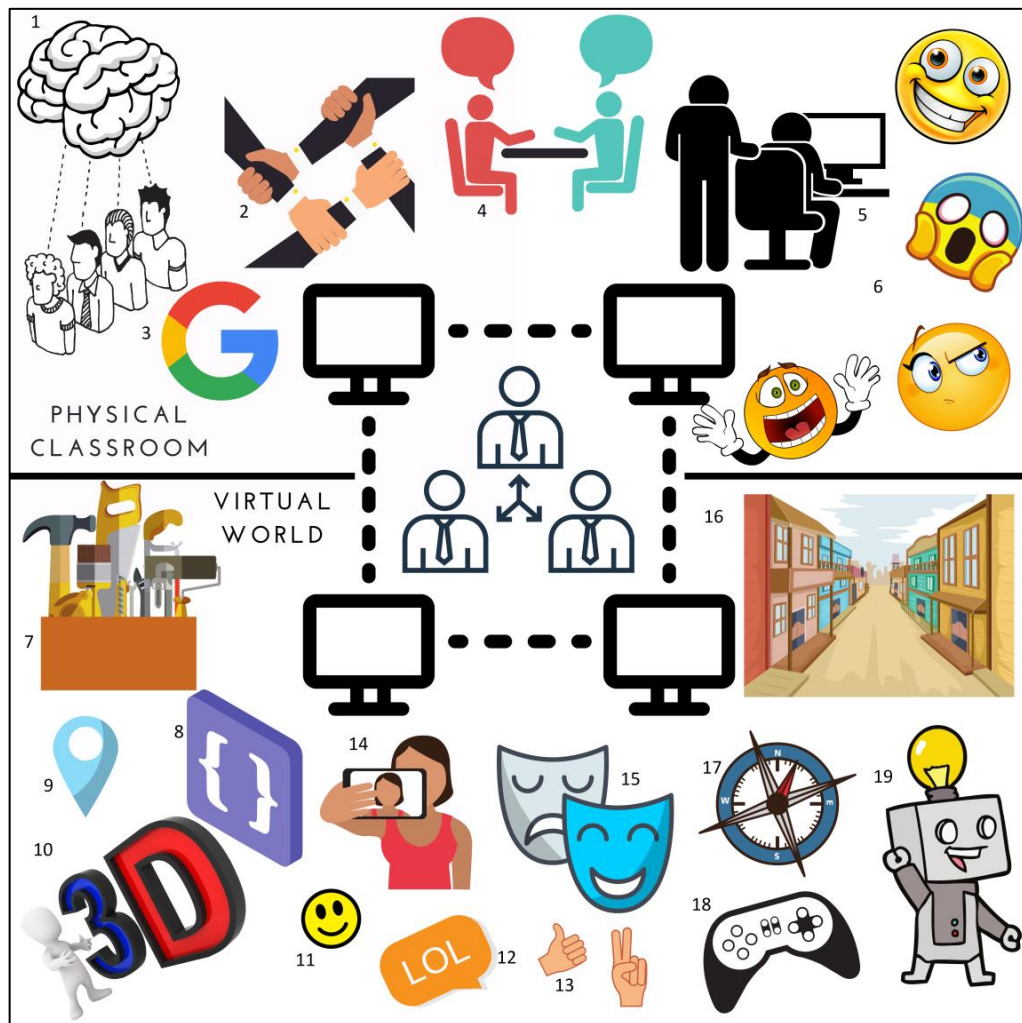


Figure 7.3 Mapping learners’ attitude, emotions & interactions in the HVL approach.

1. brainstorming of ideas, 2. collaboration, 3. use of external resources/third-party software, 4. communication, 5. peer-tutoring/peer-learning, 6. emotions/attitude towards the virtual world, 7. use of 3-D modeling tools, 8. scripting, 9. use of secondary tools (landmarks, profile etc.), 10. the 3-D element, 11. use of emoticons, 12. use of chat, 13. use of gestures, 14. replication of real identity, 15. intention to role-play, 16. exemplification, 17. orientation, 18. gamification/edutainment, 19. Pedagogical Agents.

7.5 Limitations of the Study & Future Directions

The limitations of the study provide direction for future research.

7.5.1 The sample demographics.

As the focus of this study was on interaction and engagement, it can be argued that there are also other substantive societal aspects in using virtual worlds such as the gender or the age (Martens *et al.*, 2018; Zhang, Dang & Chen, 2019). Given this, the data collection was possibly too focussed and streamlined against the aims and objectives of this thesis in order not to allow further findings based on variations in the demographics. Therefore, further research may include these societal aspects.

Also, as the collected data have been treated homogeneously, behavioural differences between the Undergraduate and the Postgraduate students might also exist. A hypothesis grounded to the nature of this study might suggest that the so-called ‘digital natives’ show less interest to such instructional approaches, compared to the more mature students, who are faced with issues related to familiarisation or potential estrangement that may face from their younger-aged fellow-students.

Moreover, the participants were Computer Science and Technology students and we can, therefore, assume an affinity towards the use of technology. While the results of this study do not crucially depend on specific skills in computing or software development, the data collected from students with a different background each, might highlight other aspects.

Considering the above, the educational institution, in which the experiments were conducted, might also set another limitation. Therefore, examining this topic with students from other institutions or, even, in the wider context of a cross-university collaborative effort might underline different aspects.

7.5.2 The Instructional Design approach.

In this study, a set of instructional design techniques was employed in the context of the HVL model, with the aim to increase the incentives for interplay and therefore, engagement. Therefore, future studies may expand the presented ideas and further introduce new instructional methods with the intention to identify additional parameters that affect hybrid interactions.

7.5.3 The virtual world technology.

The experiments were conducted using the OpenSim technology that does not scale well to larger cohorts and has limited ability to integrate with other software. In particular, the abilities of the PAs in Experiment 4 posed a constraint. Therefore, future work might further develop the OpenSim platform or migrate on a different infrastructure/architecture that better supports the integration of AI algorithms for better tailored responses by the PAs. This might also allow for the accommodation of larger student cohorts, consequently facilitating cross-institutional student interaction.

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Appendices

Appendix A

Participant Information Sheet (Surveys)

Dear student,

My name is Athanasios Christopoulos and I am a Ph.D. candidate in the School of Computer Science & Technology of the University of Bedfordshire. You are kindly asked to participate in a research study carried out by me and supervised by Dr. Marc Conrad and Dr. Mitul Shukla. Please, take some time to read the information below in order to understand all the details of the research and decide whether or not you would like to participate.

- **What is the purpose of the study?**

The aim of this study is to identify the impact that the various interactions, which take place within a virtual world, have on the development of learner engagement.

- **Do I have to take part?**

Your participation is purely voluntary. If you agree to participate, you can keep this information sheet in order to refer back to me whenever needed. Please note that regardless of your decision, no consequences will be imposed on your marks, assessments and future studies.

- **What will happen to me if I take part?**

You are kindly asked to fill in a questionnaire, prior to that start of the [unit name] curriculum and post its completion, indicating your opinion about the use of virtual worlds for educational practices and how your in-world interactions made you feel more or less engaged, respectively. Filling in the a priori questionnaire will take you approximately 2-3 minutes whereas, the a posteriori, no more than 10.

- **Will my identity be kept confidential?**

You will participate in the study anonymously. The only personal information you will be asked to reveal will be your gender, age and academic level, purely for demographical reasons. Data generated by the study will be securely kept in paper and electronic form. Upon its completion, they will be safely disposed in accordance with the University's policy. Those data will be used for no other study than this.

- **What will happen to the results of the research study?**

This research is running in the context of my Doctoral research and the results will be published (anonymously) in my Ph.D. thesis but also in conference and journal papers. All the published work will be uploaded on our University's website.

- **Who has reviewed the ethical considerations of this study?**

The research approach and material has been examined and approved by the University of Bedfordshire Research Ethics Committee.

Contact for Further Information

Should you have any questions about this study, please do not hesitate to ask me now or contact me anytime at athanasios.christopoulos@beds.ac.uk.

Thank you very much for taking the time to read the information sheet,
Athanasios Christopoulos

Preliminary Survey

Part 1. General questions about you:

G1. Indicate your gender.		G2. State your academic level		G3. Choose your age group			
Male	Female	Undergraduate	Postgraduate	18-25	26-35	36-45	46 or older

Part 2. Please express your opinion about the following statements:

		None	Up to a week	Up to a month	More than a month but less than six	More than six months but less than a year	More than one year
S1*	My experience in virtual worlds like Second Life/OpenSim is:	0	0	0	0	0	0
		Very Positive	Positive	Neither Positive nor Negative	Negative	Very Negative	I have heard no comments
S2*	I could generally describe my prior experience in these virtual worlds as:	0	0	0	0	0	0

Part 3. Please express your opinion about the following statements

S3*	The comments I have heard about the use of such a virtual world were generally:	Very Positive	Positive	Neither Positive nor Negative	Negative	Very Negative	I have heard no comments
		0	0	0	0	0	0
S4*	I am of the opinion that the use of a virtual world in an educational context has nothing to offer me.	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	
S5*	I would prefer it if the use of a virtual world had not been part of the practical sessions I am enrolled in.	0	0	0	0	0	0

Conclusive Survey

Part 1. General questions about you:

G1. Indicate your gender.		G2. State your academic level		G3. Choose your age group			
Male	Female	Undergraduate	Postgraduate	18-25	26-35	36-45	46 or older

Part 2. Please express your agreement or disagreement about the following statements:

Part 2A. Interactions with the content of the virtual world

	Interacting with the content of the virtual world in the context of the practical sessions...	Strongly Agree	Agree	NAND	Disagree	Strongly Disagree
S1	...is a good reason for me to use a virtual world.	0	0	0	0	0
S2	...made me feel I am actually present in the virtual world.	0	0	0	0	0
S3	...made me experience the knowledge.	0	0	0	0	0
S4	...was fun.	0	0	0	0	0
S5	...was real-time & that helped me have immediate awareness/feedback of my actions/work	0	0	0	0	0
S6	...made learning easier for me compared to just studying.	0	0	0	0	0
S7	...made the learning material more attractive for me.	0	0	0	0	0
S8	...made the practical session more attractive for me.	0	0	0	0	0
S9	...made me participate gladly in the practical sessions.	0	0	0	0	0
S10	...pleased me, especially when I was exploring & sightseeing.	0	0	0	0	0
S11	...pleased me, especially when I was building & scripting.	0	0	0	0	0
S12	...was interesting since I had the opportunity to see my creations 'alive'.	0	0	0	0	0
S13	...pleased me, especially when I was using the virtual objects I created.	0	0	0	0	0
S14	...pleased me, especially when I was using others' virtual objects	0	0	0	0	0

Part 2. Please express your agreement or disagreement about the following statements:

Part 2B. Interactions with the other users

Interacting with other users of the virtual world in the context of the practical sessions...	Strongly Agree	Agree	NAND	Disagree	Strongly Disagree
S15 ...is a good reason for me to use a virtual world.	0	0	0	0	0
S16 ...made me feel I am actually present in the virtual world.	0	0	0	0	0
S17 ...made me experience the knowledge along with others.	0	0	0	0	0
S18 ...was fun.	0	0	0	0	0
S19 ...helped me take real-time feedback for my work from other users.	0	0	0	0	0
S20 ...made learning easier for me compared to just studying.	0	0	0	0	0
S21 ...made the learning material more attractive for me.	0	0	0	0	0
S22 ...made the practical session more attractive to me.	0	0	0	0	0
S23 ...made me participate gladly in the practical sessions.	0	0	0	0	0
S24 ...was interesting since I had the opportunity to chat with others about our projects.	0	0	0	0	0
S25 ...pleased me, especially when we were discussing and laughing with our mistakes.	0	0	0	0	0
S26 ...made me more open & positive to collaborations.	0	0	0	0	0
S27 ...pleased me, especially when collaborating with others for a common goal.	0	0	0	0	0
S28 ...made me teach others things I knew.	0	0	0	0	0
S29 ...made me learn what others already knew.	0	0	0	0	0
S30 ...pleased me, especially when we were having breaks from our work.	0	0	0	0	0

Part 3. Questions about the content developed by the researcher.

S31	How many times have you [played one or more of the in-world games/used one or more of the in-world NPCs]?	<input type="radio"/> 1-2 times during the entire course of this unit <input type="radio"/> Once every week <input type="radio"/> More than once per week <input type="radio"/> Never
		Strongly Agree Agree Neither A. nor D. Disagree Strongly Disagree
S32	[The games/NPCs] helped me become more engaged with the virtual world & the learning activities.	
S33	[The games/NPCs] made it easier for me to understand the learning subject.	

Part 4. In your opinion, what would have helped you become more engaged with the virtual world? (*optional question*)

Appendix B

Participant Information Sheet (Observations)

Dear student,

My name is Athanasios Christopoulos and I am a Ph.D. candidate in the School of Computer Science & Technology of the University of Bedfordshire. You are kindly asked to participate in a research study carried out by me and supervised by Dr. Marc Conrad and Dr. Mitul Shukla. Please, take some time to read the information below in order to understand all the details of the research and decide whether or not you would like to participate.

- **What is the purpose of the study?**

The aim of this study is to identify the impact that the various interactions, which take place within a virtual world, have on the development of learner engagement.

- **Do I have to take part?**

Your participation is purely voluntary. If you agree to participate, you can keep this information sheet in order to refer back to me whenever needed. Please note that regardless of your decision, no consequences will be imposed on your marks, assessments and future studies.

- **What will happen to me if I take part?**

In the context of the [unit name] practical sessions I, the researcher, will be observing and logging (note-keeping) your actions and interactions, both in-class and in the virtual world. The observation will take place only in the context of the practical session and you will be asked to do nothing more than what your lecturer's assignment ask you to. Researcher's records will be used purely for this study. Should you wish to participate please sign the consent form you will find in the next page and join me in the [laboratory name]. Please note that your participation in or opt-out from the research will have no consequence on your marks, assessments and future studies.

- **Will my identity be kept confidential?**

You are ensured that all your personal information will be kept confidential. You will participate in the research anonymously and only I will keep record of the personal information that you will provide in the consent form. This information of yours and your consent form will be stored in a locked filing cabinet in researcher's university office, securely disposed after the completion of the research and never published. Data generated by the study will be securely kept in paper and electronic form by me and securely disposed right after the completion of the study, in accordance with the University's policy.

- **What will happen to the results of the research study?**

This research is running in the context of my Doctoral research and the results will be published (anonymously) in my Ph.D. thesis but also in conference and journal papers. All the published work will be uploaded on our University's website.

- **Who has reviewed the study?**

The research approach and material has been examined and approved by the University of Bedfordshire Research Ethics Committee.

Contact for Further Information

Should you have any questions about this study, please do not hesitate to ask me now or contact me anytime at athanasios.christopoulos@beds.ac.uk.

Thank you very much for taking the time to read the information sheet,
Athanasios Christopoulos

Consent Form for Observation Approval

- I confirm that I have read and understood the information sheet for the above study and have had the opportunity to ask questions.
- I understand that my participation is voluntary and that I have the right to withdraw from the study at any time, without giving reason.
- I understand that my personal data will be kept confidential.
- I understand that the data generated by the study will be securely kept by the researcher and securely disposed right after the completion of the study.
- I agree to the publication of my anonymous data gathered in this study.
- I agree to the use of anonymised quotes in publications.
- I agree to my in-world activities during the [unit name] practical sessions being logged for review purposes.
- I agree to participate in this study.

Participant's name _____

Participant's signature _____

Date _____

Observation Checklist

Actions & Interactions in the Physical Classroom	Frequency (30")
Communication	
C1. Student talks to classmate about the project/virtual world	
C2. Student talks to classmate about something irrelevant to the project/virtual world	
C3. Student talks to tutor/demonstrator about the project/virtual world	
C4. Student talks to tutor/demonstrator about something irrelevant to the project/virtual world	
C5. Student makes a positive comment about the emotional experience of the virtual world	
C6. Student makes positive comments about the technology of the virtual world	
C7. Student makes negative comments about the technology of the virtual world	
C8. Student makes a negative comment about the emotional experience of the virtual world	
Attitude/Feelings	
C9. Student seems focused on project	
C10. Student seems to enjoy the project	
C11. Student seems 'absent-minded'	
C12. Student seems displeased using the virtual world	
Student Identity	
C13. Student refers to avatar in the first person/identifies with avatar	
C14. Student refers to avatar in the second person/addresses avatar directly	
C15. Student refers to avatar in the third person	
C16. Student refers to avatar as an object	
Actions & Interactions in the Virtual World	
Communication	
V1. Student chats with classmate about the project or the virtual world	
V2. Student chats with classmate about something irrelevant to the project/virtual world	
V3. Student uses in chat words/phrases revealing enjoyment (e.g. 'that's funny', 'cool', etc.)	
V4. Student uses in chat words/phrases revealing exclamation (e.g. 'that's fantastic')	
V5. Student uses in chat words/phrases often used in social networks (e.g. 'lol', 'omg')	
V6. Student makes a negative comment about the technology of the virtual world	
V7. Student makes a negative comment about the emotional experience of the virtual world	
V8. Student uses emoticons	
V9. Student uses avatar gestures	
Attitude/Feelings	
V10. Student works on project	
V11. Student performs actions irrelevant to the project (e.g. dancing, flying, visiting places)	
V12. Student uses own virtual creations	
V13. Student uses the in-world tools	
V14. Student explores classmates' virtual artefacts	
V15. Student uses the content developed by the researcher	
Avatar Identity	
V16. Student refers to avatar in the first person/identifies with avatar	
V17. Student refers to avatar in the second person/addresses avatar directly	
V18. Student refers to avatar in the third person	
V19. Student refers to avatar as an object	
V20. Student modifies avatar appearance	

	Occupation (Physical Classroom & Virtual World)	Frequency (30")
CV1.	Student 'logs-in' before the beginning of the session.	
CV2.	Student 'logs-in' at the beginning of the session.	
CV3.	Student 'logs-in' later than the beginning of the session.	
CV4.	Student 'logs-out' before the end of the session.	
CV5.	Student 'logs-out' right after the end of the session.	
CV6.	Student stays in-world after the end of the session.	

Appendix C

Experiments' overview & participated groups

Participant group	E1A	E1B	E1C
Experiment set up	<ul style="list-style-type: none"> ○ Content created by former students. ○ Researcher was detached from the setup of the virtual world. 		
Participants' academic level	Undergraduate	Undergraduate	Postgraduate
Observation group (sample)	12	12	9
Observation weeks (Appendix E)	1.1-1.4	1.5-1.12	1.13-1.20
Preliminary survey (sample)		N/A	
Conclusive survey (sample)	50	47	64

Participant group	E2A	E2B	E2C
Experiment set up	<ul style="list-style-type: none"> ○ Technical work to enhance the stability of the server. ○ Development/integration of the orientation area, the sandbox and the socialisation spaces. ○ Alternation of the workspaces' infrastructure for Experiments B & C (conversion to exhibition areas). 		
Participants' academic level	Undergraduate	Undergraduate	Postgraduate
Observation group (sample)	17	15	11
Observation weeks (Appendix E)	2.1-2.4	2.5-2.10	2.11-2.16
Preliminary survey (sample)	44	110	42
Conclusive survey (sample)	47	78	53

Participant group	E3A	E3B	E3C
Experiment set up	<ul style="list-style-type: none"> ○ Expansion of the virtual world (simulator) from 1 standalone 'island' to 3 inter-connected. ○ Development/integration of the leisure & edutainment content. 		
Participants' academic level	Undergraduate	Undergraduate	Postgraduate
Observation group (sample)	15	23	12
Observation weeks (Appendix E)	3.1-3.4	3.5-3.10	3.11-3.14
Preliminary survey (sample)	38	86	14
Conclusive survey (sample)	41	74	18

Participant group	E4A	E4B	E4C
Experiment set up	<ul style="list-style-type: none"> ○ Development/integration of the PAs & the socialisation areas. 		
Participants' academic level	Undergraduate	Undergraduate	Postgraduate
Observation group (sample)	17	17	16
Observation weeks (Appendix E)	4.1-4.4	4.5-4.9	4.10-4.14
Preliminary survey (sample)	45	91	24
Conclusive survey (sample)	43	104	18

Appendix D

Answers to the open-ended question

Experiment 2 (respondents = 33% of 178)		
Time	<ul style="list-style-type: none"> - While I did my research about OpenSim, I found some interesting functions for my work. If I had more time to create more complex or creative objects. Scripts, I would have become more engaged. - More time to... [become more knowledgeable about this topic] (2), [familiarise with the virtual world] (2), [understand all of its concepts and work on the task] (3). More time! (6). - More practical sessions and time for practice (4). 	
Examples	<ul style="list-style-type: none"> - Having available more example scripts, buildings, objects or animation samples (2). - Being able to look at former students' work (3). 	
Technical	Graphics	<ul style="list-style-type: none"> - Better frame rate speed (2). Better resolution. Better graphics and user interface (3). - More user-friendly objects' editing options (e.g. first person).
	Programming	<ul style="list-style-type: none"> - Better programming functionality. Scripts bug out continuously and sometimes stop working completely. LSL is very experimental and physics are not performing well or at least as they should. - Better physics. - Improvement of the functions/operation of the programming language (LSL) (3).
	Other	<ul style="list-style-type: none"> - More options to customize avatars. - Ability to play music. - VoIP input. - Larger gallery of compatible 3D models (4).
	Assignment	<ul style="list-style-type: none"> - Different types of tasks such as: 'create an elevator' or 'an interactive game'. Tasks that will help to put all the knowledge. Too much freedom isn't always good. - More room and space to work (4). More primitives allowance per team (2). - A project focused just on virtual world, independently, without including other parameters.
Instructions	<ul style="list-style-type: none"> - More information about the virtual world before these projects start. It will be good to make a class about this technology in the previous year or at least a semester before to make us ready and skilled before use it for first time. - More information about the technical and educational uses of this platform. - Clear information from tutors or advisors about the work we have to undertake in the virtual world (2). - Help guides, tutorials, anything that can make it simpler and easier to use the virtual worlds (3). 	
Student Personality	<ul style="list-style-type: none"> - A game engine like Unity would have attracted more my attention and get me more engaged with the concept as it offers more compared to OpenSim. - I am a hardware engineering student, using this tool is not of my interest. - Mini virtual games as I would have been interested in the way they are coded in a virtual environment. - The company of others as I was working always alone. 	

Experiment 3 (respondents = 34% of 133)	
Time	<ul style="list-style-type: none"> - The time duration for this course was just 6 weeks which was quite little to play around with the virtual world and familiarise with. - More time to play with it before we start with the course (4). - As I was new to the virtual world, getting familiar and learning LSL consumed a lot of time. - More time (3).
Examples	<ul style="list-style-type: none"> - If we had the ability to get premade models and improve them, instead of building from scratch, would have been better. - Being able to explore sites developed by other users (non-students).
Graphics	<ul style="list-style-type: none"> - Better/improved graphics quality (3). More realistic graphics. - Higher resolution textures. Larger texture library. - Ability to model our avatars more nicely. More customisation options e.g. character, clothes. - Ability to upload audio-visual material.
Technical	<ul style="list-style-type: none"> - Suggestions from the IDE to correct our code problems. - I wish that the coding and/or 3D development process was more technical or challenging as in Unity.
Other	<ul style="list-style-type: none"> - More reliable viewer to access the virtual world (2). Easier controls & more up-to-date software. A more advanced technology to host the virtual world (2). - If the server had less latency, freezes or crashes when many users were online (3). Continually disconnecting made it difficult to remain engaged. If people were not creating multiple scripts that stressed the server for no reason. Better server stability. More reliable or stable server (5). - Option to integrate models compatible with Maya[®] & 3Ds Max[®]. - Better computers.
Assignment	<ul style="list-style-type: none"> - More creative tasks/exercises (2). Better plots so that more things and more exciting stuff could be created. - No 10 scripts limitation per team. - Limited land space on virtual world was a constraint. A bigger world/larger area to work (2). Option to create our own workspace. - More emphasis on challenges e.g. a competition to make best game.
Instructions	<ul style="list-style-type: none"> - More lectures and more step-by-step guidance in practical sessions. Not just thrown into the deep. If we were having demonstrations on how to script using this language (3). Learning the LSL scripting language earlier as we didn't even know the basics before getting started (2). More sessions on how the virtual world is used and how objects can be amplified. - Considering that I am not a fan of virtual worlds and my subject area is not relevant to this, I would prefer to have some extra practical sessions or help with this technology. The way it is now is not fair for all students since other courses have a dedicated unit for this. - Discussions of potential implementations related to our project.
Student Personality	<ul style="list-style-type: none"> - A more like 'Sims' world-environment. More sociable. As it is now, the world is meant for work. So only when work needs to be done or only during lesson time will I enter the world. - I would like to have some games that could test our scripting ability. More games similar to the maze or the racing one. - Having more interaction with other group members. More help from my group. - More social activities e.g. pub or nightclub.

Experiment 4 (respondents = 27% of 165)	
Time	<ul style="list-style-type: none"> - Additional time; probably running it as a separate unit. More time (3) - Earlier start (introduction) to the virtual world (2).
Examples	<ul style="list-style-type: none"> - Examples from previous students' work. More examples from the lecturer, just to give ideas of what is possible to do. Show us the best or most difficult things so that we can work up to that. - A library type of knowledge base to help get ideas, scripts etc. More material to refer to especially at the start. More information than the wiki. - If we had example objects/scripts in our inventory beforehand so as to get a baseline.
Graphics	<ul style="list-style-type: none"> - Better graphics (2). - If the virtual world was more real (2).
Programming	<ul style="list-style-type: none"> - Better scripting/physics mechanisms.
Technical	<ul style="list-style-type: none"> - This technology is a bit outdated. - The server issues (latencies/crashes) (3).
Other	<ul style="list-style-type: none"> - The experience was overall nice but it had many bugs which were annoying. - Allow import of models other than Collada (.dae). More flexibility on the file formats of models that can be imported.
Assignment	<ul style="list-style-type: none"> - More space to work on our project (2). Having larger space to build and expand more our showcase would have helped us put more effort into it. - To have a 'game' environment where challenges are set and completed by students (e.g. by adding parts of code in the objects). Something like a puzzle that can only be completed with user code. - An environment (e.g. blog) to generate tasks for competition.
Instructions	<ul style="list-style-type: none"> - More lectures on how to use the virtual world (4). More practical sessions to work and experiment with the virtual environment before starting with the assignment (e.g. make artifacts, LSL) (3). - Tutorials or guidelines would have been helpful as most of us were new to that (3). There are so many options for the user when entering for first time. Restrain the user for some time or give some tutorial sessions beforehand. - Instructional videos to help us adapt quickly (2).
Student Personality	<ul style="list-style-type: none"> - This added extra workload that was not needed and using such an old system was not useful. - I didn't find it challenging enough. - If more users around the university used it. - RPG element; some form of progression.

Appendix E

Frequency of observed interactions

		Experiment 1/Observation week number																			
Physical Classroom		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20
		Communication (observation frequency 30")																			
C1.	talks to classmate about the project/world	186	122	97	76	111	95	83	76	99	108	89	94	109	103	87	86	68	47	41	53
C2.	talks to classmate about something irrelevant to the project/world	67	54	81	19	56	62	34	27	39	22	49	29	67	47	33	104	47	45	11	19
C3.	talks to tutor/demonstrator about the project/world	29	31	17	54	46	53	41	24	42	35	28	61	44	56	39	37	53	77	51	93
C4.	talks to tutor/demonstrator about something irrelevant to the project/world	17	12	9	11	26	12	19	3	6	21	8	11	19	4	16	67	21	13	12	7
C5.	positive comment (emotional experience)	9	5	2	0	1	4	7	2	6	2	9	2	7	11	4	0	0	6	0	14
C6.	positive comment (technology)	4	3	0	1	0	9	2	0	6	0	1	0	2	0	4	0	0	0	0	0
C7.	negative comment (technology)	29	9	11	13	22	11	9	3	5	6	4	7	18	2	0	3	6	11	4	2
C8.	negative comment (emotional experience)	7	4	2	0	0	2	0	7	0	0	12	5	1	0	3	0	6	3	0	1
		Attitude/Feelings (observation frequency 30")																			
C9.	focused on project	68	146	121	172	74	109	149	127	106	154	126	97	78	71	146	101	126	163	104	93
C10.	enjoy the project	39	92	88	103	47	33	77	58	49	28	37	62	43	49	91	67	59	47	19	9
C11.	'absent-minded'	2	8	14	5	9	21	11	2	3	1	4	23	16	11	6	8	2	9	13	19
C12.	unpleased using the virtual world	17	11	22	29	33	16	23	14	21	27	16	9	4	17	14	11	25	34	13	8
		Student Identity (observation frequency 30")																			
C13.	refers to avatar in the first person	49	24	7	9	67	23	9	2	11	0	0	3	51	34	21	0	8	0	5	0
C14.	refers to avatar in the second person	11	5	2	0	8	6	3	0	2	0	0	0	13	7	2	0	1	2	0	0
C15.	refers to avatar in the third person	1	0	1	0	0	1	1	0	0	2	0	0	0	0	3	0	2	0	0	0
C16.	refers to avatar as an object	0	1	0	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	1	0

Experiment 1/Observation week number																					
Virtual World	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	
Communication (observation frequency 30")																					
V1.	chats with classmate about the project/world	22	7	5	0	26	0	12	3	19	0	0	0	18	5	0	14	0	9	0	0
V2.	chats with classmate about something irrelevant to the project/world	3	0	1	0	3	0	3	0	2	0	0	0	2	0	0	0	0	2	0	0
V3.	words/phrases revealing enjoyment	0	0	0	0	7	0	4	1	2	0	0	0	0	0	0	0	0	1	0	0
V4.	words/phrases revealing exclamation	2	0	1	0	4	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0
V5.	words/phrases often used in social networks	11	3	2	0	14	0	7	1	12	0	0	0	13	2	0	8	0	7	0	0
V6.	negative comment (technology)	5	0	2	0	7	0	2	0	3	0	0	0	5	1	0	2	0	2	0	0
V7.	negative comment (emotions)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
V8.	emoticons	11	2	0	0	7	0	1	2	3	0	0	0	9	0	0	2	0	6	0	0
V9.	avatar gestures	0	0	5	0	0	2	0	8	0	0	0	3	0	0	13	0	6	0	0	0
Attitude/Feelings (observation frequency 30")																					
V10.	works on project	117	156	103	235	31	138	102	93	79	95	119	97	62	95	106	71	54	83	95	77
V11.	Performs actions irrelevant to the project	98	46	31	19	74	43	39	46	48	67	53	41	59	57	34	41	63	21	29	14
V12.	use own virtual creations	76	93	47	160	18	72	54	19	34	52	47	51	37	43	36	54	37	41	33	19
V13.	use in-world tools	61	89	98	152	17	51	69	58	42	29	58	63	26	48	81	37	29	36	71	36
V14.	explores/uses students' virtual artefacts	158	40	28	19	104	36	21	43	17	29	35	26	97	24	46	28	9	26	59	34
V15.	use the content developed by the researcher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Avatar Identity (observation frequency 30")																					
V16.	refers to avatar in the first person (chat)	3	0	0	2	5	0	0	0	2	0	0	0	5	0	0	2	0	0	0	0
V17.	refers to avatar in the second person (chat)	1	0	0	0	2	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0
V18.	refers to avatar in the third person (chat)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V19.	refers to avatar as an object (chat)	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0
V20.	modifies avatar appearance	92	69	37	29	168	79	23	38	7	15	24	7	116	64	36	19	45	13	8	0

Experiment 1/Observation week number																				
Physical Classroom & Virtual World	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20
Occupation (number of students)																				
CV1. 'logs-in' before the beginning of the session.	0	6	1	5	0	2	0	0	2	0	2	10	0	1	7	3	0	0	2	0
CV2. 'logs-in' at the beginning of the session.	12	4	9	3	12	7	11	10	7	9	7	2	9	5	2	4	5	7	5	3
CV3. 'logs-in' later than the beginning of the session.	0	2	2	4	0	3	1	2	3	3	3	0	0	3	0	2	4	2	2	6
CV4. 'logs-out' before the end of the session.	0	0	1	0	8	5	9	6	6	5	3	1	0	4	5	0	1	1	7	4
CV5. 'logs-out' right after the end of the session.	10	8	9	9	4	6	0	4	5	6	9	2	7	5	2	7	5	6	2	3
CV6. stays in-world after the end of the session.	2	4	2	3	0	1	3	2	1	1	0	9	2	0	0	2	3	2	0	1

		Experiment 2/Observation week number															
Physical Classroom		2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	2.13	2.14	2.15	2.16
		Communication (observation frequency 30")															
C1.	talks to classmate about the project/world	204	181	129	118	78	103	51	89	56	47	154	103	87	91	78	41
C2.	talks to classmate about something irrelevant to the project/world	67	29	71	57	38	81	14	57	104	45	27	17	43	26	17	35
C3.	talks to tutor/demonstrator about the project/world	72	46	27	66	101	39	114	56	37	77	14	96	105	71	93	43
C4.	talks to tutor/demonstrator about something irrelevant to the project/world	9	27	13	9	7	14	5	2	21	13	15	4	16	29	11	7
C5.	positive comment (emotional experience)	7	5	0	1	0	7	0	0	2	6	4	11	4	0	7	3
C6.	positive comment (technology)	3	0	2	0	0	4	0	0	3	0	8	2	1	0	0	0
C7.	negative comment (technology)	16	7	9	13	8	6	0	2	6	1	0	9	0	4	2	6
C8.	negative comment (emotional experience)	5	2	0	0	3	0	4	1	2	7	3	2	5	0	6	2
		Attitude/Feelings (observation frequency 30")															
C9.	focused on project	51	93	127	104	64	116	109	43	71	57	47	81	113	154	126	136
C10.	enjoy the project	10	39	61	58	19	57	64	7	19	34	13	49	61	47	39	57
C11.	'absent-minded'	2	0	9	7	4	11	8	0	4	0	3	0	9	0	3	0
C12.	unpleased using the virtual world	17	25	5	11	16	8	22	3	13	19	29	4	11	7	21	9
		Student Identity (observation frequency 30")															
C13.	refers to avatar in the first person	3	1	0	0	7	0	0	2	0	0	6	4	0	0	0	0
C14.	refers to avatar in the second person	5	1	0	0	4	0	0	0	0	0	2	0	2	0	0	0
C15.	refers to avatar in the third person	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
C16.	refers to avatar as an object	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0

		Experiment 2/Observation week number															
Virtual World		2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	2.13	2.14	2.15	2.16
		Communication (observation frequency 30")															
V1.	chats with classmate about the project/world	11	0	2	0	19	0	1	9	0	0	13	2	7	2	0	0
V2.	chats with classmate about something irrelevant to the project/world	9	0	3	0	6	0	3	2	0	0	4	9	0	3	0	0
V3.	words/phrases revealing enjoyment	3	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
V4.	words/phrases revealing exclamation	0	0	1	0	0	0	0	2	0	0	6	0	1	0	0	0
V5.	words/phrases often used in social networks	2	0	0	0	7	0	0	4	0	0	4	2	1	0	0	0
V6.	negative comment (technology)	0	0	0	0	0	0	1	1	0	0	3	0	0	0	0	0
V7.	negative comment (emotions)	1	0	0	0	3	0	0	1	0	0	2	0	1	0	0	0
V8.	emoticons	7	0	1	0	11	0	0	6	0	0	9	6	4	1	0	0
V9.	avatar gestures	9	0	4	0	6	0	0	3	0	0	0	0	1	0	0	2
		Attitude/Feelings (observation frequency 30")															
V10.	works on project	98	129	155	178	24	109	134	126	67	93	87	61	86	97	106	73
V11.	Performs actions irrelevant to the project	147	94	78	49	63	53	37	28	53	64	107	82	46	59	34	29
V12.	use own virtual creations	103	129	137	149	78	94	59	76	31	49	66	57	73	61	86	39
V13.	use in-world tools	67	98	109	111	11	87	119	104	39	41	35	28	44	96	57	29
V14.	explores/uses students' virtual artefacts	18	39	54	28	6	34	23	29	31	16	39	21	43	34	23	17
V15.	use the content developed by the researcher	74	35	23	7	58	43	22	31	19	9	67	39	17	6	12	3
		Avatar Identity (observation frequency 30")															
V16.	refers to avatar in the first person (chat)	4	0	1	0	7	0	0	5	0	0	6	0	0	0	0	0
V17.	refers to avatar in the second person (chat)	1	0	0	0	2	0	0	1	0	0	2	0	0	0	0	0
V18.	refers to avatar in the third person (chat)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V19.	refers to avatar as an object (chat)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V20.	modifies avatar appearance	94	56	29	14	61	44	39	26	13	108	73	49	22	37	15	4

Experiment 2/Observation week																	
Physical Classroom & Virtual World		2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	2.13	2.14	2.15	2.16
Occupation (number of students)																	
CV1.	'logs-in' before the beginning of the session.	0	0	0	4	0	3	0	0	2	0	0	0	3	2	0	0
CV2.	'logs-in' at the beginning of the session.	17	17	17	13	15	9	9	12	11	9	11	7	6	6	11	9
CV3.	'logs-in' later than the beginning of the session.	0	0	0	0	0	3	6	3	2	6	0	4	2	3	0	2
CV4.	'logs-out' before the end of the session.	0	3	0	4	0	3	2	3	6	4	0	0	4	0	0	0
CV5.	'logs-out' right after the end of the session.	17	11	14	11	15	7	11	12	9	6	11	9	7	8	11	8
CV6.	stays in-world after the end of the session.	0	3	3	2	0	5	2	0	0	5	0	2	0	3	0	3

Experiment 3/Observation week														
Physical Classroom	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	3.12	3.13	3.14
Communication (observation frequency 30")														
C1. talks to classmate about the project/world	63	87	118	79	104	173	127	105	89	51	92	44	97	33
C2. talks to classmate about something irrelevant to the project/world	27	11	26	8	41	29	17	39	14	66	14	52	43	18
C3. talks to tutor/demonstrator about the project/world	29	21	24	37	54	61	73	41	59	63	24	39	34	29
C4. talks to tutor/demonstrator about something irrelevant to the project/world	7	17	13	4	8	11	9	12	20	9	11	6	3	8
C5. positive comment (emotional experience)	5	0	2	3	11	3	0	4	0	0	7	0	3	0
C6. positive comment (technology)	3	0	1	0	7	0	5	0	2	0	2	0	1	0
C7. negative comment (technology)	9	4	6	0	12	2	3	6	0	4	2	0	3	0
C8. negative comment (emotional experience)	0	0	1	0	0	2	0	3	0	0	1	0	2	0
Attitude/Feelings (observation frequency 30")														
C9. focused on project	71	102	98	84	42	97	139	118	156	46	78	108	64	93
C10. enjoy the project	23	63	47	45	13	71	92	103	62	31	33	49	42	21
C11. 'absent-minded'	8	16	9	3	6	12	4	7	13	11	8	4	8	19
C12. unpleased using the virtual world	2	14	0	7	9	16	11	17	9	7	9	23	6	3
Student Identity (observation frequency 30")														
C13. refers to avatar in the first person	24	7	13	4	11	17	6	9	2	0	15	0	6	0
C14. refers to avatar in the second person	8	3	9	1	7	4	2	4	0	0	7	1	4	4
C15. refers to avatar in the third person	1	0	0	0	2	0	0	1	0	0	5	1	0	1
C16. refers to avatar as an object	0	1	0	0	0	0	1	0	0	0	2	0	0	0

Experiment 3/Observation week														
Virtual World	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	3.12	3.13	3.14
Communication (observation frequency 30")														
V1. chats with classmate about the project/world	17	0	8	0	23	0	0	97	0	0	9	45	12	0
V2. chats with classmate about something irrelevant to the project/world	3	0	14	0	8	0	0	11	0	0	11	4	13	0
V3. words/phrases revealing enjoyment	2	0	4	0	5	0	0	19	0	0	0	9	5	0
V4. words/phrases revealing exclamation	1	0	2	0	2	0	0	8	0	0	2	4	2	0
V5. words/phrases often used is social networks	11	0	9	0	14	0	0	32	0	0	10	0	9	0
V6. negative comment (technology)	4	0	0	0	2	0	0	6	0	0	2	4	1	0
V7. negative comment (emotions)	1	0	2	0	3	0	0	7	0	0	3	6	2	0
V8. emoticons	8	0	5	0	12	0	0	29	0	0	5	21	14	0
V9. avatar gestures	21	17	0	13	9	6	0	56	0	19	34	2	8	0
Attitude/Feelings (observation frequency 30")														
V10. works on project	84	107	93	148	69	124	107	139	89	39	57	101	99	61
V11. Performs actions irrelevant to the project	66	119	57	42	98	73	84	106	26	31	109	60	37	19
V12. use own virtual creations	48	61	66	81	48	106	83	98	71	43	28	41	56	28
V13. use in-world tools	101	103	108	89	77	158	109	131	81	77	29	37	24	36
V14. explores/uses students' virtual artefacts	13	20	29	64	9	53	89	47	31	18	93	57	25	19
V15. use the content developed by the researcher	74	51	39	17	51	63	41	32	11	69	47	21	32	17
Avatar Identity (observation frequency 30")														
V16. refers to avatar in the first person (chat)	2	0	0	0	0	3	0	5	0	0	1	0	0	0
V17. refers to avatar in the second person (chat)	0	0	1	0	0	0	0	3	0	0	3	0	0	0
V18. refers to avatar in the third person (chat)	0	0	0	0	0	0	0	2	0	0	0	0	0	0
V19. refers to avatar as an object (chat)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V20. modifies avatar appearance	109	57	36	29	164	71	58	23	16	4	96	47	24	17

		Experiment 3/Observation week													
Physical Classroom & Virtual World		3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	3.12	3.13	3.14
		Occupation (number of students)													
CV1.	'logs-in' before the beginning of the session.	0	0	3	2	0	0	0	4	2	0	0	0	4	2
CV2.	'logs-in' at the beginning of the session.	15	15	12	9	23	17	16	13	15	19	12	9	6	7
CV3.	'logs-in' later than the beginning of the session.	0	0	0	4	0	6	7	6	6	4	0	3	2	3
CV4.	'logs-out' before the end of the session.	3	5	3	2	0	6	7	4	3	6	3	0	3	0
CV5.	'logs-out' right after the end of the session.	9	10	7	11	19	13	16	11	20	15	9	12	7	9
CV6.	stays in-world after the end of the session.	3	0	5	2	4	4	0	8	0	2	0	0	2	3

Experiment 4/Observation week															
Physical Classroom		4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	4.11	4.12	4.13	4.14
Communication (observation frequency 30")															
C1.	talks to classmate about the project/world	104	93	71	89	91	78	49	118	78	144	84	71	103	94
C2.	talks to classmate about something irrelevant to the project/world	19	37	24	48	26	11	9	43	38	17	35	23	41	57
C3.	talks to tutor/demonstrator about the project/world	46	28	34	41	61	57	23	39	71	63	33	44	66	39
C4.	talks to tutor/demonstrator about something irrelevant to the project/world	8	0	9	0	6	0	3	0	5	0	7	0	8	5
C5.	positive comment (emotional experience)	16	7	0	0	11	4	0	6	0	14	5	0	6	0
C6.	positive comment (technology)	9	3	0	0	7	0	0	2	0	3	0	4	0	0
C7.	negative comment (technology)	14	7	2	0	11	0	3	0	0	4	0	9	2	5
C8.	negative comment (emotional experience)	5	2	0	1	0	6	0	0	7	6	0	3	0	1
Attitude/Feelings (observation frequency 30")															
C9.	focused on project	51	92	108	84	73	101	124	97	102	59	95	108	113	75
C10.	enjoy the project	10	36	71	47	28	63	86	51	77	26	43	59	61	33
C11.	'absent-minded'	3	11	7	5	13	4	19	2	21	9	12	15	11	3
C12.	unpleased using the virtual world	19	6	3	9	5	1	9	7	9	4	9	2	0	2
Student Identity (observation frequency 30")															
C13.	refers to avatar in the first person	11	5	2	0	23	5	0	8	5	17	2	5	0	1
C14.	refers to avatar in the second person	4	0	0	0	3	1	0	2	0	0	0	1	3	0
C15.	refers to avatar in the third person	1	0	0	0	0	0	0	0	1	0	0	0	0	0
C16.	refers to avatar as an object	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Experiment 4/Observation week															
Virtual World	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	4.11	4.12	4.13	4.14	
Communication (observation frequency 30")															
V1.	chats with classmate about the project/world	5	14	0	6	4	7	25	9	7	4	2	8	0	3
V2.	chats with classmate about something irrelevant to the project/world	4	0	0	0	7	0	0	3	0	1	0	3	0	0
V3.	words/phrases revealing enjoyment	0	3	0	1	0	0	4	0	2	0	0	0	0	0
V4.	words/phrases revealing exclamation	2	6	0	2	4	0	7	5	0	0	0	2	0	0
V5.	words/phrases often used is social networks	4	9	0	2	6	4	11	5	3	1	0	3	0	1
V6.	negative comment (technology)	2	5	0	1	0	3	6	2	0	0	0	1	0	0
V7.	negative comment (emotions)	0	2	0	0	1	0	5	1	0	0	0	2	0	0
V8.	emoticons	6	12	0	4	9	5	14	7	4	2	1	5	0	1
V9.	avatar gestures	21	0	0	5	0	14	0	9	0	3	17	0	12	0
Attitude/Feelings (observation frequency 30")															
V10.	works on project	61	47	106	91	73	91	52	79	99	76	61	107	93	104
V11.	Performs actions irrelevant to the project	45	31	54	22	63	40	37	58	43	51	76	34	64	22
V12.	use own virtual creations	41	43	83	98	54	62	49	44	82	56	32	66	49	73
V13.	use in-world tools	65	77	44	93	56	37	24	61	78	44	28	68	41	52
V14.	explores/uses students' virtual artefacts	14	28	62	31	34	56	25	19	27	43	22	31	16	29
V15.	use the content developed by the researcher	19	5	11	3	13	7	0	9	0	47	24	9	15	6
Avatar Identity (observation frequency 30")															
V16.	refers to avatar in the first person (chat)	9	5	0	0	13	4	7	0	0	9	4	0	0	0
V17.	refers to avatar in the second person (chat)	4	0	0	0	0	0	0	0	0	2	0	2	0	0
V18.	refers to avatar in the third person (chat)	0	1	0	0	0	0	0	0	1	0	0	0	0	0
V19.	refers to avatar as an object (chat)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
V20.	modifies avatar appearance	89	73	41	12	104	61	35	17	29	98	72	51	36	18

		Experiment 4/Observation week													
Physical Classroom & Virtual World		4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	4.11	4.12	4.13	4.14
		Occupation (number of students)													
CV1.	'logs-in' before the beginning of the session.	0	0	6	4	0	0	2	0	5	0	0	0	3	4
CV2.	'logs-in' at the beginning of the session.	17	12	7	11	15	11	9	13	8	12	9	8	7	9
CV3.	'logs-in' later than the beginning of the session.	0	5	4	2	2	6	6	4	4	4	7	8	6	3
CV4.	'logs-out' before the end of the session.	3	0	3	5	3	6	4	5	7	3	4	5	6	3
CV5.	'logs-out' right after the end of the session.	14	17	11	10	14	9	13	11	7	13	12	7	10	13
CV6.	stays in-world after the end of the session.	0	0	3	2	0	2	0	1	3	0	0	4	0	1

Appendix F

Statistical tests' formulas (implemented in R software)

- **Mean & Standard Deviation**

The sample's mean and standard deviation values are calculated as follows:

$$\bar{x} = \sum \frac{x_i}{n} \quad (1) \qquad s_x = \frac{\sqrt{\sum (x_i - \bar{x})^2}}{n-1} \quad (2)$$

where x_i defines the independent observations and n the total number of observations.

- **Kruskal-Wallis H test**

The formula to calculate the \hat{H} value of the K-W test is as follows (Kruskal & Wallis, 1952):

$$\hat{H} = \left[\frac{12}{n(n+1)} \right] \left[\sum_{i=1}^k \frac{R_i^2}{n_i} \right] - 3(n+1) \quad (3)$$

where:

$n = \sum_i^k n_i$ is the total sample size,

n_i the number of data of the i^{th} group and

R_i^2 the squared rank sum of the i^{th} group.

In the presence of many ties, the test statistics \hat{H} can be corrected using Eqs. 4 and 5.

$$C = 1 - \frac{\sum_{i=1}^{i=r} (t_i^3 - t_i)}{n^3 - n} \quad (4)$$

with t_i the number of ties of the i^{th} group of ties.

$$\hat{H}^* = \hat{H}/C \quad (5)$$

The H_0 assumes that the k samples belong to the same population,

$$H_0 : \bar{R}_i = \frac{n+1}{2} \quad (6)$$

whilst given that the test statistic \bar{H} is approximately χ^2 -distributed, the H_0 is withdrawn if:

$$\hat{H} > x_k^2 - 1; a \quad (7)$$

where a is the probability of a type-I error—occurring when a true H_0 is rejected—and has been set to .05.

- **Conover-Iman**

The formula to calculate the Conover-Iman test p value is:

$$|\bar{R}_i - \bar{R}_j| > t_{1-a/2; n-k} \sqrt{s^2 \left[\frac{n-1-\hat{H}^*}{n-k} \right] \left[\frac{1}{n_i} + \frac{1}{n_j} \right]} \quad (8)$$

where \hat{H}^* is the tie corrected Kruskal-Wallis statistic according to eq. 5 and $t_{1-a/2; n-k}$ the t -value of the student-t-distribution. The variance s^2 is given in case of ties by:

$$s^2 = \frac{1}{n-1} \left[\sum R_i^2 - n \frac{(n+1)^2}{4} \right] \quad (9)$$

and is simplified to $n(n+1)/12$, if there are no ties present.

- **Cochran-Armitage Trend Test**

Technical note: Assuming we have k independent binomial variates y_i with response probabilities p_i deriving from samples of size n_i at covariate levels x_i for $i = 1, 2, \dots, k$, where $x_1 < x_2 < \dots < x_k$. The scores x_i originate from the column names (attributed values) of the ordinal variables, where the positive (agreement) responses are ranked as 3, the neutral as 2 and the negative (disagreement) as 1.

We define the following:

$$N = \sum_{i=1}^k n_i \quad (10)$$

$$\bar{p} = \frac{1}{N} \sum_{i=0}^k y_i \quad (11)$$

$$\bar{q} = 1 - \bar{p} \quad (12)$$

$$\bar{x} = \frac{1}{N} \sum_{i=1}^k n_i x_i \quad (13)$$

Following the above, the uncorrected formula for the CA test is as follows (Nam, 1987):

$$Z = \frac{\sum_{i=1}^k y_i (x_i - \bar{x})}{\sqrt{\bar{p}\bar{q} \left[\sum_{i=1}^k n_i (x_i - \bar{x})^2 \right]}} \quad (14)$$

The H_0 for this test assumes that there is no association between the observed proportions (i.e. they are independent) and the probability of a type-I error is set, once again, to .05.

$$H_0 : p_1 = p_2 = \dots = p_k \text{ vs. } H_1 : p_1 < p_2 < \dots < p_k \text{ or } p_1 > p_2 > \dots > p_k \quad (15)$$

Thus, the test rejects the H_0 if $\geq 1 - a/2$ (16).

- **Freeman's theta**

Technical note: For a data set (x_i, y_i) , where (\bar{x}, \bar{y}) are the means of the data set, and r is the correlation coefficient, we calculate:

$$SSM = \sum (\bar{y} - \hat{y}_i)^2 \quad (17) \quad \text{where, M (model): GroupMean} - \text{GlobalMean}$$

$$SSE = \sum (y_i - \hat{y}_i)^2 \quad (18) \quad \text{where, E (error): ObservedResponse} - \text{GroupMean}$$

Notice that:

$$SST = SSM + SSE \quad (19) \quad \text{where, T (total): ObservedResponse} - \text{GlobalMean}$$

The formula to calculate Freeman's theta is:

$$r^2 = \frac{SSM}{SST} \quad (20)$$

*SS abbreviates the 'sum of squares'