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Constructionism in Non-Goal Orientated Virtual Worlds

A thesis submitted to the University of Dublin, Trinity College
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy

Carina Girvan

2013



Thesis 10200

Declaration

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Related Publications

Journal Articles

- Girvan, C., Tangney, B. & Savage, T. (2013). SLurtles: A tool to support constructionist learning in Second Life. *Computers & Education* 61(1) 115-132
- Girvan, C. & Savage, T. (2012). Ethical considerations for educational research in a virtual world. *Interactive Learning Environments* 20(3) p.239-251.
- Girvan, C. & Savage, T. (2010). Identifying an appropriate pedagogy for virtual worlds: A Communal Constructivism case study. *Computers & Education* 55(1) p.342-349.

Book Chapters

- Girvan, C. & Savage, T. (in press). Guidelines for conducting text based interviews in virtual worlds. In Childs, M. and Peachey, A. (Eds.) *Understanding Learning in Virtual Worlds* UK: Springer.

Peer Reviewed Conference Papers

- Girvan, C. & Savage, T. (2011). Conducting interviews in virtual worlds. In Proceedings of *ReLIVE 2011*. Milton Keynes, UK
- Girvan, C., Tangney, B. & Savage, T. (2010). SLurtle Soup: a conceptual mash up of constructionist ideas and virtual worlds. In proceedings *Constructionism 2010*. Paris, France

Conference Presentations

- Girvan, C., Tangney, B. & Savage, T. (2012). *SLurtles: Constructionist tools for virtual worlds*. Presented at EdTech (Educational Technology), Maynooth, Ireland, 2012.
- Girvan, C., Tangney, B. & Savage, T. (2011). *SLurtles: Objects-to-think-with in a virtual world*. Presented at CAL (Computer Assisted Learning), Manchester, 2011.
- Girvan, C., Savage, T., Devitt, A. & Collins, M. (2011). *Partnering pedagogy and technology*. In Symposium: Partnerships in learning and technology. Presented at ESAI (Educational Studies Association of Ireland), Dublin, 2011.
- Girvan, C. (2009). *Aligning pedagogy and affordances in virtual worlds*. Presented at Immers[ed], Derry, 2009. (Invited)
- Girvan, C. & Savage, T. (2009). *Pedagogical design of learning experiences within virtual worlds*. Presented at Virtual Worlds – Best Practices in Education, Second Life, 2009.
- Girvan, C., FitzGibbon, A. & Savage, T. (2009). *Identification and analysis of pedagogy in action within multi-user virtual environments*. Presented at CAL, Brighton, 2009.

Summary

Non-goal orientated virtual worlds have gained particular interest from educators in recent years; however learning experiences tend to replicate traditional praxis and lack pedagogical underpinning. This thesis proposes that to move from replication towards innovation, learning experiences need to be underpinned by pedagogical theory which can leverage the unique combination of perceived educational affordances of the technology.

Constructionism is identified in this thesis as a pedagogy that could strongly leverage the features of non-goal orientated virtual worlds. However there are no existing studies that enhance our understanding of the pedagogy when implemented in non-goal orientated virtual worlds with groups of learners. There are also features of the technology that are not present in previously studied constructionist learning environments. This raises the question of whether constructionism is appropriate for use in non-goal orientated virtual worlds in practice.

Constructionism places an emphasis on the process of constructing personally meaningful and shareable artefacts. However inbuilt construction tools in non-goal orientated virtual worlds can present learners with a steep learning curve for the novice to master. To address this problem, this thesis presents the design and implementation of SLurtles. SLurtles provide learners with easy to use programmable turtles in *Second Life* which enable learners to construct a variety of complex, personally meaningful and shareable artefacts.

Through two case studies, constructionism is explored in action with groups of learners in the non-goal orientated virtual world *Second Life*. In total 50 postgraduate learners participated in SLurtle-based constructionist learning experiences. In small groups and working at distance from one another, learners programmed SLurtles to create interactive installations in *Second Life* over several weeks. Open interviews provide the primary data for qualitative analysis, with observations, learners' reflections and artefacts providing corroboratory evidence.

The findings confirm that constructionism is an appropriate pedagogy to underpin learning experiences in non-goal orientated virtual worlds and develops an understanding of the pedagogy in action. SLurtles are shown to provide learners with a powerful tool with which to engage in the exploration, testing and extending of their understanding as they construct artefacts. Finally the understanding of pedagogy and technology alignment, of barriers to constructionist learning and the opportunities to engage in distributed constructionism provide a foundation for future research on constructionist learning experiences in non-goal orientated virtual worlds.

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1 Introduction

“Nobody wants to use technology to recreate education as it is” (Scardamalia & Bereiter, 1994, p256), yet as new technologies emerge early adopters tend to replicate existing practices in these new environments (Winn, 2005). However there comes a point at which there is a need to move beyond what a technology can replace and consider the unique characteristics and potential that the technology can offer.

This thesis focuses on virtual worlds; in particular non-goal orientated virtual worlds (NGO-VWs), which support user-generated content. While this technology is increasingly being explored by educators and educational researchers, there continues to be evidence of replication. Savin-Baden et al. (2011) also highlight the lack of pedagogical underpinning in reported virtual world learning experiences, stating that as a research field we are now at a point where we need to begin looking at the relationship between pedagogy and technology.

It is argued in this thesis that to make the move from replication to transformation, pedagogy must leverage the perceived educational affordances of NGO-VWs. This is achieved through a four stage process in which pedagogical features are aligned to the perceived educational affordances of the technology. Through this process I identify constructionism as particularly strongly aligned to the technology and thus a potentially appropriate pedagogy with which to underpin the design of learning experiences in NGO-VWs.

1.1 Constructionism in non-goal orientated virtual worlds

In constructionist learning experiences, learners actively develop their understanding through the construction of personally meaningful and shareable artefacts (Papert, 1991) and NGO-VWs appear to provide an exciting new environment to engage in constructionist learning. Yet constructionism is only reported as underpinning two learning experiences in the literature (Good et al., 2008; Dreher et al., 2009) and these report no results or findings that enhance our understanding of constructionism in action in a virtual world. Compounding this problem, virtual world technologies provide features and perceived educational affordances that are not present in previously studied constructionist learning environments, for example avatars and social embodied presence. This raises the question as to whether constructionism is actually an appropriate pedagogy for use in NGO-VWs in practice.

The answer to this question is likely to be complex and dependent on contextual factors. However there is a paucity of literature on constructionism in NGO-VWs with which to direct research in this area. Thus, the primary aim of the research presented in this thesis is:

To explore constructionism in action in non-goal orientated virtual worlds.

Underpinning constructionist learning experiences is the learner's engagement with programming and the construction of personally meaningful and shareable artefacts (Hoyles, Noss & Adamson, 2002). However the inbuilt tools of NGO-VWs such as *Second Life* and *Active Worlds* present the novice with a high-floor (steep learning curve) barrier to overcome (Dickey, 2005; Sanchez, 2009), preventing learners from quickly engaging in the use of these tools to create personally meaningful artefacts.

To address these barriers, I designed and implemented SLurtles (programmable turtles in *Second Life*) to provide learners with an easy to use, programmable construction tool in-world. As the name suggests, SLurtles are designed in the tradition of Papert's (1980) Turtle, for use in the NGO-VW *Second Life*. Underpinning the design of SLurtles are the broad constructionist principles of low-floor (easy to use), high-ceiling (powerfully expressive) and wide-walls (support the creation of a variety of artefacts), concepts central in the design of constructionist tools for learning. Design concepts were drawn from a range of existing low-floor tools and constructionist learning environments particularly Turtle Graphics and *Scratch for Second Life* (S4SL) (Rosenbaum, 2008). SLurtles were originally designed to be used in conjunction with the graphical programming environment S4SL, however SLurtles have also been implemented in *OpenSim* using *Scratch for OpenSim* (Devlin, 2012).

In this thesis, SLurtles are implemented as part of a learning experience in order to achieve the research aim. Following the alignment of the perceived educational affordances of the technology to the features of constructionism, the affordances are leveraged in the design to provide opportunity for the pedagogical features to emerge during the learning experience. For example the flexible nature of the technology providing opportunity for the learners to access the environment from a location and at a time of their choosing is leveraged to support *bricolage*. However it is important to note that context is also important in the design of the learning experience. In a different context where learners had restricted access to the NGO-VW, it would not be possible to leverage this affordance and thus other approaches to supporting *bricolage* would have to be explored.

1.2 Research approach

To achieve the primary aim of this thesis two interpretive case studies are implemented with differing methods. The first is an exploratory case study, commonly used to pilot aspects of a study and generate research questions when there is a dearth of existing literature and theory in the area (Yin, 2009). Through the exploratory case study SLurtles are piloted and the proposed alignment of pedagogy and technology is explored through the purpose designed learning experience. Non-traditional, in-world data collection approaches are also piloted and refined for use in subsequent research. Finally one of the great advantages of exploratory case studies is that they allow the research to remain open to emergent findings which lead the development of research questions for subsequent studies (Yin, 2003). Thus the first case study had four research aims:

- Explore SLurtles in action with learners
- Explore the learning experience in action with learners
- Refine in-world data collection
- Generate research questions for future research.

A SLurtle-based constructionist learning experience was implemented with 24 postgraduate learners working in pairs at distance from one another. Over four weeks they programmed SLurtles to create interactive installations in *Second Life*. Interviews provided the primary source of data and were analysed using the constant comparative approach. Learners' artefacts and reflections created during the learning experience were collected and along with observational data were used in the validation process.

SLurtles were found to provide learners with an empowering low-floor, high-ceiling and wide-wall tool with which to engage in constructionist learning experiences in NGO-VWs. While the findings of the first case study broadly support the proposed alignment of pedagogy and technology, there are some aspects which require further examination. Several areas for future research emerged of which two are further examined in the second case study.

The first is the role of the avatar. Avatars were identified as a common theme across the learning experience in the first case study, highlighting the need to gain greater depth of understanding of the role of avatars in constructionist learning experiences in NGO-VWs. The second area to be examined in the second case study is the barriers encountered which limit learners' engagement in the learning experience. As constructionist learning environments are designed to lower barriers to engagement, barriers and their outcomes were further explored in a second case study. Two research questions provided the focus for the second case study:

- How do barriers affect constructionist learning experiences in non-goal orientated virtual worlds?
- What role does the learner's avatar play during a distributed constructionist learning experience in non-goal orientated virtual worlds?

The second case study follows an instrumental case study approach. A similar SLurtle-based constructionist learning experience was implemented with a similar group of 26 learners. Again interviews provided the primary source of data. Participant-observations and learners' reflections provided corroboratory data which were used for validation.

The findings of the second case study develop the emerging understanding of barriers to constructionist learning experiences in NGO-VWs and the role of avatars. While all learners may experience personal barriers, those learners that experience technical barriers may be restricted in their engagement with the learning experience and have a limited connection to their avatar. Those that had a negative association to their avatar did not experience embodied social presence, a key feature in the design of the learning experience. However when interacting with other learners in-world they identified a sense of co-presence. These findings are important in further developing an understanding of constructionism in action in NGO-VWs to meet the primary research aim.

1.3 Contributions

In *Mindstorms*, Papert (1980) advocated "the construction of educationally powerful computational environments that will provide alternatives to traditional classrooms and traditional instruction" (p182). The work presented in this thesis makes several contributions. The primary contribution is the identification and validation of constructionism as an appropriate pedagogy to underpin learning experiences in NGO-VWs. With SLurtles providing a low-floor programmable construction tool through which learners can engage in constructionist learning activities, NGO-VWs may provide Papert's educationally powerful computational environment.

I introduce a process which aligns pedagogy and technology to both identify and design for pedagogies which could successfully underpin learning experiences in NGO-VWs (Girvan & Savage, 2010). Rather than examining individual features of the technology or pedagogical praxis as per Conole et al. (2004), the process focuses on leveraging the perceived educational affordances to provide opportunities for the features of pedagogical theory to emerge. The process provides educators, designers and researchers with a systematic approach to identifying and justifying the choice of pedagogy used to underpin learning experiences. Conversely it could be used to identify whether a specific technology is suitable for use with a

particular pedagogy. However central to the approach is the idea that the technology provides a supporting platform for the pedagogy.

Following this process, a further contribution has been the development of a set of guidelines for the design of SLurtle-based constructionist learning experiences in NGO-VWs, for use by educators, researchers and designers. This includes a set of six design principles. From these design principles, a set of generic design features are derived, which should be applied regardless of context, as well as context specific features.

To validate the theoretical proposition, groups of learners engaged in a purpose designed constructionist learning experience in a NGO-VW. While there are inbuilt tools to create and programme persistent objects, these may present learners with a steep learning curve before they are able to engage in the construction of personally meaningful artefacts. I designed SLurtles to overcome this barrier to engagement (Girvan, Tangney & Savage, 2010), leveraging the pre-existing graphical programming environment *Scratch for Second Life* (S4SL).

SLurtles provide learners with an empowering tool with which to engage learners in programming through the creation of persistent objects (Girvan, Tangney & Savage, in press). The efficacy of SLurtles has also been recognised on the course in which they were implemented in this study, the upshot of which is the continued use of the learning experience on the course. The success of SLurtles is further reflected in the interest they have generated in the wider education community. For example, the use of SLurtles with 11 and 12 year-old children to explore shape (Devlin, 2012).

Other contributions include the definition of terms to address confusion within the academic discourse. 'Virtual worlds' is a term rarely and inconsistently defined in the literature, confusing the dialogue on their effective use in education. To address this I have developed a definition and classification of virtual worlds, identifying NGO-VWs as a distinct sub-set. Additionally, 'affordance' is a term often used but seldom defined. In the wider technology enhanced learning field, John and Sutherland (2005) highlight the need to develop the concept so that it can be used by educators and researchers to uncover the potential of new technologies. Consequently, this thesis introduces and defines the term 'perceived educational affordances' (Girvan & Savage, 2010).

Finally, to support the research conducted in this thesis a number of in-world ethical and data collection issues have been considered. With new technological features and educational opportunities come new ethical questions which the current literature fails to address in any depth. This thesis considers different philosophical approaches to ethics, exploring the

traditional ethical issues of informed consent, privacy protection and identity in the non-traditional NGO-VW (Girvan & Savage, 2012). Questions are also raised about data collection procedures. To begin to further the discussion of best-practice for data collection within NGO-VWs; the opportunities, constraints, interviewer techniques and research implications of conducting interviews in-world are presented (Girvan & Savage, 2011; Girvan & Savage, in press). The work presented in this thesis on in-world ethical and data collection issues provide researchers with guiding principles for the design and implementation of research in NGO-VWs.

1.4 The structure of this thesis

The work referred to above is presented in detail across six further chapters:

Chapter 2 presents a structured review of the literature. It begins by clearly identifying NGO-VWs within the wider virtual world genre, as well as their perceived educational affordances, a term defined in this thesis. This is followed by the systematic alignment of the perceived educational affordances to several constructivist pedagogies. Constructionism emerges from the analysis as particularly strongly aligned to the perceived educational affordances of NGO-VWs and is discussed in detail. The alignment is presented in Table 2.5 and for ease of reading is reproduced in Chapters 3, 5 and 7. Maintaining consecutive numbering of tables, the original table number is also provided in brackets. Through the review of the literature the research problem emerges which in turn defines the primary aim of this thesis.

Chapter 3 addresses the barriers to engaging in constructionist learning activities in NGO-VWs by presenting the design of SLurtles (low-floor programmable Turtles in *Second Life*). This is followed by the systematic alignment of pedagogy and technology to identify design principles for SLurtle-based learning experiences.

Chapter 4 considers a range of methodological issues in order to explore constructionism in action. This chapter identifies the case study method, particularly exploratory and instrumental, as an appropriate method for use in this research. This chapter considers both data collection and ethical concerns of conducting research in NGO-VWs and clearly identifies the approaches taken in this thesis.

Chapter 5 presents the first implementation of a SLurtle-based constructionist learning experience with 24 learners, through an exploratory case study. The research focuses on the lived experience of the learners and data analysis follows the constant comparative approach. A discussion of the findings takes place towards the end of this chapter. Both SLurtles and the learning experience are examined in action and research questions about constructionism in NGO-VWs are generated for the subsequent case study.

Chapter 6 utilises an instrumental case study with content analysis to examine two aspects of constructionist learning experiences in NGO-VWs: barriers to the learning experience and the role of the avatar. This provides an opportunity to explore these areas in more depth and raises yet more areas for future research.

Chapter 7 concludes the thesis by drawing together the findings of the two case studies to present the understanding of constructionism in action in NGO-VWs developed through this thesis. It develops the initial theoretical alignment of pedagogy and technology, examines the barriers to engaging in constructionist learning in NGO-VWs and discusses the role of the avatar in distributed constructionism. Additional outcomes of the research, together with limitations and directions for future research are also presented.

2 Literature Review

2.1 Introduction

This chapter presents a structured review of the educational literature on NGO-VWs which informs the research undertaken in this thesis. Boote and Beile (2005) highlight the messy and complex problem of reviewing educational literature. To provide some clarity, this review is divided into five sections, focusing on three key areas: virtual worlds, affordances and pedagogy.

The review of **virtual worlds** in education begins by discussing and resolving the ambiguity of the terms used to label different forms of virtual worlds in the literature. Through the literature search process, a growing list of terms used to label the technology was identified. However these labels are often applied without definition. This results in confusion in the literature and as a consequence, articles were retrieved on technologies that were outside the scope of this research. Therefore, this chapter begins by defining different types of virtual worlds and key terms. These are used to provide inclusion and exclusion criteria for the remaining review.

Non-goal orientated virtual worlds (NGO-VWs) are identified as the focus of this research and a broad overview of the research literature on their use in third level education is presented in the second section. This concludes by examining the arguments surrounding the use of pedagogy to underpin technology enhanced learning experiences in NGO-VWs. The role of technology in identifying appropriate pedagogies is discussed and the approach taken in this thesis is outlined.

Affordance is a term often used but seldom defined in educational technology literature. For the purpose of this thesis, this is resolved through the use and definition of the term **perceived educational affordances**. Using this definition to provide inclusion and exclusion criteria, this section concludes by presenting a synthesised list of five perceived educational affordances in the educational use of NGO-VWs, identified from the literature.

Pedagogy is the focus of the final two sections of the literature review. The first identifies six pedagogical theories which could be used to underpin learning experiences in NGO-VWs. Of these, constructionism is identified as a pedagogical theory strongly aligned to the perceived educational affordances of the technology. The second section discusses constructionist learning experiences and their application in NGO-VWs. This highlights the potential barriers of high-floor construction and programming tools in NGO-VWs. There are also few studies that report the use of constructionist learning experiences in NGO-VWs. Those that do, provide no

description as to how the pedagogy is used to underpin the design of the learning experience and no results or findings that enhance our understanding of constructionism in action with groups of learners in a NGO-VW. Yet there are features and perceived educational affordances of NGO-VWs that are not present in other constructionist learning environments and their impact on constructionist learning needs to be examined. Thus, thorough the review of the literature, the research problem emerges and in turn defines the primary aim of the research presented in this thesis:

To explore constructionism in action in non-goal orientated virtual worlds

2.2 Virtual worlds

2.2.1 Defining virtual worlds

The ongoing development of virtual worlds, from text to graphical environments as well as providing a widening range of user experiences, has resulted in a fragmented understanding in the literature of what a virtual world is and is not. To further complicate this problem a variety of terms are used in the literature to label the technology: virtual world (VW); virtual environment (VE); multi-user virtual environment (MUVE); immersive virtual world (IVW); serious virtual world (SVW); social virtual world (also SVW in Reinhard, 2010); and synthetic virtual world.

While the lack of a clear and common understanding of a term is not uncommon in a developing field such as virtual worlds, there are implications. For example the variety of terms used by authors can cause confusion, such as MUVE and virtual world both used to label *Second Life* in one article by Honey et al. (2012), while others label *Second Life* an IVW (McArdle & Bertolotto, 2012), a social virtual world (Jarmon & Sanchez, 2008), or a virtual environment (Singh & Lee, 2009). Virtual environment is also used by Minocha et al. (2010) to label *Facebook*, however social applications such as *Facebook* are very different to virtual worlds. As Bell (2008) and Minocha et al. (2010) note, although both of these applications use avatars to represent the user, the role or functionality of the avatar differs significantly. While both forms of avatar provide a digital representation of the user, only the avatar in *Second Life* has agency and is controlled in real-time.

In addition to the variety of terms, there is inconsistency in the definition or description of these terms within the literature. For example while Marsh (2010) describes virtual worlds as either two-dimensional (2D) or three-dimensional (3D), they are only described as 3D by other authors. The inconsistent use of terms (e.g. virtual world, MUVE and SVW) and descriptors (e.g.

2D and 3D), means that it is unclear as to whether these terms are synonymous or refer to subtle differences between applications.

Schroeder (2008) emphasises the importance of accurately defining what virtual worlds are in order to guide research. Although the literature lacks a commonly used and accepted definition of the term 'virtual world', Bell (2008) has attempted to address this by reviewing existing definitions by Bartle (2003) and Castronova (2005), combining elements of each of these to provide a new definition:

"A synchronous, persistent network of people, represented as avatars, facilitated by networked computers" (Bell, 2008, p2)

Bell (2008) goes on to define what is meant by each term used in the definition. He makes a clear distinction between avatars used to represent a user in an application such as *Facebook*, in which the avatar is a static representation of the user on a website, and avatars in virtual worlds, in which the avatar has agency. Bell's (2008) description of 'synchronous', while describing real-time interactions, also includes the concept of space and sense of environment. Yet it is unclear as to how synchronous interactions provide the user with a concept of space or sense of environment. Additionally, descriptors commonly used in the literature such as 'immersive' (e.g. Warburton, 2009; de Freitas et al., 2010; Grenfell & Warren, 2010) are not accounted for in this definition. Consequently, this definition requires further development.

In a thought piece, published in the same journal issue as Bell's definition, Schroeder (2008) describes virtual worlds as "persistent virtual environments in which people experience others as being there with them - and where they can interact with them" (p2). Schroeder (2008) goes on to highlight the immersive qualities of virtual worlds, facilitated though the visual nature of the technology. While there are similarities between the work of Schroeder (2008) and Bell (2008), such as the importance of 'persistence' in defining a virtual world, there are also differences such as Bell's emphasis on the representation of the user as an avatar within the virtual world.

In order to establish a clear understanding of the term 'virtual world' for the purpose of this thesis, a systematic review of 87 peer-reviewed articles was conducted. Articles were selected which provided a description or definition of virtual worlds, or of any of the commonly used terms identified above such as MUVE or IVW. Multiple articles by the same author remained in the review (for example Dickey 2003, 2005a, 2005b & 2011) if they described different applications or there was evidence in a change to the author's definition or description of virtual worlds, otherwise they were excluded.

As shown in Table 2.1 below, across the articles the most commonly used term was virtual world (63 articles), followed by MUVE (14 articles) and immersive virtual world (8 articles). Social virtual world, serious virtual world, synthetic world, virtual environment and virtual reality were used in three or less articles each. 68 articles provided a description, 10 a definition and 9 provided both. As part of the description or definition, 59 articles specified a particular application, with *Second Life* the most common (46 articles), followed by *Active Worlds* (7 articles). Other applications were specified in only one article and are collated under 'other' in Table 2.1 which illustrates the frequency with which each term and application appeared within the review. It should be noted that some articles use more than one term (e.g. Honey et al., 2012) and some use more than one application (e.g. Johnson & Levine, 2008).

Table 2.1 Frequency of terms and applications identified

Term	Application				Total
	<i>Active Worlds</i>	<i>Second Life</i>	Other	None identified	
IVW	1	4		3	8
MUVE		8	1	4	13
Social VW		2			2
SVW			2		2
Synthetic world				3	3
Virtual environment		3			3
Virtual reality		1			1
Virtual world	6	28	3	26	63
Total	7	46	6	36	95

The descriptions and definitions of virtual worlds presented in each article were analysed using *in vivo* coding to identify key words or phrases. Codes which emerged in only one article or used by only one author were removed (*2D*, *expansive*, *fidelity* and *world-like*) or merged with another (*sense of place* with *sense of presence*). To further refine the set of codes, redundancy was identified in strongly related codes (*build with user-generated content*; *network of people* and *online* with *facilitated by networked computers*; *real-time* with *synchronous*; and *sense of presence* with *immersive*).

Multimedia, although a common feature identified in the literature, was not used in the final definition or categorisation of virtual worlds in this thesis. *Multimedia* was disregarded as any technology using a combination of media, such as text, images and sound, can be classed as multimedia. Thus, all graphical virtual worlds contain multimedia.

At the end of this process there was a set of 16 codes:

- *3D*
- *Avatar*
- *Communication*
- *Educational*
- *Facilitated by networked computers*
- *Goal orientated*
- *Graphical*
- *Immersive*
- *Interact with environment*
- *Interact with objects*
- *Interact with people*
- *Multiple user*
- *Persistent*
- *Simulated*
- *Synchronous*
- *User-generated content*

Appendix A provides a summary of the articles reviewed and their use of the 16 codes.

The final set of codes was analysed across terms and the applications they were identified in, such as *Second Life* and *Active Worlds*, to examine any notable differences. From this analysis it is worth noting several points. The first is that both *Quest Atlantis* (which is described as educational and goal orientated) and *Second Life* (which is not) are described as MUEs. This suggests that there may be different ways to categorise the technology. However there are some key features present regardless of terminology. For example, *immersive* was used across terms, not just immersive virtual worlds (IVWs). It is also important to note that the code *goal orientated* included both goal and NGO-VWs indicating a distinguishing feature between different types of virtual worlds.

While some authors describe *Second Life* as a virtual world, others describe it as a 3D virtual world. While *3D* can be used as a pre-fix to describe the type of virtual world, it is listed as a characteristic of virtual worlds by some. Despite this discrepancy across the literature, *3D* and *graphical* are useful terms to delineate between early text-based MUDs (multi-user dungeon/domain depending on source) and current three-dimensional graphical virtual worlds. It is important to note that from a historical perspective, 2D graphical virtual worlds provided an intermediary step between text-based and 3D virtual worlds prior to the introduction of broadband and improved computer graphics (Bell et al., 2010), however they are uncommon in the current research literature.

Some authors described interacting with people, objects and the virtual environment as discrete features of virtual worlds (e.g. Richardson et al., 2011) whilst others described them as aspects of interacting with the environment (e.g. Braman et al., 2011). In the latter case, the environment includes both objects and people represented as avatars. Thus, as users interact

with them in different ways objects, people and the environment were considered in the analysis as separate.

Finally some features, particularly *user-generated content*, are not available across all virtual world applications. For example, *River City* which was developed as a discrete implementation of *Active Worlds*, does not provide tools to create content. However the standard *Active Worlds* application provides all users with tools to create objects in the environment.

Through the analysis of codes across terms and applications, the codes *3D*, *educational*, *goal orientated*, *graphical* and *user-generated content*, were identified as criteria with which to distinguish between different virtual worlds. The remaining codes were used to create a final definition of the term 'virtual world' used in this thesis:

A persistent, simulated and immersive environment, facilitated by networked computers, providing multiple users with avatars and communication tools with which to synchronously interact with people and objects in the environment

2.2.1.1 Terms used in the definition

Each of the terms used in the definition of virtual worlds presented in this thesis makes a specific contribution to the understanding of the definition. As such they are briefly discussed below.

2.2.1.1.1 Persistent

Persistence is a defining characteristic between video games and virtual worlds as noted by Bell (2008). While multiple users can engage in online video games, either working together in a shared environment to achieve a common goal or playing against each other, video games are not persistent. A persistent environment remains whether users are logged in or not, retains the location of people and objects as well as information about object ownership (Castranova, 2001). Thus, if a user creates an object and leaves it within the virtual world, a second user will view the object in the same location whether the first user is online or not. If the second user removes the object from the location, when the first user returns to the location they will no longer be able to view the object. This is achieved through the use of a client-server architecture, in which the central server(s) manages the persistence and interactions by storing serialized versions of the objects the user creates.

2.2.1.1.2 Simulated

In 20 articles *simulated* was used as a descriptor of virtual worlds, referring to the computer-simulation of the virtual world. A simulated environment can be designed to be similar to the physical world and as Boulos et al. (2007) note, such environments allow users to engage in

otherwise risky behaviour without harming themselves or others. Virtual worlds can also be designed to simulate a fantasy environment. The location of a user within the simulated environment, as represented by their avatar, is often described as being 'in-world'.

2.2.1.1.3 Immersive

The term 'immersive' refers to the ability of some learners to become immersed in the virtual world. However, as noted by Jennett et al. (2008), 'immersion' is a term which is commonly used but seldom defined in the literature on games. This is also true of the literature on virtual worlds (for example, Johnson and Levine, 2008).

In a grounded theory study, Brown and Cairns (2004) identify three levels of immersion in gamers: engagement, engrossment and total immersion. Users who experienced total immersion, identified a sense of presence within the game in which they were no longer aware of the computer interface. However this was experienced rarely and it was much more common for users to experience engagement, in which learners had overcome initial barriers such as learning controls, or engrossment, in which the game controls became 'invisible' and the user was less self aware and more directly involved in the story of the game.

Jennett et al. (2008) argue that immersion is distinct from the strongly related concept of flow. Csikszentmihalyi (1997) describes flow as an 'optimal experience', related to psychological immersion, focus and involvement which occur through intrinsic motivation in a task. In a quantitative study of 80 participants, Faiola and Smyslova (2009) explored flow in the virtual world *Second Life*. They suggest that flow is experienced when all senses are involved; users are presented with challenges; and interactions remain effortless. In relation to immersion, Faiola and Smyslova (2009) state that participants experienced time distortion and a sense of presence within the virtual world. This suggests that at the very least, users need to experience the second level of immersion, engrossment, in order to experience flow. As such not all users may experience flow within a virtual world.

Whilst in virtual worlds, learners' engagement with learning activities may be influenced by interactivity and representational fidelity (Choi & Baek, 2011). In turn, a user's level of engagement in an activity has been found to influence the level of immersion (Brown & Cairns, 2004). Based on the work of Jennett et al. (2008) and Brown and Cairns (2004) immersion in virtual worlds is also likely to be a result of engagement, resulting in a lack of awareness of time, loss of awareness of the world outside the game environment and a sense of presence. Therefore, if learners are able to move beyond learning the basic controls of the application they will be able to engage in learning activities and have some sense of immersion. From this they may then experience engrossment and possibly total immersion.

2.2.1.1.4 Facilitated by networked computers

Facilitated by networked computers was a defining characteristic of virtual worlds identified by Bell (2008). Through a network of computers vast quantities of data about the virtual world are stored and shared. Thus a popular descriptor of virtual worlds is *online*. However to acknowledge the influence of Bell's (2008) definition, the definition in this thesis uses the descriptor *facilitated by networked computers*.

2.2.1.1.5 Multiple users

Without the network of computers it would not be possible for multiple users to engage in a shared environment. The importance of this term in the definition is to highlight that while users may interact directly with other users they can also indirectly alter the experience of users they never meet due to the persistent nature of the technology.

2.2.1.1.6 Avatars

Each user is represented in the virtual world by an avatar, which has an associated inventory of assets. It is interesting to note that in Hinduism, an avatar is the representation of a god on earth (Parrinder, 1982). This representation could be as a human or animal and allows the god to act within the world and interact with humans.

In virtual worlds avatars also have agency (Bell, 2008). Controlled by the user, they provide a representation of the user within the environment and can be used to interact with others. As such the avatar, rather than the user, is described as interacting with an object in the virtual world, although it is understood that the avatar is controlled by the user. Thus, there is a clear distinction between virtual world avatars and static icon avatars, for example those used on forums, which do not have agency.

2.2.1.1.7 Communication tools

Communication tools are essential in virtual worlds, facilitating communication between users. Depending on the application these tools include voice and text based media, through public and private messaging systems.

2.2.1.1.8 Synchronous

Virtual worlds are synchronous, with interactions occurring in real-time. This supports shared and collaborative activities such as attending a concert or planning an event.

2.2.1.1.9 Interact with people and objects in the environment

Facilitated by the network of computers, users are able to interact with other people and objects in the simulated environment. As noted, these interactions may be through communication tools or mediated by the user's avatar. When a user describes their

interactions as taking place 'in-world', this term is used to identify the locus to be in the virtual world (e.g. Kemp & Livingstone, 2006). The use of 'in-world' aims to address the contentious issue of using the terms 'real' and 'virtual'. It is argued that the use of 'real' and 'virtual' creates a dichotomous perspective in current research resulting in inaccurate assumptions, for example between 'virtual identity' and 'real identity', (Lehdonvirta, 2010). Instead, 'in-world' highlights that the user is performing an action within the virtual world environment.

2.2.1.2 Types of virtual worlds

The definition of the term 'virtual world' could equally be applied to the terms MUVE and IVW; however as 'virtual world' is more common within the literature it is used in this thesis. The definition does not distinguish between text and graphical virtual worlds and does not account for all 16 codes derived from the analysis of the literature. To address some of the differences between individual applications, the remaining codes (*graphical*, *3D*, *goal orientated* and *user-generated content*) were used to categorise the different types of virtual worlds. *Educational* was excluded as each category could include educational applications. The final classification of virtual worlds is illustrated in Figure 2.1.

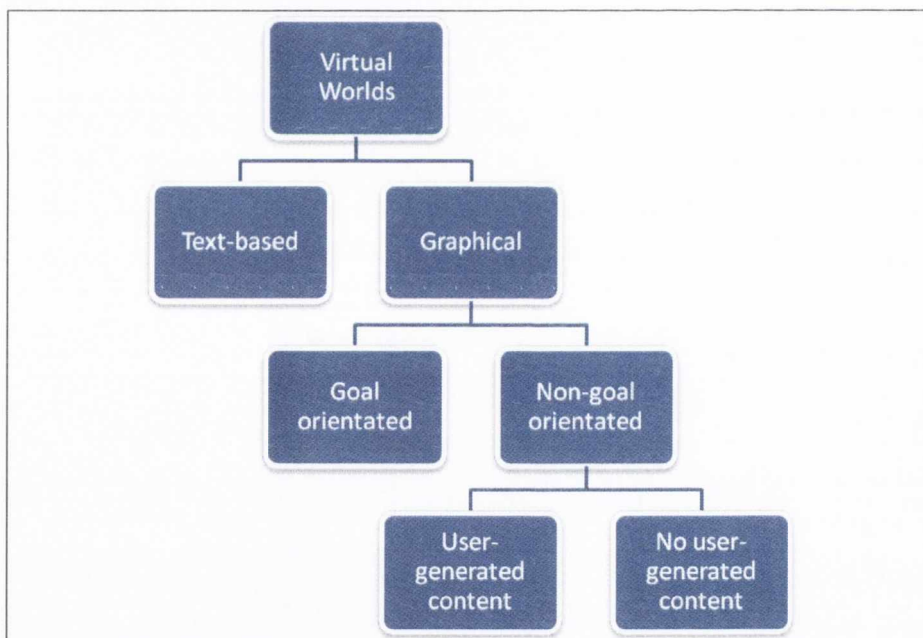


Figure 2.1 Classification of virtual worlds

As shown in Figure 2.1 the initial distinguishing criterion is whether the virtual world is text-based or graphical. As previously highlighted, from a historical perspective graphical virtual worlds can be further sub-divided into 2D (e.g. *The Manor*) and 3D, however the use of 2D virtual worlds is uncommon in educational research literature.

The second criterion considers whether the virtual world is goal-orientated or not. There are a wide range of 3D goal orientated virtual worlds designed as games, typically known as MMORPGs (massively-multiplayer online role-playing games) such as *World of Warcraft*. Goal orientated virtual worlds such as *Quest Atlantis* and *River City* are designed to provide users with an educational experience and are often termed serious virtual worlds (SVWs). All goal orientated virtual worlds have a pre-designed narrative in which users must achieve goals in order to advance. NGO-VWs lack this narrative and an inherent set of goals for users to achieve.

Finally, the construction of user-generated content within the virtual world is currently only available in NGO-VWs. Although a certain level of customisation is available in goal-orientated 3D virtual worlds, it is difficult to introduce user-generated content into a pre-determined plot. While available in some NGO-VWs, user-generated content is not available in all or to the same extent. For example, the now unavailable *Lively*, Google's browser-based virtual world, did not allow user-generated content. *There.com* provides users with the opportunity to create content however this needs to be submitted and approved, before it can appear in-world. Whereas *Second Life* allows users to freely generate and distribute content. As Delwiche (2008) notes, the influx of non-goal orientated, 3D virtual worlds launched around 2008 tend to avoid user-generated content.

Another approach to this classification is to consider each criterion on a dimension as shown in Figure 2.2. This highlights that text based, goal-orientated virtual worlds could also include limited user-generated content. Thus each virtual world can be placed at a point along each dimension, allowing each criterion to be further refined.

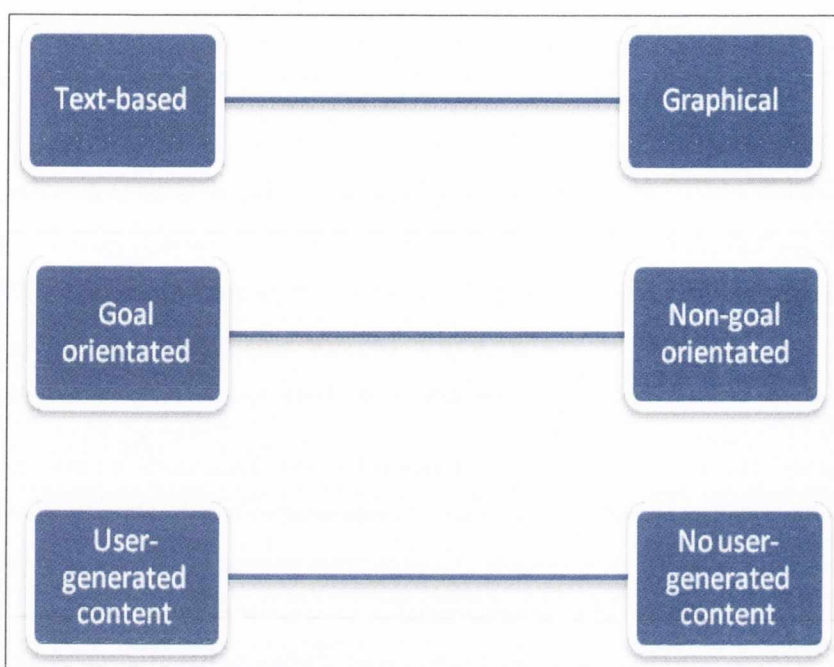


Figure 2.2 Classification of virtual worlds on dimensions.

2.3 Educational use of virtual worlds

NGO-VWs which support user-generated content are the focus of the remaining review of the literature. This technology is particularly interesting as it provides a wide range of features and flexibility which can be leveraged to design a variety of learning experiences across education sectors. There is a growing, although fragmented, literature on their use in education, particularly at third level.

Prior to examining educational literature on NGO-VWs, it is important to place the research in the historical context of the field. This is achieved through a brief chronological account of the educational use of text-based and goal orientated virtual worlds, which have influenced the development and educational use of NGO-VWs.

This is followed by an in-depth review of the wide range of issues pertinent to the educational use of NGO-VWs including: teaching and learning approaches, content management systems, barriers to education and ethical concerns. Most current research occurs in third-level education settings and this may in part be due to age restrictions of popular applications. However, with the growth of open source applications and institution run private servers, it is anticipated that the literature in the K-12 sector will grow substantially over the coming years. Although there are several strands of research in the literature, there is a tendency towards single implementations and only a few areas have been developed beyond the original

community of researchers. As such the literature is quite disparate, lacking development from one area to another.

2.3.1 Historical context

2.3.1.1 Text-based virtual worlds

Dating from the late 1970s text-based virtual worlds, known as MUDs, were developed as goal-orientated game environments (Bartle, 1999). Players navigated through these simulated environments and interacted with people and objects using text commands. While early MUDs allowed users to generate content in the form of new rooms and commands, Bartle (1999) describes these as not in keeping with the original game design.

Advances in computational power led on to the development of TinyMUD which provided users with, what is often described as, the first non-goal orientated MUD (Sanchez, 2009). Although objects created by users could not be interacted with, this project is considered to be the first development away from virtual worlds as gaming environments and towards their use as environments for socialising.

Object orientated MUDs (MOOs) allow users to create interactive objects within the virtual world and have been used in K-12 and third-level education (e.g. von der Emde et al., 2001). Bruckman (1997) developed *MOOSE Crossing*, providing children with a programming language (MOOSE) with which to create content in the virtual world. The aim was to move away from web-based information transfer towards collaborative construction of knowledge. Although text-based, Bruckman (1997) describes the move towards graphical media as inevitable. Since this work there has been a significant move away from text-based virtual worlds to graphical virtual worlds as advances in technology have supported increasingly complex graphics.

2.3.1.2 Graphical, goal orientated virtual worlds

With the development of graphical virtual worlds, *MOOSE Crossing* was developed into *AquaMOOSE 3D* (Edwards et al., 2001) with the aim of leveraging children's engagement with video games, for educational purposes (Elliot & Bruckman, 2002). In *AquaMOOSE 3D*, learners engage in mathematical thinking about parametric equations by programming the movement of their avatar in the underwater environment (Elliot et al., 2002). The later work of Sancho et al. (2009) suggests that it is the narrative of goal-orientated virtual worlds that can motivate learners, much like video games and MMORPGs. However *AquaMOOSE 3D* lacked a strong narrative and this may have been a contributing factor to the learners' reported dissatisfaction, despite initial motivation (Elliot et al., 2002).

MMORPGs provide users with a strong narrative and educational research has been conducted in popular MMORPGs. For example, focusing on the zone of proximal development (Vygotsky, 1986), Nardi et al. (2007) explored learning that occurs in order for users to participate in *World of Warcraft*. Beyond learning to participate, Delwiche (2006) and Dickey (2011) provide examples of how MMORPGs can be used to support learning in higher education courses. While a strong narrative can be motivating, the narrative also limits the use of MMORPGs across subject domains. Consequently, educators may choose to use goal orientated virtual worlds specifically designed for educational purposes with a strong narrative.

Designed for K-12 education, goal orientated virtual worlds such as *Quest Atlantis* and *River City* have been designed to meet explicit educational goals as well as providing users with an engaging narrative. Metcalf et al. (2009) suggest four key reasons for the educational use of goal-orientated virtual worlds:

- Simulate otherwise impossible settings
- Increase engagement in learning through immersion
- Support interaction and collaboration
- Increase knowledge, skills and self-efficacy

They also identify scaffolding, jigsaw pedagogy (an integral feature of WebQuests (Dodge, 1997)) and role-playing as useful supports for learners in goal-orientated virtual worlds. *Quest Atlantis* is one example, providing opportunities for both formal and informal education. It is designed to engage learners (ages 9-12) through quests on personal, social, ethical and environmental issues (Barab et al., 2005).

Clarke et al. (2008) state that goal orientated virtual worlds can provide learners with shared experiences and may be viewed as a stepping stone from the classroom to the 'real-world' beyond the classroom. As such, Ketelhut et al. (2008) identify goal-orientated virtual worlds designed for educational purposes as a potential solution to undertaking scientific enquiry in the K-12 classroom. In *River City*, school children collaborate to solve problems in the 19th Century town of River City. The *River City* application is designed to support children gain scientific enquiry skills and content knowledge, through problem-based inquiry. Areas of research have included: learners' engagement in inquiry; learning gains; and methods of assessment (Ketelhut, 2007; Ketelhut et al., 2008; and Ketelhut et al., 2010).

While there is some research into the use of goal orientated virtual worlds in third-level education, current research tends to focus on K-12. Instead third-level educators have shown a propensity towards the use of NGO-VWs.

2.3.1.3 Non-goal orientated virtual worlds

Unlike goal orientated virtual worlds, NGO-VWs lack any form of pre-determined narrative. Despite this, some authors continue to link NGO-VWs to MMORPGs, suggesting that user motivation to participate in MMORPGs is transferable to NGO-VWs (e.g. Cheal, 2009; Savin-Baden et al. 2011). However, as highlighted by Sancho et al. (2009), this motivation comes from the narrative, a feature which is absent from NGO-VWs. Others claim that certain characteristics of virtual worlds are motivating and engaging. For example, Allison et al. (2010) suggest that this is achieved through the immersive 3D nature of the technology and collaboration.

Since 2004 the New Media Consortium (NMC) have published an annual Horizon Report on the educational impact of new technologies in the short (within a year), medium (two to three years) and long term (four to five years). In 2007 the report forecast virtual worlds to impact higher education in 2009-2010 (Johnson et al., 2007). Their description of virtual worlds fits in the category of non-goal orientated virtual worlds. Martin et al. (2011) examined the success of the technologies identified in the Horizon Report, through analysis of the literature. They determined that virtual worlds were indeed successful in education. However they suggest that the reason for the success may only be the removal of a learners' fear of failure, as tasks can be redone in the virtual world.

2.3.2 Educational use of non-goal orientated virtual worlds

While NGO-VWs can support the repetition of tasks, for example through simulations, there are many other uses of the technology in third-level education. Warburton and Perez-Garcia (2010) propose eight ways in which innovative teaching and learning experiences can be supported in NGO-VWs:

- Community presence
- Content production
- Exposure to authentic content and culture
- Extended or rich social interactions
- Identity play
- Immersion
- Simulation
- Visualisation and contextualisation

However, the literature commonly shows that educators choose to use NGO-VWs due to four key features of the technology: immersion (e.g. Rapanotti et al., 2012); presence (e.g. De Lucia et al., 2009); communication (e.g. Minocha & Roberts, 2008); and user-generated content

(Baker et al., 2009). For example, Grenfell & Warren (2010) argue that immersion results in greater student interaction which leads to deeper engagement with the course material over traditional paper- and web-based repositories. It is also these four features which Dickey (2011) and Hollins and Robbins (2009), amongst many others, describe as supporting constructivist learning experiences in NGO-VWs.

Kemp and Livingstone (2006) note that NGO-VWs such as *Second Life* and *Active Worlds* provide educators with an opportunity to create their own settings and metaphors. Educators are able to introduce a narrative that fits their purpose due to the flexible nature of the environment (e.g. Edwards et al., 2008), however many learning experiences reported in the literature do not overtly feature a narrative.

Much of the current literature focuses on the educational use of NGO-VWs that support user generated content in third-level education, particularly *Second Life*. Although *Second Life* was not designed for educational use, there has been significant financial investment from third-level institutions purchasing land for marketing and educational purposes. As Baker et al. (2009) note, NGO-VWs which facilitate user-generated content have particular educational potential. Beginning with teaching and learning approaches, this section reviews the key issues relevant to the research presented in this thesis.

2.3.2.1 Teaching and Learning Approaches

Adopting a new technology into existing teaching practice requires the educator to consider the new features available and how they might be best applied to support the learning context (Mascitti et al., 2011). This section reviews the literature, highlighting the continued replication of traditional learning experiences; use of constructivist approaches such as problem-based learning and social constructivism; and concludes with a discussion on the rationale for pedagogical choices.

In spite of the variety of learning experiences reported in the literature, the natural reaction of early adopters of any new technology is to replicate what has gone before in these new environments (Winn, 2005). For example, in the recent literature on NGO-VWs there are several examples of educators continuing to replicate pre-existing learning experiences, such as replicating lecture theatres for co-located or distance learners to attend lectures (e.g. de Lucia, et al., 2009b). McCaffery et al. (2011) note that reported learning experiences which involve more than discussion and presentations are uncommon; yet it would appear that without innovation it is unlikely that the use of the technology will lead to fundamental changes in practice.

Several forms of constructivist and social constructivist learning experiences are becoming increasingly common in the literature. For example, the results of Jarmon et al.'s (2009) study into an interdisciplinary communication course in *Second Life*, found evidence that learners had engaged in experiential learning. Those that are narrative based, such as role-play (Jamaludin, Chee & Ho, 2009), leverage the flexible nature of the technology, sense of immersion in a 3D environment, construction tools and avatars. Warburton (2009) suggests that co-presence in NGO-VWs supports the sense of educator and learner presence, necessary for a community of inquiry, which can be leveraged in role-playing and simulation based learning experiences.

Good et al. (2008) describe NGO-VWs, such as *Second Life*, as providing an opportunity to address some of the traditional implementation difficulties of problem-based learning, which employs a limited form of narrative as well as simulation. Problem-based learning is a form of enquiry-based learning and is defined by Barrows (1980) as learning that occurs through engaging in a process of problem solving. Barrett (2005) describes the process as having five operational stages in which learners are introduced to the problem and then engage in independent research and group-based discussion to find a solution which is presented and reflected on. Savin-Baden et al. (2011) report on the *PREVIEW* project (Problem-based Learning in Interactive Educational Worlds) tested in educational settings such as health, medicine, social care, physiotherapy, education and psychology. These courses all involve a practice component and as such NGO-VW simulations provide a 'safe' environment in which to practice skills (Dreher et al., 2009). The flexible nature of NGO-VWs along with construction tools, provide educators with an opportunity to recreate physical world settings such as crime scenes and hospital wards in which learners can engage in problem-based learning without danger to student or patient if the student fails (Savin-Baden et al., 2011).

Moving away from overtly narrative-based learning experiences, there are a number of learning experiences reported in the literature which are identified as constructivist but, with their emphasis on communication, may be considered to be social constructivist. Minocha and Roberts (2008) found that the communication tools in NGO-VWs provide a range of collaboration opportunities, which Mascitti et al. (2011) state can be particularly difficult to achieve in distance education.

As Petrakou (2010) highlights, online education requires students and educators to be able to communicate and collaborate, however there are challenges to providing students with interactions that take place in the physical world, in online environments. While NGO-VWs present learners and educators with a number of challenges to overcome, Petrakou (2010)

notes that they enhance interactions through spatial awareness within the 3D environment and that social interaction supports collaboration.

While some authors locate the learning experiences in their research as broadly constructivist (e.g. Dickey, 2003; 2005; 2005b; 2011), and justify their pedagogical choice with reference to some of the features of NGO-VWs, they rarely align the design of the learning activity to the technology, pedagogical theory or praxis (e.g. Papadamou et al., 2010). The lack of justification for choosing teaching and learning approaches with reference to the technology, is compounded by a lack of discussion of the chosen pedagogical theory or praxis following implementation with reference to findings, with the exception of Savin-Baden et al. (2011).

Savin-Baden et al. (2011) state that there is little understanding in the literature with regard to which pedagogies are most appropriate in NGO-VWs, or about the impact of the technology on student learning and engagement. However, work on student learning and engagement tends to be reported as part of subject specific learning experiences (e.g. Ang & Wang, 2006) and may therefore be missed in a review of the literature. Additionally there is much that can be learned from the literature on goal-orientated virtual worlds.

Many of the learning experiences reported in the literature act as vehicles through which researchers can investigate specific aspects of teaching and learning in NGO-VWs, such as identity. However this does not negate the need for such learning experiences to be underpinned by pedagogical theory which leverages the features of NGO-VWs. In studies investigating motivation, engagement and learning achievement, it may be argued that a clear pedagogical underpinning of learning experiences is essential in order to fully evaluate results.

2.3.2.2 Assessment

Assessment of learning facilitated by in-world activities is an important educational issue which has received little attention in the literature to date (Wiecha et al., 2010). This may be because courses have pre-determined and institutionally approved assessment procedures and approaches. However if NGO-VWs are to provide new educational opportunities, perhaps assessment methods should also be reconsidered.

One approach could be to include in-world assessment, linked to the teaching and learning approach adopted by the educator. For example, the content management system *SLoodle* (Kemp & Livingstone, 2006) provides some in-world assessment tools focusing on the use of multiple-choice formats. Several studies have described learners creating in-world artefacts, from poster displays to simulations (Dreher et al., 2009b). However the assessment of in-world artefacts raises a number of issues.

Allison et al. (2010) highlight several issues for educators to consider when choosing whether or not to conduct in-world assessment of artefacts created by learners. These include privacy of work from other students, provenance and a reliable submission method. They explored a number of approaches to resolve these problems. Although they state that access to the work space of one student by another should be prohibited using access controls, they found this system to be unreliable in *OpenSim*. They also do not consider the potential for learners to use camera controls to explore objects that are inaccessible to their avatar. An approach to assessment, such as that proposed by Allison et al. (2010) removes the opportunity for learners to share and discuss their artefacts as they progress, a learning opportunity which would be supported by the features of NGO-VWs. Thus it is questionable as to the purpose of conducting in-world assessment, if limitations of the technology are not considered or external limitations are to be imposed.

Allison et al. (2010) also highlight a number of administration issues such as identity validation and accessibility of artefacts for assessment. *SLoodle* provides one approach to validating identity, by aligning avatar and physical world identities, however if *Moodle* is not used by the institution this solution may not be feasible. An alternative approach could be for students to submit the name of their avatar to the educator. This would already be necessary if the learning activity and assessment took place in an access controlled space and so would require no additional administration time. It should, however, be noted that this is a perennial problem in traditional education and neither of these approaches provides a water-tight solution.

The final issue is the accessibility of artefacts for assessment. Those assigning a mark to artefacts may or may not require access to scripts inside objects. For Allison et al. (2010) access to scripts was necessary as they intended to assess the learners' programming skills. Using *Opensim* on their own privately run server provided them with root privileges which could be used to assess coursework if required, however such privileges are not available through hosted services such as *ReactionGrid* or *Second Life*. There should also be consideration of the reliability of the back-up process (Derrington, 2011). If this is infrequent it could lead to coursework being lost.

Due to the lack of literature on assessment in NGO-VWs, educators and researchers should also consider research from related areas, for example assessment in goal orientated virtual worlds. As part of the *River City* project, Ketelhut et al. (2010) examined assessment methods, comparing standardised multiple-choice testing and performance assessment. They found that there were few differences in standardised testing between those that participated in the *River City* virtual world and a control group. However those that participated in the virtual world

demonstrated a greater understanding of the inquiry process in a performance assessment which required learners to write a letter. It is important to note that unlike Dreher et al. (2009b) and Allison et al. (2010), these assessment methods were used in the physical world.

2.3.2.3 Barriers to education

While there are a number of barriers to the educational use of NGO-VWs reported in the literature, these tend to be based on the reflections of participant-researchers, rather than those reported by learners. As such it is perhaps unsurprising that there is some difference of opinion between authors. Warburton (2009) identifies eight key areas under which most barriers can be classified:

- Technical
- Identity
- Culture
- Collaboration
- Time
- Economic
- Standards
- Scaffolding persistence and social discovery

Technical barriers include: client-side issues such as accessibility, bandwidth, hardware and firewalls (Kemp and Livingstone, 2006; Warburton, 2009; Allison et al., 2010; Savin-Baden et al. 2011); server-side issues such as down-time (Warburton, 2009); and developing in-world skills such as movement and communication (Sanchez, 2007; Cheal, 2009; and Jarmon et al. 2009). One particular constraint Warburton (2009) notes for the widespread educational use of NGO-VWs is down-time which can result from system updates. However through updates a number of features which support the educational use of the technology have been introduced, such as streaming multimedia, spatial audio and simplification of importing existing educational resources.

Petrakou (2010) identifies a number of issues that arise when learners engage in the NGO-VW when participating in distance education. These tend to centre on technical problems which might more easily be resolved in a face-to-face setting. Savin-Baden et al. (2011) found that avatars distracted some learners, however the quotes presented suggest that this was a skill barrier, rather than due to embodiment as an avatar. Staff involved in the *PREVIEW* project (Savin-Baden et al., 2011) stated their concern that the user interface (in this case, *Second Life*) required significant effort to learn and this could be a barrier to learners' engagement in learning. While skills such as using communication tools and avatar movement may limit

learners' engagement with almost any NGO-VW learning experience, not all activities require learners to master all skills.

Sanchez (2009b) notes the steep learning curve for learners to engage in the construction and programming of objects in NGO-VWs, while Allison et al. (2010) describe the programming language used in *Second Life*, Linden Scripting Language (LSL), as limited. Both of these are barriers identified by the authors but it is important to note the contexts of each: Allison et al. (2010) worked in the context of undergraduate computer science, while Sanchez (2009b) studied a world literature class. Thus the context of the learning must be considered when deciding on which (potential) barriers to expose students to, how they may be overcome and available alternatives. For example, Allison et al. (2010) chose to use *OpenSim* rather than *Second Life* as it supported LSL as well as C#, J# and VBScript.

Identity is described as affecting both social relationships (Warburton, 2009) as well as course administration (Kemp et al., 2009), however it may also influence learners' willingness to engage in learning experiences in NGO-VWs. Through tools such as *SLoodle* educators are able to associate the actions of an avatar to a person in the physical world, providing educators with an opportunity to validate identities (Kemp, et al., 2009). However beyond course administration, identity is a multi-faceted area of research which may have implications for education. For example, Boellstorff (2008) highlights that it is not uncommon for multiple users to use one avatar, or multiple avatars (alts) to be used by one user. As such the topic of identity is discussed in 2.3.2.5.

Warburton (2009) discusses **culture** in reference to the individual in the wider NGO-VW context, beyond a designated course island. He states that communities are difficult to find and these may have their own norms and etiquettes with no boundaries on behaviour. Meadows (2008) notes that through the use of pseudo-anonymous avatars social norms can be distorted, leading to behaviour such as 'griefing' which Kemp and Livingstone (2006) identify as a limitation of NGO-VWs for learning. Allison et al. (2010) note that NGO-VWs, such as *Second Life*, are not designed for education and therefore there are social limitations. However with the increased use of privately run grids using *OpenSim*, these barriers may be minimised.

With a variety of in-world communication tools, NGO-VWs are often described in the literature as supporting **collaborative** learning (e.g. Minocha & Roberts, 2008). However Warburton (2009) suggests that in-world collaboration is a potential barrier to learning as it requires the use of external tools to support interaction. Savin-Baden et al. (2011) found that some learners found group work in a NGO-VW difficult. Rather than the use of external tools, Savin-Baden et al. (2011) suggest that as some learners thought of *Second Life* as a game, this may have

encouraged a focus on individual learning rather than collaboration as well as learners taking a simplified approach to scenarios. However there is no data presented to support this hypothesis and as Lawlor et al. (2010) note, group work requires careful scaffolding by the educator to be successful. Savin-Baden et al. (2011) also suggest that the perception of *Second Life* as a game may also be an advantage, increasing motivation. However, as noted in previous studies on goal-orientated virtual worlds, without the graphics (Elliot et al., 2002) or strong narrative (Sancho et al., 2009) of MMORPGs and console games, this motivation may be temporary.

Object permissions, accessibility, design and construction of learning experiences as well as developing skills all require educators to invest a significant amount of **time** (Warburton, 2009). For example, Allison et al. (2010) note that ownership and permission systems in NGO-VWs such as *Second Life* are proprietary, preventing the transfer of objects to other NGO-VWs, thus increasing the time required to replicate resources. In addition, while a permission system supports copyright control, the restrictions and potential unreliability can negatively impact in-world assessment (Allison et al., 2010).

Educators choosing to run their own NGO-VW need the technical expertise, hardware and **time** to deploy and maintain the system (Allison, et al., 2010, Derrington, 2011). In-world tools for construction and programming of learning experiences can present educators with a steep learning curve and the creation of even a simple set of slides can be labour intensive (Kemp & Livingstone, 2006).

Savin-Baden et al. (2011) identify that learners without prior experience of NGO-VWs may require more **time** than anticipated to become familiar with the environment in order to fully engage in learning. Learning experiences which require learners to construct artefacts can present additional barriers for learners to overcome before engaging in learning (Dickey, 2005b; Sanchez, 2007, 2009b; Cheal, 2009).

As Warburton (2009) notes, **economic** models differ across platforms. While clients are available free to users, hosted platforms charge users for server-side services. For example a basic account in *Second Life* is free which can be attractive to educators requiring students to create accounts. However there are costs associated with buying 'land' (a server-side simulator) which allows educators to create teaching and learning environments with full access controls. Uploading images and textures as well as purchasing in-world items also cost money. While Warburton (2009) describes the costs as "relatively low", recent changes to the pricing structure of land, particularly the removal of an educational discount, has resulted in an increased interest and use of *OpenSim* and other NGO-VWs by educators (Feenan, 2011).

The lack of **standards** and interoperability between NGO-VWs (Warburton, 2009) is an ongoing issue. Hyper-gridding, supported by *OpenSim*, provides users with the opportunity to move from one privately owned virtual world to another, retaining all aspects of their avatar's identity. This may be of particular interest to educators leaving the content rich virtual world *Second Life* to other hosted services or their own private server.

Finally, Warburton (2009) reports that the social identity of avatars is limited in NGO-VWs as it is not possible to see the social connections between avatars as might be accessed through social networking sites such as *Facebook*. This reduces opportunities to **scaffold persistence and social discovery**. Some users have created online profiles for their avatars outside of the virtual world using sites such as *Facebook* and *Flickr*. Whether this is a barrier to education in NGO-VWs is unclear.

2.3.2.4 Ethical concerns

Childs et al. (2012) identify several ethical issues when implementing learning experiences in NGO-VWs. For example, those NGO-VWs that are not designed for education are primarily used for social activities and tend to have an adult demographic. Although they provide educators with a wide range of in-world content and resources, using such public environments has accompanying risks which could be limited through the private hosting of NGO-VWs such as *OpenSim*. However, by preventing learners from participating in activities in-world, learners may be deprived of educational opportunities (Childs et al., 2012). Considering the Kantian approach to ethics, activities should be designed for the good of the student with appropriate safe-guards applied. Therefore the need to provide learners with an alternative to in-world activities should be considered carefully.

Another risk is that learners may not treat activities in a NGO-VW seriously, dismissing them as games (Jarmon et al., 2009; Pasquinelli, 2010; Childs et al., 2012). The notion of NGO-VWs as a game may come from learners' preconceptions or early experiences as learners in this technology. As a result, Childs & Kuksa (2009) note that learners may experience an initial period of distraction from the intended learning outcomes, as they experiment and gain initial skills. While this can be constructive, it may also be destructive if learners come to view learning in a NGO-VW as a game and tangential to the course.

Childs et al. (2012) note that while avatars can support learning they not only present a skill barrier but can also be disconcerting. Annetta et al. (2008) identified that by giving learners an opportunity to personalise their avatar, learners gained an increased sense of presence within the virtual world and in turn co-presence with others. While Childs (2010) suggests that this

may enhance learning there are risks that need to be considered, for example the attachment of learners to their avatars and relationships they develop in-world.

Finally, Childs et al. (2012) highlight that as part of the educator's duty of care they should outline the risks to students learning in NGO-VWs, including: technical problems; culture clashes; and deception or apparent deception by others, for example, those taking an augmentationist approach would consider the concealment of offline identity to be deceptive. There are additional ethical issues specific to conducting research in NGO-VWs, discussed at length in Chapter 4.

2.3.2.5 Avatars and identity

As previously described, the use of avatars can raise a number of administrative issues for educators. While knowing who is behind an avatar for attendance and assessment as well as to address safety concerns may be important issues, the use of avatars may provide a great range of opportunities for educators and learners to explore.

Avatars provide users with an opportunity to visually present themselves in the virtual world in a number of ways, including customisation and physical actions. As Taylor (2002) notes, avatars can be used to reflect the identity or look like the user in the physical world, while other users may choose to use their avatar to experiment with various aspects of their identity. In the case of the latter, Taylor (2002) described users typically referring to their avatar in the third person, allowing for greater reflection on action. In his work on video games, Gee (2007) notes a similar phenomenon in which children acting as a character in a given game narrative will express a sense of responsibility to and for a character. As such, failure or success in the game can reside with the character and/or the user. This route to reflection may be useful for learners as they engage successfully or unsuccessfully on a given task.

The division between physical and virtual identities, or even whether one exists has been discussed by a number of authors. Taylor (2002) suggests that reconciliation of the different versions of oneself could be a potential issue. Gee (2003) proposes that role-play, a feature of MMORPGS and some NGO-VWs, requires three identities: the virtual, physical and projective identity. The projective identity lies between the physical and virtual identities, through which users can project values and desires onto virtual characters. In this way the projective identity is a conscious formulation, or as Gee describes it, it is owned and provides an opportunity to reflect on action.

When projecting a different identity through their avatar than their physical identity, Taylor (2002) suggests that avatars can be seen to be autonomous, in the eyes of the user. Outside of their control, the user doesn't know how the avatar will react in a given situation. This is not

related to overcoming problems with new user interfaces but rather the social context that the user finds themselves in. This highlights a key point of Taylor's (2002), that it is through communication, social integration and presence that users experience embodiment within the virtual world through their avatar.

Considering the interplay between virtual and physical world identities Adams et al. (2011) identify that in this context identity reformation of the self by students is limited by the educator. Virtual worlds provide an opportunity for image slippage (Robbins, 2006), and thus an opportunity for educators and learners to present themselves differently in the virtual world. This may occur through choice of clothes or appearance of a user's avatar, the way they communicate or act.

Taylor (2002) describes avatars as providing "access points in the creation of identity and social life" (p40) within a virtual world. Through a two year ethnographic study, she found that avatars embody relationships and interactions with other users and provide an intersection between the technology and the person. These interactions may be both verbal and non-verbal. Avatars provide a visual indication of being present in the virtual world. However, users may not feel a sense of presence within the virtual world without social interactions. Taylor (2002) found that while avatars grounded the user within a body in the virtual world, it was not just the existence but the use of the body with which to act and interact with the environment and other users, that the user gained a sense of immersion. Interestingly, Cheng et al. (2002) found that regular users of virtual worlds focus their efforts on interpersonal relationships rather than moving around the environment.

Schroeder (2002) suggests that the extent to which users know each other and have been involved in a virtual world affects social norms. Using in-world scripts to capture data such as the coordination position of avatars and whether they were talking, Yee et al. (2007) examined the social norms of didactic interactions between different gender couplings. The quantitative analysis of this data focused on interpersonal distance and eye gaze. They found the same social norms enacted in the virtual world as would be in the physical world. Taylor (2002) suggests that avatars that do not observe these social norms, in particular standing too close to other avatars, that this indicates that the user is new to the environment.

Focusing on education, Adams et al. (2011) found that learners' physical world identities and social norms affected their interactions within the virtual world. Their identities in the virtual world as learners were constrained by existing notions of what it is to be a student and how to learn and thus learners perceived they were having fun rather than learning, similar to the

findings of Cheal (2009). Presentation or reformation of the self can both be supported and constrained by virtual world contexts and physical world experiences.

Bennetsen (2006) presents two forms of representation within the virtual world, used in recent literature (e.g. Childs et al., in press; Smith, in press). In the augmentationist approach, a user represents themselves and interacts with others in the same way in both physical and virtual worlds. By contrast those that take an immersionist approach view the virtual and physical worlds as entirely separate, unwilling to reveal their offline identity to users in-world. Childs et al. (2013) argue that in educational settings it is likely that there will be users at multiple points on the continuum between these opposing views, however it is interesting to note that in earlier work Childs (2010) identified that all learners in his study that were identified as immersionists disliked learning in the virtual world.

2.3.2.6 Summary

Since the start of this research in 2008, there has been considerable growth in the literature investigating learning in NGO-VWs, with particular focus on third-level education and applications that support user-generated content. However general uptake has been slower than anticipated. The previous year Gartner Inc. had published their 'hype cycle for emerging technologies', showing publicly available virtual worlds sliding down from the 'peak of inflated expectations' towards the 'trough of disillusionment', predicting that mainstream adoption would take two to five years (Zastrocky, 2007). In 2011 the 'hype cycle for education' placed virtual worlds firmly in the 'trough of disillusionment' and it was predicted that it would take a further five to ten years for the technology to gain mainstream adoption in education (Lowendahl, 2011).

Whether the current position of virtual worlds on the hype cycle and associated predictions are related to the significant economic changes that have occurred around the world or to the apparent lack of innovation by some early adopters, it is not possible to comment. However to move through the trough and onto the 'slope of enlightenment' towards mainstream adoption in education, there is a need to move beyond what virtual worlds can replicate and consider the unique characteristics and potential for learning that the technology can offer. It has been argued that learning experiences require strong pedagogical underpinning to fully leverage the features of the technology whether or not they are the focus of research studies. The following section considers how pedagogy and technology can be aligned to create innovative learning experiences to help draw the use of NGO-VWs from the 'trough of disillusionment' towards mainstream adoption.

2.3.3 Pedagogy and technology

Whether pedagogy should lead technological choice or technology should lead pedagogy is a common debate in technology enhanced learning. In the literature on NGO-VWs, Savin-Baden et al. (2010) have argued against technology leading pedagogical choice, which they describe as a common trait in the research literature. In contrast, Pfeil et al. (2009) argue that a chosen pedagogy needs to fit with the technology that is used. From a pragmatic perspective it is likely that the choice of pedagogy and technology will be strongly linked to an individual teacher's epistemological views.

The term 'pedagogy' is often used to refer to different things in the literature. For example Campbell (2009) describes *Second Life* as a pedagogical tool, Gerstein (2009) describes *Quest Atlantis* as a pedagogy and Good et al. (2008) refer to both problem-based learning and constructionism as pedagogies. In this thesis, 'pedagogy' is used to refer to pedagogical theories of knowledge acquisition, which provide generalised understandings of learning and teaching such as behaviourism, rather than pedagogical praxis, which focuses on the implementation of theory through specific learning activities such as WebQuests (Dodge, 1997).

De Freitas et al. (2010) argue that currently established pedagogical approaches are necessary for effective learning in virtual worlds. However the previous section highlighted the lack of justification of pedagogical choice by researchers, in relation to the chosen technology and as Savin-Baden (2008) notes, reported learning experiences in NGO-VWs tend to lack pedagogical underpinning. In 2008 there was limited evidence in the literature of pedagogical theory being used to underpin learning experiences and although some authors noted that NGO-VWs could broadly support constructivist and social constructivist learning experiences, there was little exploration of how these theories could be implemented. The current literature demonstrates an increased awareness of the pedagogical choices made in the design of NGO-VW learning experiences, however Savin-Baden et al. (2011) have since reiterated the lack of pedagogical underpinning of learning experiences in NGO-VWs.

The previous section identified a number of approaches to teaching and learning in NGO-VWs, for example problem-based learning (e.g. Good et al., 2008; Esteves et al., 2009; Savin-Baden et al., 2011) and experiential learning (e.g. Jamaludin et al., 2009; Mayrath et al. 2011) are increasingly used. However the reasons for choosing these approaches is often based on broadly constructivist features which are linked to opportunities for socialising (Johnson et al., 2011) and interactivity (Jamaludin et al., 2009; Dickey 2003) within the NGO-VW. As a result there is a lack of justification for the approaches taken with regard to the features of the

technology. This is surprising as Warburton (2009) notes that it is the features of the technology and their potential that are of interest to educators.

As NGO-VWs which support user-generated content are the focus of the research in this thesis, there needs to be an understanding of how the technology can support specific pedagogical approaches. Whether choosing a pedagogy to fit a technology or a technology to fit a pedagogy, there needs to be an understanding of both pedagogy and technology and an understanding of how one may leverage the other in order to design effective learning experiences.

Vrellis et al. call for “guidelines and principles for designing and evaluating effective learning activities” (2010, p210) in NGO-VWs. In the broader literature on technology enhanced learning, several authors have discussed the importance of pedagogy in the design of technology enhanced learning experiences. John and Sutherland (2005) highlight that pedagogic opportunities emerge from the affordances of specific technologies. Although a study by Hobbs et al. (2006) linked learning outcomes to the affordances of NGO-VWs, it did not focus on pedagogy or consider the design of the learning experience.

Beyond the literature on NGO-VWs, John and Sutherland (2005) also note the importance of developing the concept of affordance so as to understand the potential of new technologies in education. Although John and Sutherland (2005) do not provide any clear process to align pedagogy and technology, earlier work by Conole et al. (2004) describes mapping pedagogical praxis to tools and resources. This work develops an approach to map discrete mini-learning activities to tools and resources, for example brainstorming using online chat systems. However this approach lacks the broader understanding of how aspects of a technology can be used to support the features of a chosen pedagogical theory.

Developing on from this, the research presented in this thesis introduces a four stage process in order to identify and implement a potentially appropriate pedagogy with which to underpin the design of learning experiences in NGO-VWs, illustrated in Figure 2.3.

1. The first stage of the approach is the identification of the perceived educational affordances of the technology. This is addressed in the following section (2.4).
2. The second aligns these affordances to the features of various pedagogies, implemented in section 2.5. Through mapping the perceived educational affordance to the pedagogical features which could be supported, pedagogies which may be appropriate for use with the technology can be identified.

3. The third stage considers how the wide range of affordances could be leveraged to provide opportunities for the pedagogical features to emerge. This is implemented in Chapter 3 which describes the design of the learning experience implemented in this thesis.
4. Finally this alignment is used in the design of the learning experience (Chapter 3). The designer can identify which affordances need to be leveraged or minimised to provide opportunities for the features of the pedagogy to emerge. Through this approach both pedagogy and technology can be employed to their full effect in the learning experience while pedagogy remains central to the design of the learning experience.

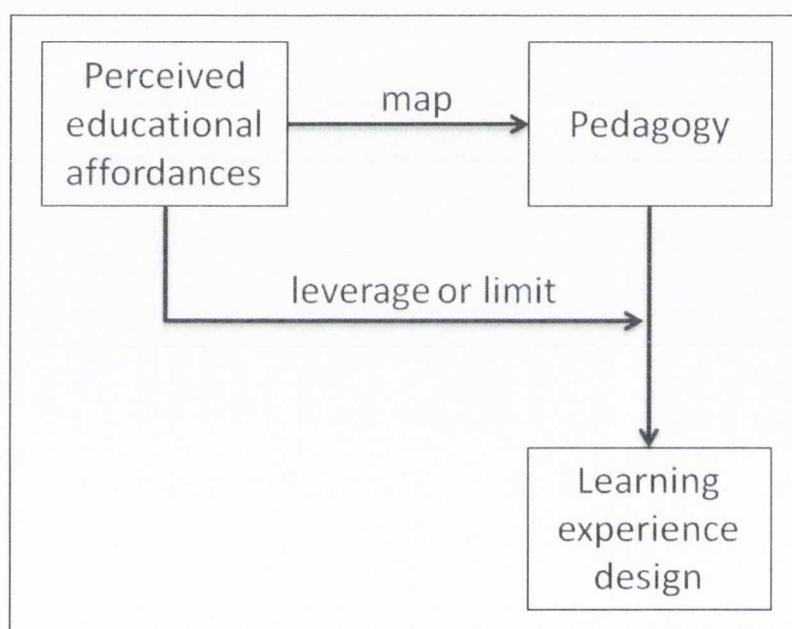


Figure 2.3 Overview of approach to support the design of pedagogically underpinned learning experiences

2.4 Perceived Educational Affordances

Within the literature on NGO-VWs, ‘affordance’ is a term often used but seldom defined. As a result, research in this area runs the risk of listing and discussing affordances without first defining what is understood by the term and confusing affordances with features. Of those articles that do provide a definition, various definitions of ‘affordance’ are offered, resulting in confusion.

In the broader literature, Oliver (2005) considers the existence of multiple and differing definitions of ‘affordance’ as devaluing the term. However, the prevalence of this concept and the confusion surrounding it places a requirement on researchers to clearly outline their

understanding of the term 'affordance' in their work. Additionally John and Sutherland (2005) highlight the need to develop the concept so that it can be used by educators and researchers to uncover the potential of new technologies.

This section addresses these points by defining and using the term 'perceived educational affordances'. This definition is then used to identify a clear set of perceived educational affordances from the literature. It supports the identification of literature which is in scope and supports the critical examination of the literature on NGO-VWs. Once identified these educational affordances are then aligned to the features of potentially appropriate constructivist pedagogies in the following section.

2.4.1 Definition

Gibson (1979) originally described affordances as relationships between what an environment offers or provides for an organism. These relationships are intuitive and can be both positive and negative. Norman (1999) went on to appropriate this term within the sphere of design, introducing a perception-action coupling where the relationship between the perceived affordance of an object and the actions of the organism may need to be learned. For example, an object perceived as a switch has an associated and learnt set of actions that can be performed. Following this development, varying definitions have emerged. Kirschner (2002) specifically defined educational affordances of a technology as the "characteristics of an artefact that determine if and how a particular learning behaviour could possibly be enacted within a given context" (p.19).

Norman (1999) makes a distinction between perceived and designed affordances. He describes the user's perceived affordances of a technology as more important to the designer, although there may be an additional 'real' or designed set of affordances. However as there is not just one 'user experience' the perceived affordances of a technology are likely to vary between users.

For educational purposes it may not be necessary to identify all possible affordances of a technology and the designed affordances may be appropriated for activities not intended by the designer. Instead it is the combination of features and/or affordances when the technology is used in an educational setting that give rise to the educational affordances perceived by the individual. Thus 'perceived educational affordances' are defined in this thesis as:

**The user's perceived set of characteristics of an artefact that may support or
constrain learning**

As the identification of perceived educational affordances is based on an individual's perception, it is likely that this perception will be influenced by the user's own epistemological views. Also as it is related to learned behaviours it will depend on the user's past experience. Thus, what one person may identify as supporting learning another may identify as a constraint.

Although Dickey (2003) distinguishes between affordances and constraints, Gibson (1979) notes that affordances may be both positive and negative. Perceived educational affordances identified in the literature on NGO-VWs have been described as potentially both positive and negative. For example, Robertson and Kipar (2010) present flexibility in both time and location of learning as potentially negative for learners, while Johnson et al. (2011) present the positive outcomes such as real-time teaching and learning. Whether identified as positive or negative may depend on the specific learning context and whether the perceived educational affordances provides an opportunity or constraint for the educator and/or learner in that context. It is also worth noting that while the identified perceived educational affordances may influence how the technology is used for educational purposes, they do not prescribe the type of teaching and learning that occurs.

There is an important distinction between the features of a technology and the perceived educational affordances. For example, communication is a perceived educational affordance of the communication tools which are a feature of NGO-VWs. Some perceived educational affordances may emerge through a combination of features and/or affordances. For example it may be suggested that it is the combination of communication tools and multiple avatars that result in the perceived educational affordance of communication (Figure 2.4), particularly in the context of a group seminar.

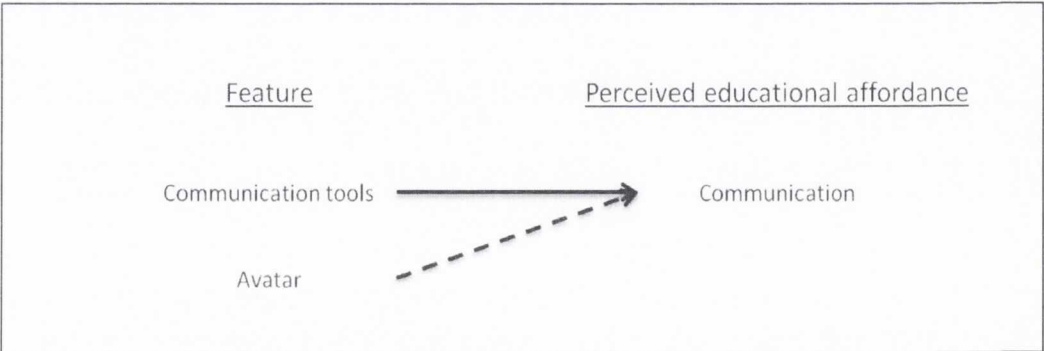


Figure 2.4 Features of the perceived educational affordance communication

In the wider literature on NGO-VWs, Dalgarno and Lee (2010) identify what they describe as the distinguishing features of 3D virtual environments: representational fidelity and learner interaction. Also described as features, Dalgarno and Lee (2010) state that identity, immersion,

presence and co-presence are characteristics of the learner experience, which emerge as a result of the distinguishing features and that these emergent characteristics afford a variety of learning tasks. Following the definition used in this thesis, the latter are identified as perceived educational affordances, although Dalgarno and Lee (2010) go on to identify what they describe as the affordances of virtual environments: facilitation of spatial knowledge representation, experiential learning, engagement, contextual learning and collaborative learning. This highlights a common occurrence in the literature whereby one or a combination of features leads to a perceived educational affordance and in turn one, or a combination of these, may result in additional perceived educational affordances.

2.4.2 Perceived educational affordances of non-goal orientated virtual worlds

As previously stated, perceived educational affordances are identified from the individual's perspective. Combined with the ongoing development of the technology, this means that there are a growing number of perceived educational affordances described in the literature on NGO-VWs. However some of these are features rather than affordances. Through analysis of the current literature, this section presents a set of five key perceived educational affordances of NGO-VWs for use in the alignment of pedagogy and technology in the following section.

In order to identify and review perceived educational affordances in the literature, a systematic process was required. Following identification of an article which used the term 'affordance', 'learning affordance' or 'pedagogical affordance', the article was reviewed to determine the approach to defining or use of the term. If congruent with the definition of perceived educational affordances, the article was included in the review, otherwise it was excluded.

For example, Dickey (2003) examined the pedagogical affordances and constraints of discourse, experiential and resource tools in *Active Worlds*, which had emerged in interviews and observations of learners and instructor in a constructivist, synchronous distance learning experience. Although she uses the term 'pedagogical affordances' Dickey does not provide any definition of this term and simply references Gibson (1979) and Norman (1999). The affordances and constraints identified by Dickey (although not always specifically labelled as such) are treated in this thesis as perceived educational affordances, as these may both support or constrain learning and were perceived by the learners or instructor. For example, while the instructor identified 'multiple simultaneous conversations' as an affordance of the chat tools, Dickey (2003) identifies that some educators may find this a negative affordance to manage. Thus, this affordance meets the definition of perceived educational affordances used in this thesis as it can both support and constrain teaching and learning.

However it should be noted that there is also a lack of consistent approaches to the identification of affordances. Some articles report a list of affordances based on the authors' experience (e.g. Hollins & Robbins, 2009), while others explore the affordances that emerge through the implementation of a specific learning activity with rigorous data collected including observation and interviews with participants (e.g. Dickey, 2003). It is perhaps only when learners fully engage can the perceived educational affordances be fully exploited (Zhang et al., 2010) and therefore identified. However the tasks that learners engage in are likely to influence the educational affordances that they identify. Yet as they are all perceived, they all fit the definition of perceived educational affordances and are thus included in the following analysis.

There was hesitation over including one article due to the research method used. Gamage et al. (2011) examine educators' perceptions of educational affordances of *Second Life*. Both experienced NGO-VW educators and those with no experience were interviewed and the findings suggest that both groups identified similar perceived educational affordances. However it is important to note that their appended schedule of questions highlights that participants were not asked to identify these but rather how they could impact student learning. As such, while the authors report that participants identified these perceived educational affordances there is no evidence to support this claim within the article. The decision was taken to include the article as these were perceived by the authors; however this limitation was considered during data analysis.

2.4.2.1 Five key perceived educational affordances

In total ten articles were identified as providing a set of perceived educational affordances of NGO-VWs. While only one did not refer to any specific application (Dalgarno and Lee, 2010), the remaining nine identified the perceived educational affordances of *Second Life*, *Active Worlds* and the now unavailable *Adobe Atmosphere* (Dickey, 2003; Dickey 2005b; Castronova, 2005; Jamaludin et al., 2009; Jarmon, 2009; Salmon, 2009; Warburton & Perez-Garica, 2010; Dickey, 2011; Gamage et al., 2011; and Olasoji & Henderson-Begg, 2011). An additional nine articles made reference to one to three perceived educational affordances of *Second Life* (Hobbs et al., 2006; Minocha & Roberts, 2008; Chodos, 2009; Robertson & Kipar, 2010; Walker, 2009; Mallum, 2010; Minocha et al., 2010; Richardson et al., 2011; and Johnson et al., 2011). In total nineteen articles were analysed to uncover links between the various perceived educational affordances identified in the literature. From this analysis a set of five key perceived educational affordances of NGO-VWs was developed:

- Immersion
- Embodied social presence

- Flexibility
- Creation of persistent objects
- Collaborative learning

Immersion, identified in four of the six sets from the literature (Jamaludin et al., 2009; Salmon, 2009; Warburton and Perez-Garcia, 2010; and Olosoji & Henderson-Begg, 2011), is described by Olosoji and Henderson-Begg (2011) as affording presence and social interaction. As described earlier in the definition of terms (2.2.1), there are several levels of immersion that users may experience while some may not experience immersion at all. Immersion, which can result from engagement with an in-world activity, may support a 'flow' experience. There are other features and affordances, such as embodiment through an avatar, which may lead to immersion (illustrated in Figure 2.5 at the end of this section).

Embodied social presence, identified by Jarmon (2009), combines several perceived educational affordances under one term. Embodiment refers to the visual representation of the user within the NGO-VW as an avatar (Dickey, 2011). Embodied through an avatar, users may experience a sense of presence (Olosoji & Henderson-Begg, 2011) within the environment, supporting both social and virtual proximity (Minocha & Roberts, 2008) to other users. While other technologies such as forums support socialisation (Minocha & Roberts, 2008), NGO-VWs afford an embodied social presence through a combination of multiple users, communication tools and avatars.

Robertson and Kipar (2010) suggest that *Second Life* can afford **flexibility** in both time and location of learning. It is of interest that this is presented as a potentially negative affordance for learning, while others present the positive outcomes of this affordance, for example real-time synchronous teaching and learning (Johnson et al., 2011).

The **creation of persistent objects** is an example of a perceived educational affordance which emerges from a combination of other perceived educational affordances and features. The focus in the literature is typically on the construction of objects. Jamaludin et al. (2009) identify creation, described by others as create and build (Dickey, 2011) or building (Jarmon, 2009). The personalisation of avatars, creation of objects and environments can support the creation of authentic and artificial 3D experiences, as well as activities in the NGO-VW. It is worth noting that Gamage et al. (2011) present both authentic and artificial 3D experiences as separate learning affordances, aligning them in turn with Dalgarno and Lee's (2010) spatial knowledge representation and experiential learning. However it is unclear as to why authentic 3D experiences align with spatial knowledge representation but not experiential learning and vice versa for artificial 3D experiences. While Hollins and Robbins (2008) identify tools as a

perceived educational affordance of NGO-VWs, these are features of the technology in the same way as an avatar is. As such it is through the use of tools that authentic and artificial experiences can be created.

Creation is supported through construction tools, while programming tools can add interactivity to objects. These tools can be used to create a wide range of learning activities including visualisations and simulations (Jarmon, 2009). However persistence of objects is also required. Persistence is not considered in any of the sets of perceived educational affordances analysed, although identified by Castronova (2005). This may be due to some authors considering it to be a feature of the technology rather than an affordance. As there are a number of features and perceived educational affordances linked to the creation of objects, this thesis uses the term **creation of persistent objects** which is sub-divided into *construction*, *programming* and *persistence* for the purpose of alignment with pedagogies in the following section.

Finally, Gamage et al. (2011) link **collaborative learning**, identified as a perceived educational affordance by Dickey (2005b) and Dalgarno and Lee (2010), with the awareness of co-presence and emotional connection. As such there appears to be a link between collaborative learning and embodied social presence, however it is not clear whether one affords the other. It may be that through collaborative learning, learners may gain an enhanced sense of co-presence and in turn an emotional connection to other learners, mediated through their avatars. This is in line with the work of Kreijns et al. (2003) who suggest that social interaction is a key aspect of computer supported collaboration. While collaborative learning is a form of activity, there are features such as communication tools and avatars which in combination with an activity, afford collaborative learning. Dalgarno and Lee (2010) separate collaborative learning from engagement, which suggests that engagement in an activity is required before collaborative learning can take place. Consequently, there is a set of perceived educational affordances which in combination with other features of the technology support the perceived educational affordance of collaborative learning and may be an outcome of the same.

Figure 2.5 illustrates the connection between features and perceived educational affordances, with the five key perceived educational affordances in bold. This work has highlighted the lack of understanding in the literature about what features or affordances lead users to identify this set of perceived educational affordances. Further research is required to develop this understanding, however this is beyond the scope of the research presented in this thesis.

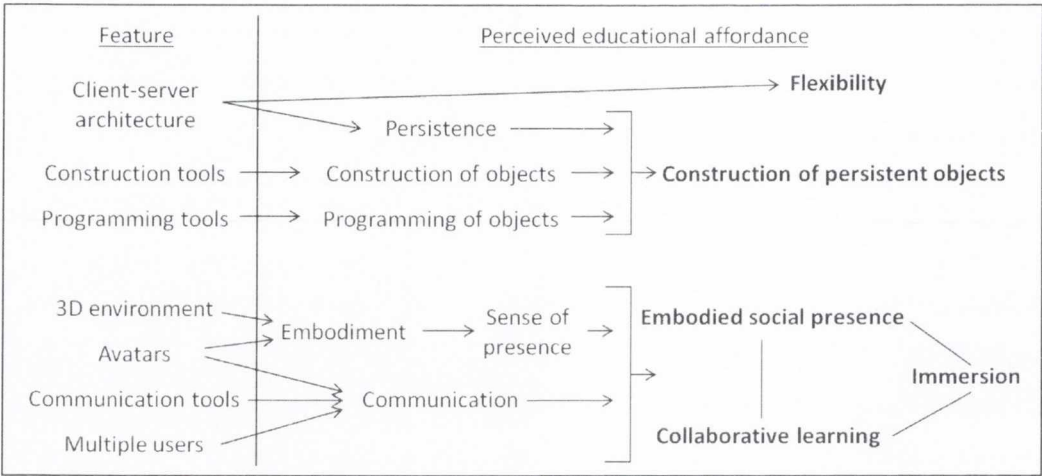


Figure 2.5 Features and perceived educational affordances of non-goal orientated virtual worlds

2.5 Aligning pedagogy to technology

The earlier section on pedagogy and technology in NGO-VWs (2.3.3) presented a systematic approach to identifying potentially appropriate pedagogies with which to underpin and design learning experiences in NGO-VWs. The first stage of the approach is the identification of the perceived educational affordances of the technology (described earlier).

The second stage of the approach aligns these affordances to potentially appropriate pedagogies. As demonstrated through my analysis of the literature, there are a variety of perceived educational affordances and thus several approaches may be appropriate. However as not all perceived educational affordances are required for each pedagogy it is also important to identify those that will not be leveraged and may need to be limited in the third stage. This will then inform the design of the learning experience.

In addition to the use of established pedagogies there is an increasing literature exploring the formulation of new pedagogies specifically for use in NGO-VWs: e.g. presence pedagogy (Bronack et al., 2008) grounded in social constructivism and dependent on the persistent nature of NGO-VWs and the opportunity for serendipitous encounters. However de Freitas et al. (2010) argue that currently established pedagogical approaches are necessary for effective learning in NGO-VWs. Therefore this section focuses on established pedagogies, mapping them to the perceived educational affordances of NGO-VWs. A number of constructivist pedagogies are considered and while all may be appropriate, constructionism is identified as particularly strongly aligned as it provides an opportunity to leverage the range of perceived educational affordances to the greatest extent.

2.5.1 Constructivism

Constructivism is a theory of knowledge acquisition, which suggests that learning occurs through experience. Heavily influenced by the work of Jean Piaget, whose work focused on the development of children's acquisition of knowledge, constructivist philosophy has influenced the development of a number of pedagogical theories such as social constructivism and constructionism.

Constructivist pedagogies focus on the active construction of knowledge through experience. By engaging in new experiences learners develop their understanding, or schemata (Piaget, 1978). A schema is the mental framework used to represent a person's understanding of an aspect of their experience. When learners engage in assimilation of knowledge they incorporate new experiences into their pre-existing schemata without changing them. When new experiences contradict existing schemata, the existing schemata are changed to accommodate the new experiences. This of course is a very simplistic description of a very complex process, however it emphasises the learner as the centre of the learning experience and actively engaged in the learning process.

Experiential learning (Kolb, 1984) is often used as an example of constructivism in action as it focuses on the learners' active engagement with a learning experience. It has also been identified in learning experiences in NGO-VWs (e.g. Mayrath et al. 2007; Jamaludin et al., 2009). Prior to the learning experience the learner has an existing understanding (schema) which supports their abstract conceptualisation during problem solving. By engaging in active experimentation, the learner gains a concrete experience which they then reflect on. This reflection focuses on whether the outcome of the active experimentation fits with the learners' abstract conceptualisation. If it does the experience is assimilated, if not the learner modifies their initial conceptualisation, experiments and observes the outcomes. Once a positive outcome has been achieved the learner may accommodate the new experience, changing their existing schema. Although heavily critiqued and developed, Kolb's experiential learning cycle (Figure 2.6) provides a useful conceptualisation of a constructivist learning process.

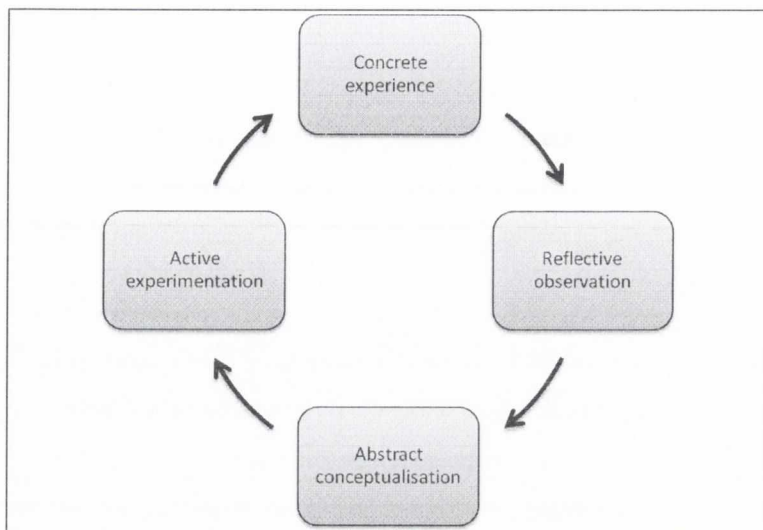


Figure 2.6 Kolb's (1984) experiential learning cycle

In the literature on NGO-VWs, constructivist learning experiences are often associated with the features of immersion (Raponott et al., 2012), presence (De Lucia et al., 2009), communication (Minocha & Roberts, 2008) and user-generated content (Baker et al., 2009). As such constructivist pedagogies may be able to fully leverage the five key perceived educational affordances, particularly collaborative learning and embodied social presence. However constructivism encompasses a wide range of theoretical approaches to learning which emphasise different features. Those considered for use in this thesis were social constructivism, knowledge building, communal constructivism, constructionism and problem-based learning. Each is discussed in the following sub-sections, presenting a proposed mapping of pedagogy and technology.

2.5.1.1 Social constructivism

Social constructivism is influenced by the work of Vygotsky (1986) and emphasises the importance of social interaction during learning. Although a contemporary of Piaget, the earlier work of Vygotsky only came to prominence after the work of Piaget was published. Whilst largely agreeing with the work of Piaget, Vygotsky (1986) suggests that as speech embodies thought learners achieve more within a community than in isolation. Thus knowledge may be considered to be the sum of what is known by all people in a group (Mercer, 2000). Primarily this knowledge is considered to exist in spoken and written language, the 'mediating tools' (Wertsch, 1991) of communities.

Although community is important, as with constructivism, social constructivism focuses on the learning of the individual rather than that of the community. The 'zone of proximal development' (Vygotsky, 1978) describes the gap between what an individual is able to achieve

on their own and their potential when engaged in problem solving with a more knowledgeable other who may be an educator or peer. This may be achieved through cognitive apprenticeship or as part of a community of inquiry (Lipman, 2003). Over time, as the learners’ schemata develop, they no longer require the support of the more knowledgeable other.

Social constructivism, with its emphasis on social interaction provides a strong opportunity to leverage immersion, embodied social presence and collaborative learning (Table 2.2). As several authors note, the communication tools in NGO-VWs can support a range of social constructivist learning activities (e.g. Minocha & Roberts, 2008). However there is no particular feature of the pedagogy which would require learners to leverage flexibility or the creation of persistent objects, although they could be incorporated into a specific learning activity. As such, while social constructivism aligns with some of the key perceived educational affordances, there are related pedagogies which have greater emphasis on construction and may therefore leverage the creation of persistent object and flexibility more strongly.

Table 2.2 Alignment of the features of social constructivism and the perceived educational affordances of non-goal orientated virtual worlds

Social constructivism	Perceived educational affordances	
-	Creation of persistent objects	Construction
		Programming
		Persistence
-	Flexibility	
Social interaction More knowledgeable others	Embodied social presence	
	Immersion	
	Collaborative learning	

2.5.1.2 Knowledge Building

Knowledge Building is a constructivist pedagogy based on the use of authentic problems; self-organisation, monitoring and correction; collective responsibility; discourse; and the creation of artefacts to advance the collective knowledge (Scardamalia, 2002; Scardamalia and Bereiter, 2003; Scardamalia and Bereiter, 2006). While there is structure there is also freedom to pursue individual lines of enquiry, although individual learning is considered to be a by-product of the process. The focus is on the process of community knowledge creation, a process in which individuals contribute by questioning, researching and working with others to build community knowledge. At the end of the knowledge building process, the community creates a final artefact to represent the advancement of the community knowledge.

Whilst acknowledging that discourse is central to knowledge building theory, purpose built knowledge building environments such as Computer- Supported Intentional Learning Environment and Knowledge Forum (Scardamalia and Bereiter, 2006) provide limited modes of communication. Within the environment synchronous communication is not possible, while asynchronous communication is only made possible through the use of notecards placed on the work of others to provide comment. As NGO-VWs provide a range of communication tools, they may provide an enhanced learning environment for knowledge building activities.

The emphasis on community and discourse could strongly leverage the key perceived educational affordances of embodied social presence and collaborative learning, while immersion could support the use of authentic problems. Finally, flexibility and the creation of persistent objects could provide an opportunity not only to construct artefacts but to modify them to follow individual lines of enquiry as the collective knowledge of the community grows. As such knowledge building may provide an opportunity to leverage all five of the key perceived educational affordances of NGO-VWs (Table 2.3).

Table 2.3 Alignment of the features of knowledge building and the perceived educational affordances of non-goal orientated virtual worlds

Knowledge building	Perceived educational affordances	
Construct knowledge artefacts	Creation of persistent objects	Construction
		Programming
		Persistence
Modify artefacts to reflect individual inquiry	Flexibility	
Community and discourse	Embodied social presence	
Authentic problems	Immersion	
Community and discourse	Collaborative learning	

2.5.1.3 Communal Constructivism

Communal constructivism (Holmes et al., 2001) closely resembles the underlying processes of knowledge building and extends it with not only a focus on constructing knowledge for current learners but for future learners as well. Learning artefacts created by one group of learners are fed back into subsequent iterations of the learning task, emphasising the role of past learners and their artefacts on the learning experience of future learners. New groups of learners are then able to take part in the same activities, which provide context to the artefacts left by previous groups, and leverage the artefacts to extend their own knowledge.

Consequently, in an earlier study (Girvan & Savage, 2010) it was anticipated that the pedagogy would leverage the creation of persistent objects to a greater extent than knowledge building.

In particular persistence would be leveraged beyond its use in knowledge building, providing future groups with the opportunity to explore the artefacts created by previous groups. However the findings showed that while learners created artefacts with and for others, leveraging collaborative learning and the creation of persistent objects, the majority of construction took place in other applications. Thus in-world construction was limited to the compilation of a final artefact constructed largely offline and then uploaded. Thus flexibility and construction were not as strongly leveraged as expected. Table 2.4 illustrates the proposed alignment between communal constructivism and the perceived educational affordances of NGO-VWs.

Table 2.4 Alignment of the features of communal constructivism and the perceived educational affordances of non-goal orientated virtual worlds

Communal constructivism	Perceived educational affordances	
Construct artefacts with and for others	Creation of persistent objects	Construction
		Programming
		Persistence
Modify artefacts to reflect individual inquiry	Flexibility	
Community and discourse	Embodied social presence	
Authentic problems	Immersion	
Community, discourse and artefacts	Collaborative learning	

2.5.1.4 Constructionism

Constructionism was developed from the theoretical underpinnings of constructivism (Papert, 1991) and as such focuses on the active construction of knowledge through experience. Constructionism extends this, with the construction of artefacts to support learning. By constructing personally meaningful and shareable artefacts, learners are provided with an opportunity to actively explore, test and extend their understanding (Papert, 1991). These artefacts may develop *in-situ* (Ackerman, 2004) and through a process of *bricolage* (an incremental process of trying and testing), rather than following a pre-existing design (Papert, 1991).

Distributed constructionism, as described in the seminal work of Resnick (1996), focuses on the design and construction of artefacts by more than one person. Drawing on ‘distributed cognition’ (Salomon, 1994), distributed constructionism focuses on the use of computer networks to facilitate interactions between people and in turn, knowledge construction. However, unlike knowledge building, distributed constructionism involves the construction of meaningful artefacts and not just the sharing of information.

Resnick (1996) describes distributed constructionism as taking three forms: discussing constructions, for example on an online forum; sharing constructions, for example uploading an artefact which others can copy and reuse; and collaborating on constructions. Thus providing opportunities to discuss, share and collaborate on constructions. As with other constructionist activities reported in the literature, distributed constructionism is facilitated by technology. However, by engaging in a constructionist learning experience the technology should become ‘invisible’ (Papert, 1980s; 1991; Bruckman & Resnick, 1996).

With the emphasis on construction, it is anticipated that constructionism would leverage the construction of persistent artefacts to a greater extent than the previous pedagogies mentioned. In addition, Hoyles et al. (2002) describe the programming of objects as an important aspect of constructionism, which would also leverage the programming aspect of the creation of persistent objects. The emphasis on *bricolage* could leverage the perceived educational affordance of flexibility (Table 2.5). Collaborating on constructions should be supported by leveraging collaborative learning while embodied social presence may support an *in-situ* learning experience. Finally, immersion may support the sense of ‘invisible’ technology.

Table 2.5 Alignment of the features of constructionism and the perceived educational affordances of non-goal orientated virtual worlds

Constructionism	Perceived educational affordances	
Construct personally meaningful artefacts	Creation of persistent objects	Construction
Actively explore, test and extend understanding		Programming
Opportunity to programme		Persistence
Shareable artefact		
<i>Bricolage</i>	Flexibility	
<i>In-situ</i>	Embodied social presence	
‘Invisible’ technology	Immersion	
Collaborating on constructions	Collaborative learning	

2.5.1.5 Problem-based learning

Margeston (1997) argues that problem-based learning is a theory of knowledge, understanding and education. It is one of the few reported pedagogical approaches implemented in multiple learning contexts in NGO-VWs (e.g. Good et al., 2008; Esteves et al., 2009; Savin-Baden et al., 2011) and as such is discussed here.

Problem-based learning is a form of enquiry-based learning and is defined by Barrows (1980) as learning through engaging in a process of problem solving. Barrett (2005) describes the process as having five operational stages through which learners are introduced to the problem, engage

in independent research and group-based discussion to find a solution which is presented and reflected on. In an online environment Savin-Baden et al. (2011) describe problem-based learning as taking a slightly different form, where groups of learners are engaged in multiple scenarios providing opportunities to practice skills and can be particularly valuable for learners unable to meet face-to-face.

To support group-based collaboration, the client-server architecture affords learners the flexibility of an always-on environment, embodied social presence and the opportunity to engage in collaborative learning (Table 2.6). The creation of persistent objects in NGO-VWs provide educators with an opportunity to recreate physical world settings in which learners can engage in problem-based learning without danger to the student or others if the student fails (Savin-Baden et al., 2011). However learning experiences reported in the literature do not require learners to create persistent objects to demonstrate their knowledge, instead they are typically engaged in skill practice through simulation and role-play. Consequently, there is limited opportunity for learners to engage in the creation of persistent objects.

Table 2.6 Alignment of the features of problem-based learning and the perceived educational affordances of non-goal orientated virtual worlds

Problem-based learning	Perceived educational affordances	
The creation of scenarios for learners	Creation of persistent objects	Construction
		Programming
		Persistence
Group-based collaboration	Flexibility	
	Embodied social presence	
Skill practice	Immersion	
Group-based collaboration	Collaborative learning	

2.5.2 Behaviourism

Although constructivist pedagogies are the focus of the research in this thesis, behaviourism is a viable approach that should be considered (Good et al., 2008; Whitton & Hollins, 2008; Dreher et al., 2009c). Within a behaviourist learning context, behaviour is developed through stimulus-response conditioning and is considered to be acquired once the learner exhibits the behaviour expected by the educator.

Immersion and embodied social presence may support the engagement of an emotional response in the learner and the creation of persistent objects may be leveraged to produce a positive or negative stimulus (Table 2.7). However it would not be possible to leverage collaborative learning.

Table 2.7 Alignment of the features of behaviourism and the perceived educational affordances of non-goal orientated virtual worlds

Behaviourism	Perceived educational affordances	
The creation of stimuli for learners	Creation of persistent objects	Construction
		Programming
		Persistence
-	Flexibility	
Emotional response	Embodied social presence	
	Immersion	
-	Collaborative learning	

Unlike constructivism, there are no related pedagogies which develop behaviourism and provide an opportunity to leverage the remaining key perceived educational affordances. Consequently, behaviourism is not considered for use in this thesis. However, it should be noted that behaviourism may be appropriate for basic skill acquisition in-world, such as avatar movement. Although considered a viable approach, there is no evidence in the literature reviewed of behaviourist approaches underpinning learning experiences in NGO-VWs.

2.5.3 Summary

This section has mapped the features of potentially appropriate pedagogies to the perceived educational affordances of NGO-VWs. While several constructivist pedagogies were considered, constructionism is identified as strongly aligned to all five key perceived educational affordances. Although knowledge building and communal constructivism may provide similar opportunities, earlier research suggests that they may not leverage the construction of persistent objects and the flexible nature of NGO-VWs to their full potential. As such this thesis explores the use of constructionism in NGO-VWs. Having completed the second stage of the alignment, the third considers how the wide range of affordances could be leveraged to provide opportunities for the features of constructionism to emerge (described in the following section).

2.6 Constructionism

Having identified constructionism as a theoretically appropriate pedagogy to underpin learning experiences in NGO-VWs, this section examines constructionism in more detail. As construction and programming tools have been identified as barriers to the educational use of NGO-VWs in education, due to the steep learning curve ('high-floor'), this section explores easy to use (termed 'low-floor') tools traditionally used in constructionist learning experiences.

Although limited, the existing literature on constructionist learning experiences in virtual worlds is also discussed. This highlights the need for further research to understand the pedagogy in action and leads to the identification of the research aim which underpins the research implemented in this thesis.

2.6.1 Critique

Constructionist theory emphasises the use of physical artefacts by learners in order for them to engage with various components of knowledge. The oft referenced example Papert provides from his own childhood is the use of gears and how engaging with these objects supported his developing understanding of mathematical concepts (1980). However constructionist theory suggests that learners can best engage in creating their own ideas, which they can then explore and test, when engaged in creating external objects. Thus it is through the construction of artefacts that learners construct their understanding (Kafai & Resnick, 1996).

While constructionism provides a basis for understanding the ways in which materials in the learner's environment can support learning, unlike constructivism, it also provides an educational approach situated in a social context (Kafai & Resnick, 1996; Kafai, 2006; Butler, 2007). The emphasis is therefore not on internal knowledge construction but external representation of that understanding to be shared with others. Although knowledge may be developed through sharing, discussing and even co-creating artefacts, the knowledge is understood to be held by the individual rather than the community.

One difficulty of constructionist theory for both educators and researchers is that it has not and may never become a fully formalised theory of learning. As Kafai and Resnick (1996) note: "Constructionism is not a static set of ideas. Consistent with the theory we are writing about, we as researchers are continually constructing new educational activities and tools to help us in this effort." (p2). As such constructionism may be considered a philosophical approach rather than a theory of learning and thus it can be difficult to clearly define what is and is not a constructionist learning experience.

Papert (1980) suggests that Piaget's developmental stages of intellectual ability are influenced by the materials available in our culture. What the computer provides is access to objects and environments that can support concrete engagement with ideas that would otherwise require formal teaching. Thus the computer is introduced as a central component of constructionist learning experiences to provide access to materials that would otherwise be unavailable to the learner.

Although early use of the *Logo* programming environment provided an opportunity for learners to engage with mathematics, foreign languages and poetry, there is a tendency in the literature

to focus on the design of constructionist tools for learning mathematics. Papert acknowledges in the second edition of *Mindstorms* (1993) that the first edition over emphasised mathematics and programming, however this trend continues across constructionist literature. As such educators and researchers may presume that constructionist approaches to teaching and learning are only appropriate or possible when engaging in programming or mathematics. This issue was raised at the Constructionism 2010 conference at which both dance and music performances were given as examples of engaging in construction through programming without an emphasis on developing mathematical understanding. However no evidence was presented to suggest that those involved had developed their understanding of dance or music. It is therefore feasible that they engaged in the construction of performances without engaging in constructionist learning.

Following the 2010 conference, the issue of programming in constructionist learning experiences was followed up by Papademetri-Kachrimani (2012) who describes a successful mathematical learning experience which has all the features of constructionist learning but without the use of a computer. Indeed while Papert's writings emphasise the potential role of computers in learning, the foundation of this are in physical everyday objects. However Papert viewed computers as potentially providing purposefully constructed computational materials for learners to engage with which would not otherwise be available in the given culture and without which learners would have to be formally taught (Papert, 1993). Thus, while it is possible to engage in constructionist learning without the use of a computer, from a Papertian perspective any such learning experience is limited by the materials of the culture.

Along with active engagement in the construction process, there is an emphasis on self-directed learning. This *Empowering Minds* project (Butler, 2007) provides illustrative example of the form this may take in a primary classroom, whilst acknowledging the need for adequate time for learners to be able to engage in constructionist learning. These types of learning experiences stand in stark contrast to instructionist approaches, in which knowledge is transmitted to passive learners who are expected to assimilate the knowledge. When behaviourist approaches are applied, this can lead to not only rapid delivery but also assessment of learners' knowledge and this form of teaching and assessment can be easily supported through computer software. While it can be argued that it is the process and not the product of learning which may be most valuable to the learner over time, it can be difficult for some teachers to identify how constructionist approaches to teaching and learning fit within the rigid curricula and summative assessment procedures common in many Western educational systems when instructionist approaches appear so efficient. However, as demonstrated by Butler (2007), constructionist learning objects and environments empower

both students and teachers, allowing them to determine the nature of the learning activity to address personal needs and interests whilst achieving curricula aims.

2.6.2 Low-floor constructionist environments

Many low-floor constructionist tools stem from Logo, the seminal low-floor, high-ceiling (powerful) programming language, developed to support learners engaged in construction, exploration and investigation (Feurzeig, 2007) in subject areas such as mathematics and foreign languages. Building on Logo, Turtle Graphics was developed, providing learners with an 'object-to-think-with' whilst engaging in Logo programming and is described by Papert (1980) as a microworld. In this instance the object was a turtle character and since then 'turtle' has become a common feature of many constructionist learning environments, although often represented as an arrow.

To support engagement with the turtle character, Turtle Geometry was proposed as a computational style of geometry (Papert, 1972). Unlike Euclidian geometry, in which there is a 'point' which has no properties other than 'position', Turtle Geometry uses a 'turtle', which has a position but also a 'heading' resulting from the direction it is facing (Papert, 1972; 1980). The Turtle 'object-to-think-with' thus provides the entry point to Turtle geometry which is dependent upon both position and heading and the child's existing knowledge of their own movement (Ackerman, 2004).

Whether physical or on a screen, by issuing the 'pen down' command Turtle draws a line as it moves until the 'pen up' command is executed. By creating lines on paper or screen, learners are able to observe the movement of Turtle and reflect on the result (Papert, 1980). They may then reconsider their conceptualisation of their solution to the problem, and actively experiment by changing the programme and running it again. Thus learners may engage in Kolb's (1984) experiential learning cycle, through the construction of shareable artefacts.

The 'pen' commands have featured in many microworlds which have been developed since Turtle. 3D examples of constructionist tools with clear links to Logo and Turtle Graphics include *PlayLOGO 3D* and *VRMath*. *PlayLOGO 3D* is designed to leverage the features of videogames such as narrative to motivate young learners to engage in programming (Paliokas et al., 2011), while *VRMath* supports the user by providing them with a first-person perspective of the turtle character (Yeh, 2010). Using *VRMath*, Yeh (2010) explored primary school students' understanding of 3D rotation by comparison to traditional pen, paper and body movement in the physical world. He found that traditional classroom approaches led to misconceptions which could be identified and conceptually resolved by the children in the 3D environment. While these tools provide 'pen' commands, they only allow learners to create 2D lines in the 3D

environment as 3D constructions were considered to require advanced skills (Yeh & Neson, 2004).

Following on from Logo and Turtle, *Scratch* (Maloney et al., 2004) provides learners with a visual programming interface in which graphical blocks are snapped together in an intuitive fashion to create programmes to implement 2D interactive games or animations. Again the 'pen' commands are available and allow the learner to create lines on the screen based on the movement of a programmed sprite. *Scratch* provides a good example of how some of these more recent microworlds have begun to 'widen the walls'. By this it is meant that *Scratch* supports the creation of a wide variety of artefacts depending on the interests and learning styles of the user (Resnick et al., 2009).

Each of these environments can be labelled a microworld, broadly described by Ackerman and Strohecker as "carefully crafted artificial settings for creative exploration" (1999, p.14).

Computer-based microworlds are designed to enhance the most important features of a given phenomena and remove those that might distract the learner by "muddying" the outcome (Edwards, 1998). By comparison NGO-VWs neither enhance the most important features for learning nor remove the distracting ones. However, they do provide educators with control over aspects of the environment, for example whether gravity is on or off. Consequently, if an educator wishes to provide a construction environment without natural physical laws in *Second Life*, they can.

2.6.3 Constructionism in non-goal orientated virtual worlds

Despite the introduction of 3D NGO-VWs there has been a lack of literature on constructionist learning experiences. One reason may be the initial high barrier for learners and educators to overcome before they can engage in construction and programming.

In contrast to purpose built microworlds, NGO-VWs do not provide learners with low-floor construction or programming tools. Instead these tools present the novice with a steep learning curve, preventing the novice user from easily creating and programming objects. They also do not support 'bidirectionality' between the programming tools and objects.

Bidirectionality is described by Hoyles et al. (2002) as an important feature of microworlds, showing the movement of the object in the code and the coding of the object in its movement.

This is not a problem specific to any one application. For example, while *Active Worlds Education* provides pre-created objects for users to construct their environment, if educators wish to create unique objects additional software is required which Dickey (2005b) states has a steep learning curve. Dickey goes on to describe *Adobe Atmosphere*, which, while lowering the

barrier to entry, still required knowledge of 3D object modelling. Similarly, the programming and object construction tools of *Second Life* present a high-floor barrier for learners to master before they can engage in learning. Object construction in *Second Life* and *OpenSim* requires knowledge of 3D object modelling and *Second Life* uses a text based, C-style programming language called Linden Scripting Language, while *OpenSim* additionally supports the use of C#, J# and VBScript.

As a result of the steep learning curve, learning experiences in NGO-VWs tend not to focus on construction but rather on social activities (Sanchez 2007; 2009b). A notable exception is the work by Dreher et al. (2009; 2009c) who focus on the construction of in-world artefacts through which learners engage in exploring and extending their understanding. In these articles the authors describe a constructionist learning experience in which learners, having visited and interacted with several manufacturing environments in *Second Life*, created their own environments to demonstrate their understanding of production and logistics. These constructions required both 3D modelling and programming skills, however it is worth noting that this was a degree level module undertaken by Information Systems undergraduate students. Kahn (2007) also consider the potential of NGO-VWs for learning to programme, however to date his work has not been extended to this technology.

To address the issue of high-floor programming tools in *Second Life*, *Scratch 4 Second Life* (S4SL) was designed by Rosenbaum (2008). Based on *Scratch*, S4SL provides a visual programming environment outside *Second Life*, in which graphical blocks are snapped together to create a programme. On the click of a button on the user interface, the S4SL code is compiled into equivalent Linden Scripting Language (LSL) code and copied to the clipboard. The user then returns to *Second Life* and pastes the script into an object created in *Second Life* (Figure 2.7). Thus, S4SL allows users to quickly add behaviours and interactivity to otherwise static objects without learning the complex c-style programming language.

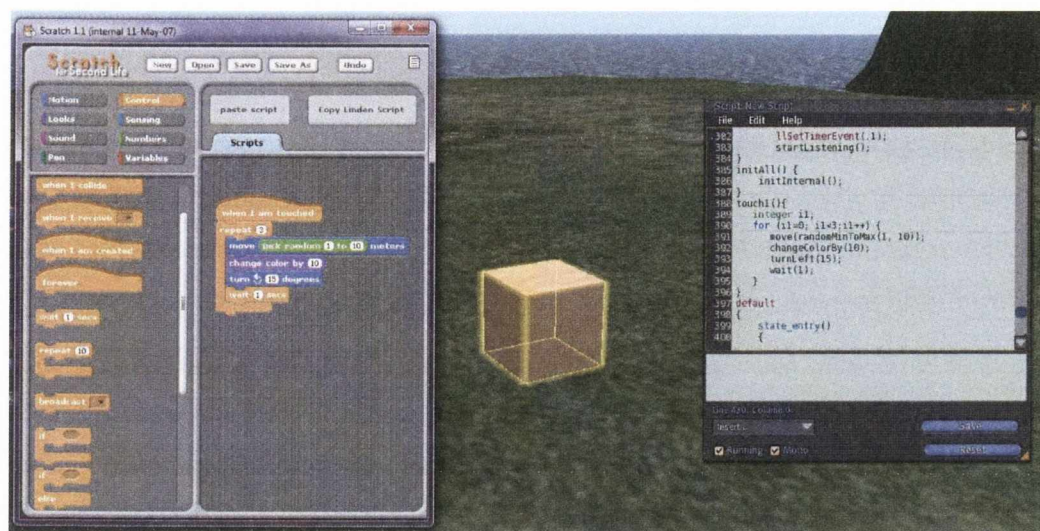


Figure 2.7 On left: Code in external S4SL interface. On right: Generated code in *Second Life*.

While text-based and 3D goal orientated virtual worlds have already been excluded from the focus of this research, the early use of distributed constructionism occurred in text-based virtual worlds (Bruckman and Resnick, 1996) and as such provide a useful historical context to draw from. Using a MUD, learners participated in the collaborative construction of objects and environments which could be shared with others. In this context, Bruckman and Resnick (1996) found that adult learners who learned to programme in order to create artefacts in the MUD, learned to programme more easily in the MUD than other programming environments. The reason given for this was that the programming was authentic and motivating as the artefacts were to be shared.

Of the literature reviewed, Dreher et al. (2009) and Good et al. (2008) provide the only reports on constructionist learning experiences in NGO-VWs. Unlike Good et al. (2008), Dreher et al. (2009) do not provide a description of how constructionist learning was supported in the design of the learning experience. In both articles there is limited discussion as to how the specific features of the technology support constructionist learning activities and neither report findings that enhance our understanding of the pedagogy in action within NGO-VWs.

2.6.4 Research aim

The lack of understanding about the implications of designing and implementing constructionist learning experiences in NGO-VWs, may discourage educators from using this technology. If virtual worlds are to move through the trough of disillusionment and into mainstream adoption in five to ten years (Johnson et al., 2011b) it has been argued earlier in this chapter (2.3) that there is a need to move beyond what NGO-VWs can replicate and consider the unique characteristics and potential for learning that the technology can offer.

The paucity of literature on constructionism in NGO-VWs highlights a need to develop an understanding of the pedagogy in action with the technology. However there are a wide variety of research streams that could be examined such as: each aspect of the proposed alignment of pedagogy and technology; the design of learning experiences for various contexts; the impact of features unavailable in other constructionist technologies; learners' perceptions; and knowledge acquisition. However it is not possible to achieve any great depth in understanding in any one of these areas without first exploring a purpose designed constructionist learning experience, implemented with learners. Thus, the primary aim of the research presented in this thesis is:

To explore constructionism in action in non-goal orientated virtual worlds

2.7 Conclusion

Following a structured review of the educational literature on NGO-VWs, this chapter has:

1. Defined the essential qualities of a virtual world;
 - Positioned the research within the sphere of education in NGO-VWs which support user-generated content;
 - Examined the literature on the educational use of NGO-VWs;
2. Defined the term 'perceived educational affordance';
 - Identified five key perceived educational affordances of NGO-VWs;
3. Identified the need for an approach to align pedagogical theory and the perceived educational affordances of the technology;
 - Presented a four stage approach to the identification and implementation of appropriate pedagogies to underpin learning experiences in NGO-VWs;
4. Identified constructionism as a potentially appropriate pedagogy for use with this technology;
 - Outlined how the perceived educational affordances could be leveraged to support the features of constructionism;
 - Identified potential barriers to engaging in constructionist learning in-world;
5. Outlined the research problem;
6. Presented the primary aim of the research presented in this thesis.

This chapter has established that while an increasing number of studies have reported on the use of broadly constructivist teaching approaches within NGO-VWs, they often lack a clear justification for their choice of pedagogy in relation to the technology. While existing work by Hobbs et al. (2006) has attempted to align the affordances of *Second Life* and learning

outcomes, de Freitas (2010) and Savin-Baden (2008) highlight the importance of the initial underpinning of learning experiences with established pedagogies. This thesis proposes that the pedagogy should be aligned with the perceived educational affordances of the technology so as to leverage the full potential of both pedagogy and technology, providing learners with the opportunity not only to achieve the learning outcomes but to engage in an enriched learning experience.

This thesis follows a systematic approach to the identification of potentially appropriate pedagogies for use in NGO-VWs based on the perceived educational affordances of the technology. The first stage of the process is the identification of the perceived educational affordances of the technology. The second stage aligns these affordances to the features of the pedagogy. Through mapping the pedagogical features to the perceived educational affordances which could support these features, pedagogies which may be appropriate for use with the technology can be identified. Through this process constructionism was identified as a potentially appropriate pedagogy and is the focus of study in this thesis.

The third stage considers how the wide range of affordances could be leveraged to provide opportunities for the pedagogical features to emerge. This theoretical alignment is then implemented in the final stage of the approach to design a learning experience. Through this approach both pedagogy and technology should be employed to their full effect in the learning experience with pedagogy remaining central to the design.

From a research perspective this approach provides an opportunity to implement the theoretical alignment and develop an understanding of pedagogy and technology in action, in order to achieve the primary research aim:

To explore constructionism in action in non-goal orientated virtual worlds

However it is noted in the literature that the construction tools in NGO-VWs present the learner with a steep learning curve which must be overcome before they can engage in constructionist learning experiences. To address this, the following chapter presents the design of SLurtles (low-floor, programmable Turtles for the construction of artefacts in *Second Life*) which draws on the design of existing constructionist learning environments and the alignment of pedagogy and technology. This is followed by the implementation of the theoretical alignment of pedagogy and technology in the design of constructionist learning experiences for NGO-VWs.

3 Design

3.1 Introduction

Underpinning constructionist learning experiences is the learner's engagement with programming and the construction of personally meaningful and shareable artefacts (Hoyles et al., 2002). On first glance, NGO-VWs appear to provide an exciting new environment to engage in constructionist learning experiences. However the inbuilt programming and construction tools of NGO-VWs such as *Second Life* and *Active Worlds* present the novice with a high-floor (steep learning curve) barrier to overcome (Dickey, 2005; Sanchez, 2009).

This chapter begins by identifying *Second Life* as the most appropriate platform to implement the research in this thesis. While *Scratch for Second Life* (S4SL) provides a low-floor and high-ceiling (powerfully expressive) programming environment for use in *Second Life*, it does not support the construction of shareable artefacts. Learners must first learn how to use the high-floor modelling tools before they can engage in exploring, testing and extending their understanding through the construction of artefacts. Thus to enable constructionist approaches to learning within NGO-VWs, it is first necessary to lower the barriers to engaging in construction.

To address this problem, this chapter presents SLurtles (programmable turtles in *Second Life*), that were designed as part of this research, to provide a low-floor construction tool to be used in *Second Life*. Underpinning the design of SLurtles are the broad constructionist principles of low-floor (easy to use), high-ceiling (powerfully expressive) and wide-walls (support the creation of a variety of artefacts), concepts central in the design of constructionist tools for learning.

Borrowing design concepts from Lego and Turtle graphics, SLurtles build upon S4SL and are designed to provide learners in *Second Life* with programmable tools with which to create personally meaningful and shareable artefacts. Much like Turtle Graphics was developed to engage learners in Logo programming, SLurtles have been designed to engage learners in programming through the creation of persistent 3D artefacts in the NGO-VW. By leveraging the persistent nature of NGO-VWs and using S4SL as the programming environment, SLurtles can be programmed to create increasingly complex structures as the learner's understanding develops.

The final section of this chapter presents the guiding design principles of SLurtle-based constructionist learning experiences, implementing the final two stages of the approach to the

alignment of pedagogy and technology outlined in Chapter 2. Two context specific examples of SLurgle-based constructionist learning experiences are presented, before a detailed description of the learning experience implemented in this thesis.

3.2 Platform for implementation: *Second Life*

To achieve the research aim it is necessary to design and implement a constructionist learning experience in a NGO-VW. There are a number of NGO-VW platforms that could have been used in the research presented in this thesis, such as *Open Wonderland* and *Active Worlds*. However since 2006, *Second Life* has rapidly become the most commonly used NGO-VW in higher education (Warburton, 2009; Kirriemuir, 2010; Dalgarno, Lee, 2010; Carlson et al., 2011) with the research literature exploring educational activities across a wide variety of disciplines including anatomy (e.g. Richardson et al., 2011), human-computer interaction (e.g. Perera, et al., 2009), literature (e.g. Webb, 2011), information systems (e.g. Dreher et al., 2009), business (e.g. Lee, 2009), languages (e.g. Deutschmann & Panichi, 2009; Wehner et al., 2011), physics (Crider, 2006), psychology (e.g. Baker et al., 2009) and teacher education (e.g. Campbell, 2009; Cheong, 2010).

Open Simulator (OpenSim) is increasingly reported in a number of third-level and K-12 educational settings. *OpenSim* is an open source application server, similar in many ways to *Second Life*, supporting the creation of privately hosted NGO-VWs. These can be particularly useful in educational and research settings, providing access to user logs, greater security, no age restrictions and lower costs (Allison et al., 2010; Konstantinidis et al., 2010; and Korolov, 2011). Restrictions on the number of objects, scripts or size of 'land' are only dependent on the capability of the local server, rather than externally imposed. However there are limitations such as the lack of a pre-existing community on private grids, reliability (Allison et al., 2010) and the quality of voice communication (Derrington, 2011). In addition, while there are privately owned grids such as *Reaction Grid* which are devoted to educational experiences and remove some of the technical requirements, there are associated costs and restrictions.

To achieve the research aim, *Second Life* was chosen for implementation. The primary reason for this choice is the development of S4SL which provides an existing low-floor programming environment for use with *Second Life*. It is also a popular choice for educators and researchers in the field. While there has been recent development of S4SL for *OpenSim*, reliability and stability are important factors in choosing an application as a vehicle for research. At the time of writing, *OpenSim* does not provide the reliability or stability for conducting educational research from both a practical and ethical perspective. Therefore *Second Life* is the application used in this study to explore constructionism in NGO-VWs.

3.3 High-floor construction tools in *Second Life*

While S4SL provides a low-floor programming environment for *Second Life*, it does not support the construction of persistent artefacts. Instead learners must first learn how to use the complex 3D object modelling tools in *Second Life* (Figure 3.1). These tools present learners with a high-floor barrier which they must first overcome before they can engage in the construction of artefacts, as highlighted in the literature (e.g. Sanchez, 2009b) reviewed in Chapter 2.

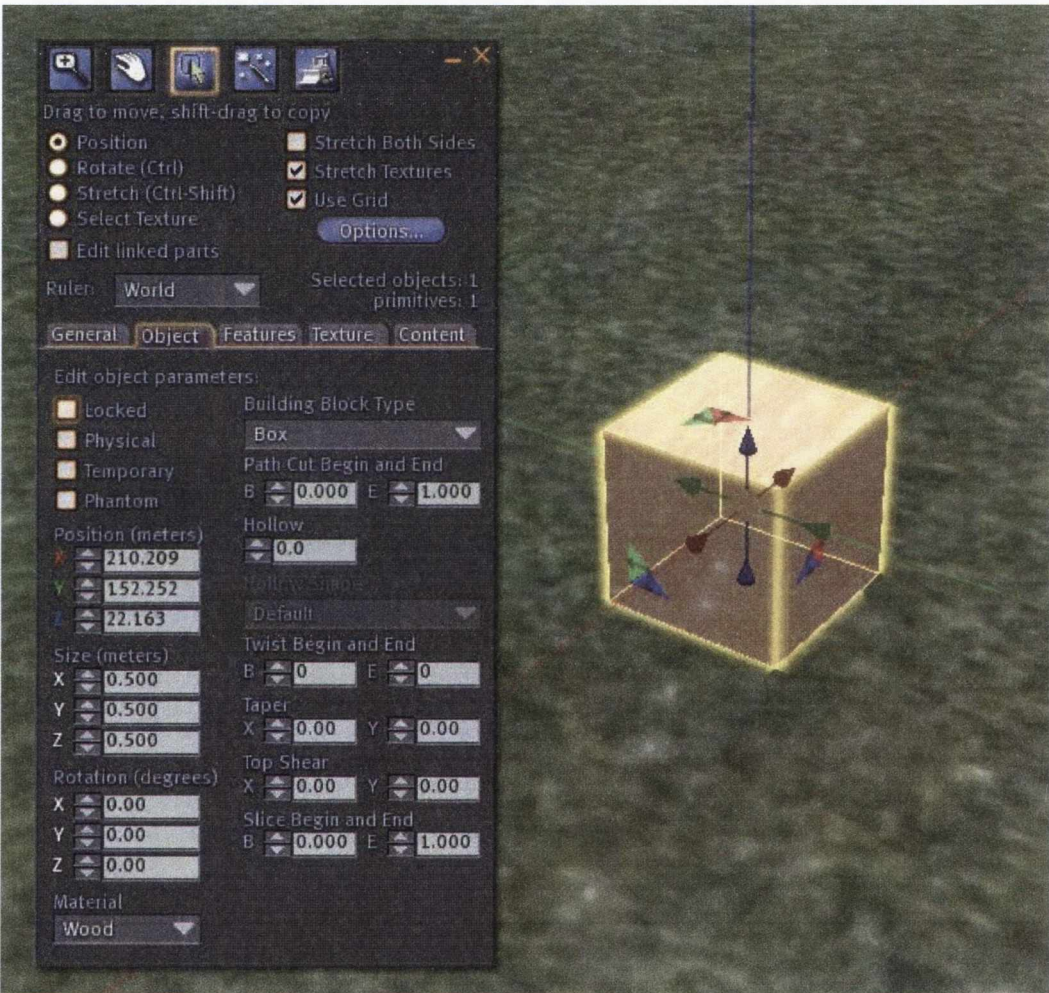


Figure 3.1 'Box' primitive and modelling tools

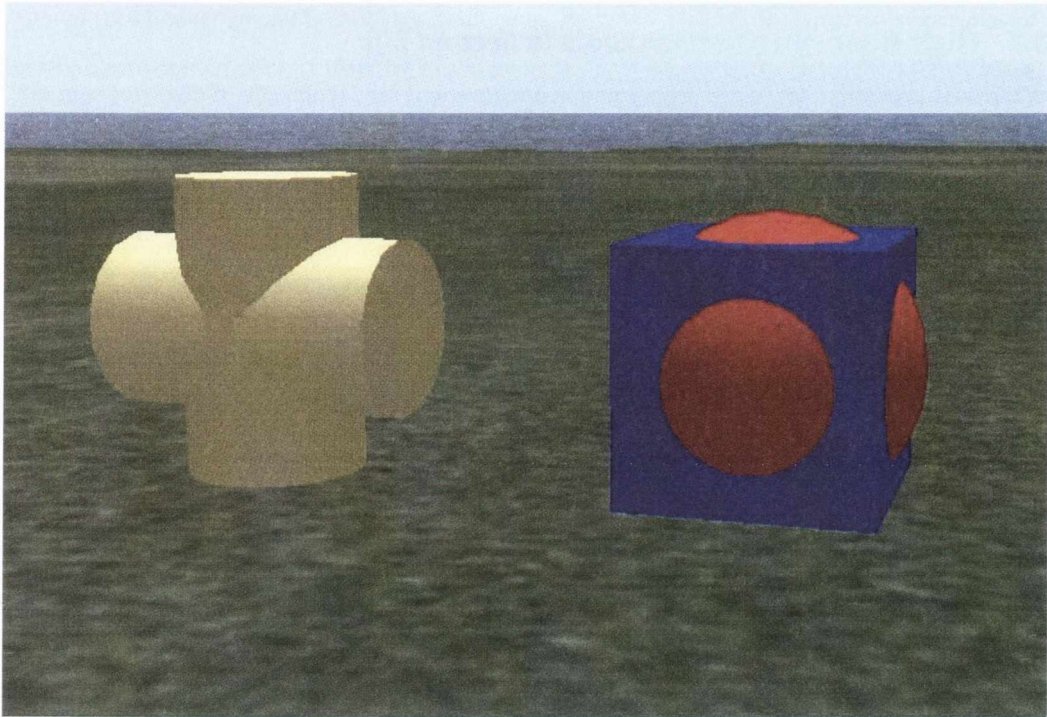


Figure 3.2 Complex objects created through the union of prims

Constructive solid modelling is the construction technique used in *Second Life*, allowing the user to create complex artefacts (Figure 3.2) through the union of simple solid objects known as primitives (prims) (Figure 3.3).

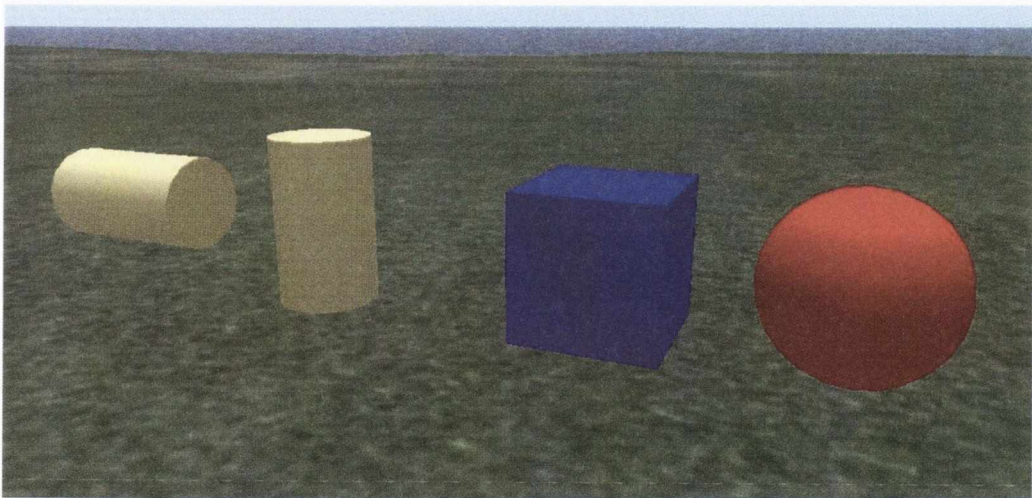


Figure 3.3 Individual prims used to create the complex objects in Figure 3.2

However *Second Life* does not support the subtraction of one object from another or the taking of intersecting portions of two or more shapes. Without these common constructive solid modelling approaches, the construction of an object which appears to be a square with a round hole at its centre (shown on the left in Figure 3.4) requires two prims which have be resized, rotated and hollowed (shown on the right in Figure 3.4) then repositioned. To achieve this, the tools shown earlier on the left in Figure 3.1 are required in addition to an understanding of 3D geometry. While highly complex objects can be created, suggesting a high-ceiling, these limitations raise the floor for novices even higher.

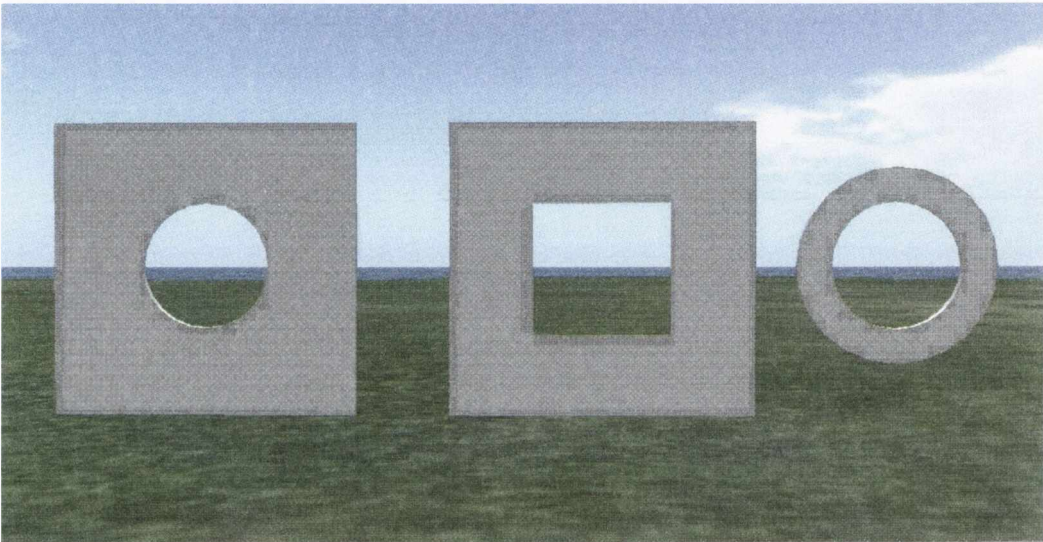


Figure 3.4 Round hole in a square construction

3.4 SLurtles: Low-floor construction tools for *Second Life*

Central to constructionism is the design and construction of artefacts with low-floor, high-ceiling and wide-wall tools. However the construction tools available in NGO-VWs, including *Second Life*, present the learner with a high-floor barrier which they must master before they can engage in construction. In order to achieve the primary research aim of this thesis it is first necessary to lower this barrier.

In order to create a low-floor, high-ceiling and wide-wall tool for the construction of objects in *Second Life*, existing constructionist environments NGO-VWs were considered. Of these Turtle Graphics, *Lego* and *S4SL* influenced the design of SLurtles, presented in the first sub-section below. This is followed by a description of SLurtles demonstrating how each of these concepts was implemented. Finally a brief walk-through of the use of SLurtles is presented.

3.4.1 SLurtle design influences

3.4.1.1 Turtle Graphics

As previously indicated in Chapter 2, Papert's (1980) Turtle Graphics provided learners with a low-floor, high-ceiling microworld, through which they could observe the effects of their programmes. Three important design concepts that came from turtle were 'position and heading', 'construction' and 'persistence'.

The programmable turtle on the screen or physical turtle robot showed the learner both its position and heading (Papert, 1972; 1980). Based on this the learner knew which direction it would move when given the command 'fd' (forward). An understanding of position and heading is necessary to engage in Papert's (1972) proposed computational style of geometry which was proposed in place of Euclidian Geometry in which a 'point' only has position.

Another feature of Turtle was the 'pen' command, through which a learner could create persistent patterns on screen or on paper by issuing the command 'pen down' or 'pen up' as the Turtle moved. It was the construction of these patterns with Turtle that would be used to engage the learner in programming (Papert, 1980) and support reflection in the learning cycle.

3.4.1.2 Lego

Lego bricks provide users with a set of simple building blocks from which complex constructions can be developed. Much like other construction tools designed as toys for children, *Lego* allows the user to engage in the *bricolage* construction of increasingly complex artefacts. However unlike *Meccano* and similar toys which require some dexterity, *Lego* has a particularly low barrier to engagement, providing modular bricks which can be connected and pulled apart easily.

In the design of SLurtles, several aspects of *Lego* were influential. The simple *Lego* blocks provide a low-floor with which to engage in construction whilst the complexity, or ceiling, of construction is very high. While there is some variety, for example in length and width, the form of blocks available is typically limited to cuboid shapes, although others are available. *Lego* also strongly supports the concept of wide-walls which can be supported within *Second Life* due to the flexible nature of the environment. Individually the simple blocks do not influence the type of artefacts that can be constructed and if a limitless box of bricks is available, users are free to create a variety of artefacts that reflect their own interests.

3.4.1.3 Scratch for Second Life (S4SL)

Hoyles et al. (2002) note that programming remains an essential aspect of constructionist learning experiences. Of the low-floor programming tools available for use with *Second Life*,

Scratch for Second Life (S4SL) was identified as having the highest potential ceiling. As described in Chapter 2, S4SL (Rosenbaum, 2008) provides a low-floor, visual programming interface for *Second Life*. Graphical command blocks are selected and dragged to the scripting area where they are snapped together to create a programme (Figure 3.5). The concept of modular blocks that are easily snapped together and pulled apart is evident in the design of the *Scratch* interface which S4SL was developed from. On the click of the ‘Copy Linden Script’ button in the user interface, the S4SL code is compiled into equivalent Linden Scripting Language (LSL) code.

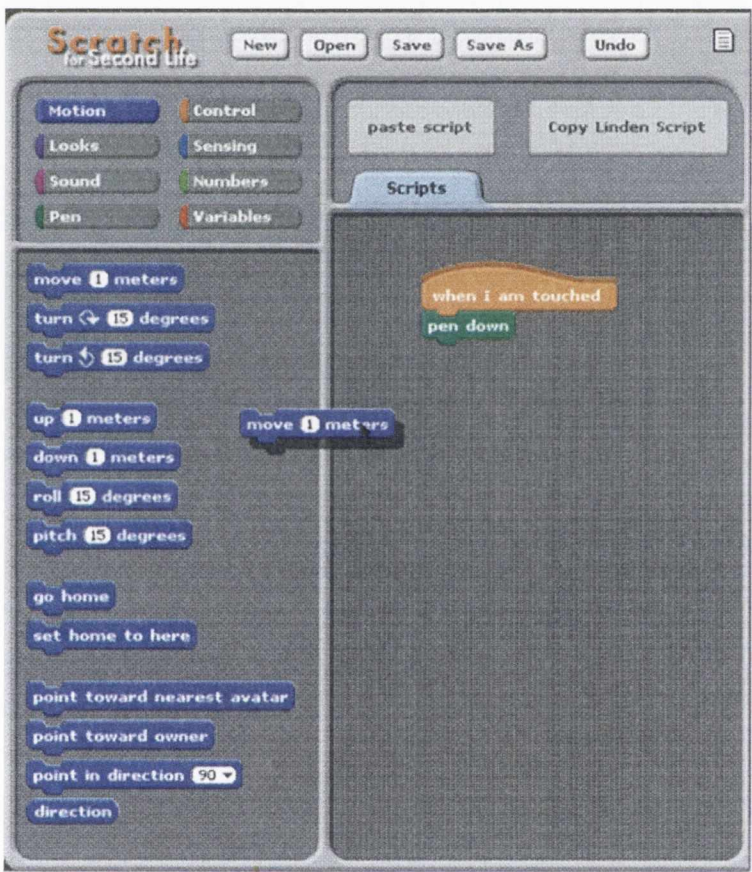


Figure 3.5 S4SL application showing a block being dragged from the list of available commands to the scripting area.

The user then returns to *Second Life*, creates a default script, pastes the code and places it in an object. Figure 3.6 shows a section of compiled code in *Second Life*. The script is located within the cube highlighted in yellow.

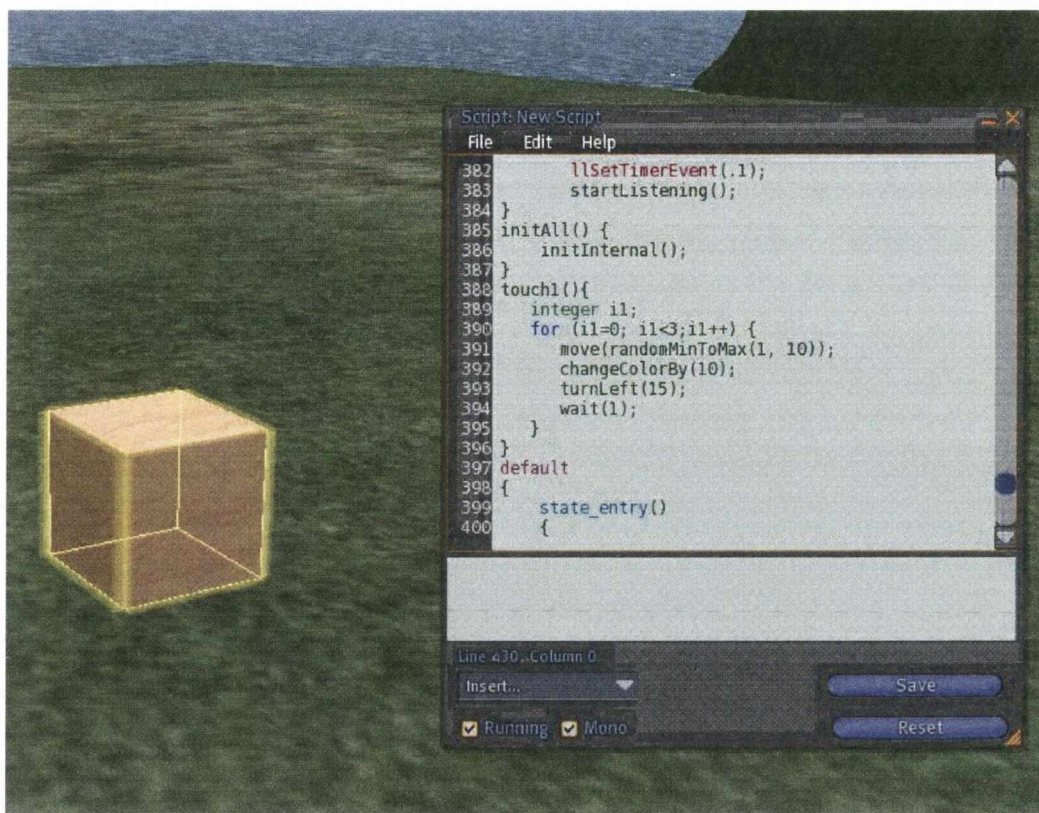


Figure 3.6 Compiled code in a script in *Second Life*

As part of the Logo/Turtle legacy, a selection of ‘pen’ blocks remain in the S4SL library. Physical Turtles hold a physical pen at their centre and when programmed the pen moves up and down. In conjunction with the movement of Turtle, this allows learners to draw patterns on paper (Papert, 1980). On-screen Turtles include a metaphorical pen. When the ‘PEN DOWN’ command is executed, as the Turtle moves across the screen a line is drawn on the screen. ‘PEN UP’ allows the learner to reposition Turtle without creating a line on the screen. This notional ‘pen’ has featured in microworlds which have been developed since Turtle, such as *Scratch* (Maloney et al., 2004) which S4SL is based on.

‘Pen’ blocks in S4SL provide an opportunity with which to create objects in *Second Life* mirroring the 2D creation of patterns with Turtle but in a 3D environment. To achieve this Rosenbaum (2008) created a ‘lineSegment’ object which could be placed in an object to be programmed using S4SL. When ‘pen down’, followed by a movement forward occurs, an instance of the 3D ‘lineSegment’ appears (is drawn) within the NGO-VW. The location and length of the new object are determined by the initial location of the parent object and how far it travelled in one action. For example, Figure 3.7 shows the S4SL programming environment and what happens in *Second Life* after an avatar has clicked on the object (the cube) which contains both the LSL script generated by S4SL and a ‘lineSegment’.

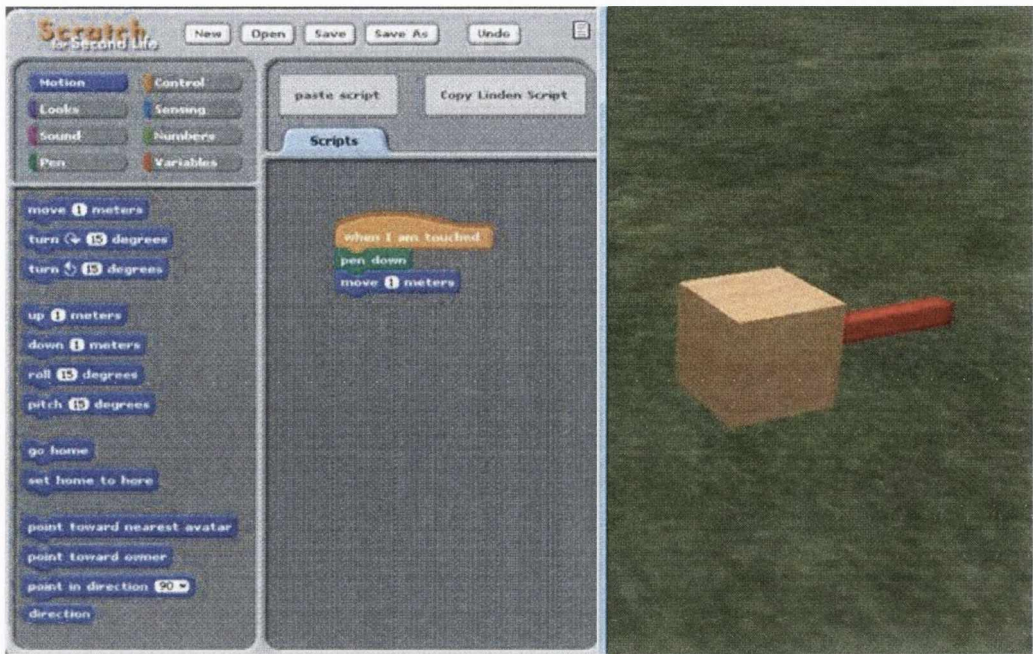


Figure 3.7 S4SL programming environment on left, results of the programme in *Second Life* on right

However there are constraints which need to be addressed in order to use S4SL for the construction of objects. The first is that the cube in Figure 3.7, when first created, is much like the Euclid point. It can be observed to have a position but no obvious heading. When programmed to move forward it will move forward but to the learner it is not clear what direction this will be until the programme is executed. In addition, S4SL users must explicitly embed a ‘lineSegment’ in an object so that those objects can respond to ‘pen up/down’ commands, introducing a new barrier for learners. Finally the ‘lineSegment’ is temporal lasting only a few seconds before permanently disappearing, therefore objects are not persistent and the construction and sharing of artefacts would be extremely limited.

3.4.2 SLurtles: Design concepts

Drawing on the features of Turtles Graphics, *Lego* and S4SL, six design concepts were identified in the development of SLurtles (programmable turtles in *Second Life*):

- provide position and heading
- construction as a process to engage in programming
- persistence
- simple building blocks
- complex constructions possible
- variety of constructions possible

Table 3.1 summarises the implementation of each design concept in the final SLurtle design, described below.

Table 3.1 SLurtle design concepts and implementation

Design Concept	Implementation
Provide position and heading (Turtle Graphics)	Turtle character (SLurtle) used to provide position and face direction of forward motion. SLurtle must be programmable.
Construct to engage in programming (Turtle Graphics)	Use S4SL to programme SLurtle to move and create blocks using the 'pen' commands. An instance of the 'lineSegment' block (SLurtle blocks) is created as the SLurtle moves. The length of the SLurtle block is dependent on the distance the SLurtle moves in a single step.
Persistence (Turtle Graphics)	Adapted 'lineSegment' in each SLurtle is persistent
Simple building blocks (Lego)	Each SLurtle creates one type of cuboid, prism, cylinder or spherical object
Complex constructions possible (Lego)	Only limited by the programmes that can be created in S4SL
Variety of constructions possible (Lego)	SLurtle blocks are available in a variety of simple shapes. No restrictions as to how these blocks may be used.

Following the turtle tradition, a 3D turtle was created in *Second Life* (Figure 3.8) using the inbuilt object modelling tools. These objects were linked together, with the domed body of the SLurtle acting as the root prim, the centre of which becomes the pivot point of the object. This character provides a clear illustration of both position and heading.

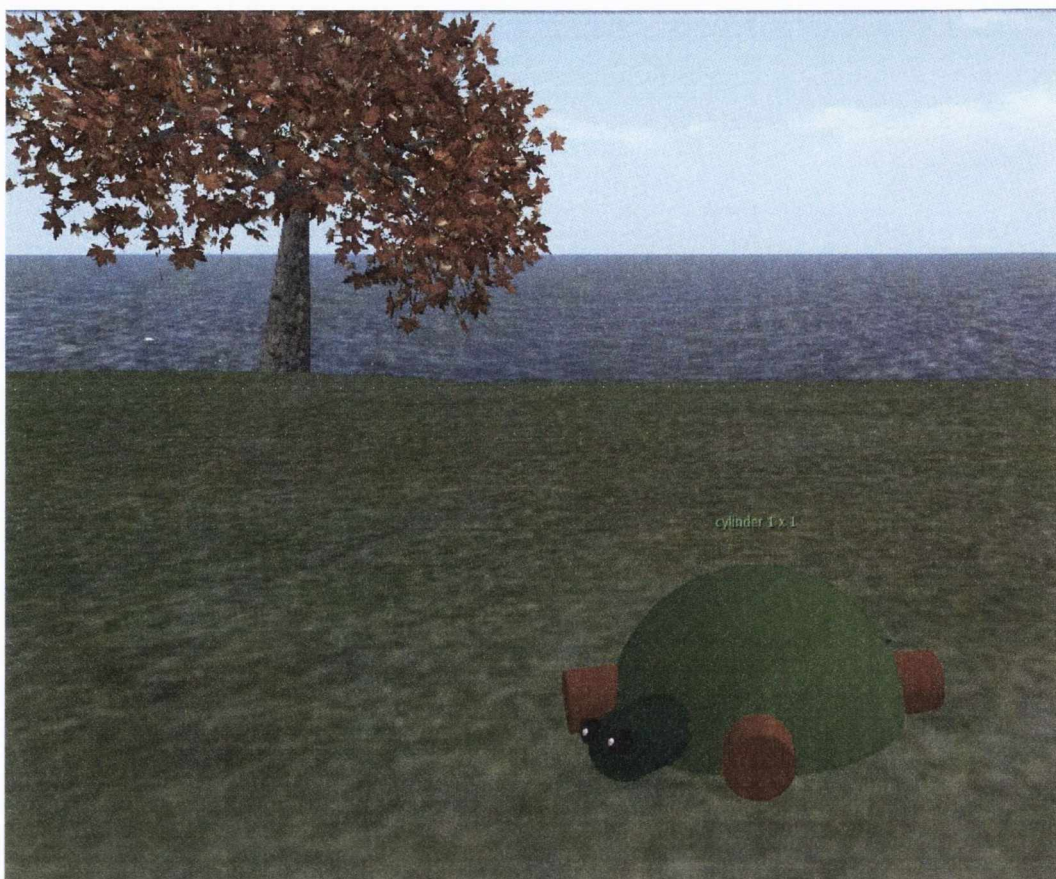


Figure 3.8 A SLurtle in *Second Life*

S4SL is leveraged to provide the programming environment for SLurtles. When the ‘pen down’ command is used, the subsequent move forward by the SLurtle will create a ‘SLurtle block’. Each block is an instance of the ‘lineSegment’ embedded in the SLurtle which determines the height, width and primitive shape.

As identified in Chapter 2, NGO-VWs afford the creation of persistent objects and environments. However to leverage this perceived educational affordance, the ‘lineSegment’ had to be adapted. To achieve this, I had to edit the original code developed by Eric Rosenbaum which is embedded in the ‘lineSegment’. As a result of this adaptation, all SLurtle blocks created are persistent, meaning that they will stay in the environment until deleted.

Each SLurtle can create only one type of SLurtle block, determined by the ‘lineSegment’ embedded in the SLurtle, for example a spheroid 0.1 metres in height by 1 metre in width. The block begins at the starting position of the SLurtle and the length is determined by the distance the SLurtle is programmed to move in a single step. SLurtle blocks have no texture so as not to influence the type of artefacts that could be created.

The complexity of constructions and variety of artefacts should only be limited by what can be programmed in S4SL. Using S4SL a SLurtle can be programmed to move around the *Second Life* environment in three dimensions, and using the 'pen down' command can create instances of the SLurtle block. Unlike *Lego* bricks, SLurtle blocks are not connected to each other and with physical laws turned off will remain where created by the SLurtle.

To support the construction of a variety of artefacts, an initial set of 16 SLurtles was created. These SLurtles create either 0.1 x 1 (height x width), 0.1 x 0.1, 0.5 x 0.5 or 1 x 1 metre blocks, in either cuboid, prism, cylinder or spherical form. While a wide variety of primitive shapes could have been chosen and made available in a variety of sizes, the four shapes and sizes were chosen keeping in mind the 'simple building blocks' design concept.

3.4.3 Walk-through

SLurtles are available to learners at a 'SLurtle collection point' (Figure 3.9) at which they can see a sample of each available block created with a length of 1 metre. When the learner has decided on the type of block they wish to create they click on the block and a SLurtle which will make that type of block is copied into their avatar's inventory ready for them to use.

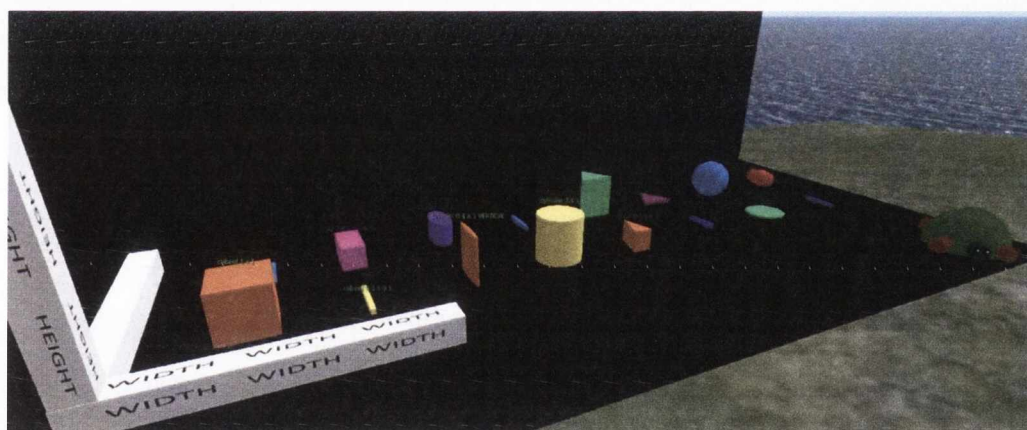


Figure 3.9 SLurtle collection point.

To use the SLurtle the learner takes the SLurtle from their inventory and places it in the environment. To programme the SLurtle they go to S4SL and create their code, export it via the clipboard and return to *Second Life* where they create a new script into which they paste the generated LSL code. When this script is placed in the SLurtle the SLurtle will then execute the programme (Figure 3.10). Learners can then reflect on the experience before returning to S4SL to re-programme the SLurtle.

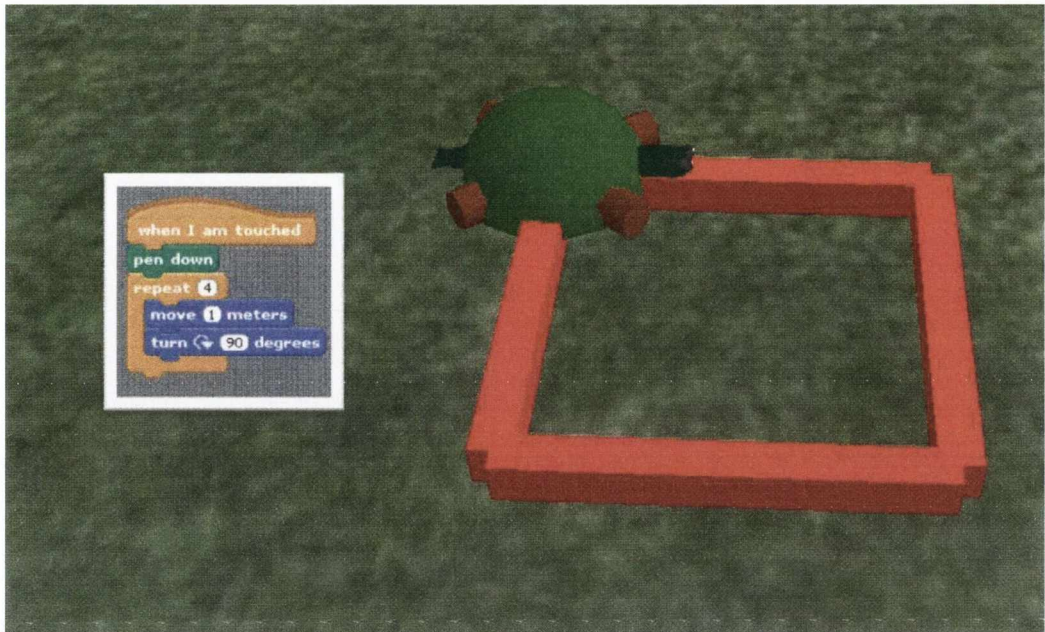


Figure 3.10 On left: S4SL code for square. On right: Imperfect square in *Second Life*

The width component of SLurtle blocks has an interesting implication. As shown in Figure 3.10, the commands which in traditional turtle graphics would create a perfect square, create an imperfect square in *Second Life*. This is due to the width of the cuboid block and the fact that they are created from the centre of the SLurtle itself. This was recognised in initial user testing and has the potential to engage learners in more complex problem solving.

3.5 SLurtle-based constructionist learning experiences

To achieve the primary aim of the research presented in this thesis, it is necessary to design and implement a constructionist learning experience in a NGO-VW. As described in Chapter 2, this thesis follows a four stage approach to underpin learning experiences in NGO-VWs with appropriate pedagogy. Following this approach the five key perceived educational affordances of NGO-VWs were identified and used to identify constructionism as a pedagogy which could leverage these to the greatest extent.

This section completes this process, considering how the perceived educational affordances could be leveraged to provide opportunities for the features of constructionism to emerge (3rd stage). This is then used to draw out six design principles to underpin the design of constructionist learning experiences in NGO-VWs. Through this approach both pedagogy and technology can be employed to their full effect in the learning experience while pedagogy remains central to the design of the learning experience.

While the final design of the learning experience will depend on the learning context, each of the design principles has generic features to be applied across contexts and variable features which will be determined by the specific learning context. This is illustrated by two examples of applying the design principles of a SLurtle-based constructionist learning experience in different contexts. Finally, a detailed description of the learning experience implemented in this research is presented.

3.5.1 Leveraging the perceived educational affordances

In order to design a constructionist learning experience in a NGO-VW, it is necessary to consider how the wide range of affordances could be leveraged to provide opportunities for the pedagogical features to emerge. The potential impact of perceived educational affordances which do not clearly align with the pedagogy also need to be considered. It is this alignment that will be used in the design of a learning experience. Table 3.2 summarises the proposed alignment between the features of constructionism and the key perceived educational affordances of NGO-VWs.

Table 3.2 Alignment of the features of constructionism and the perceived educational affordances of non-goal orientated virtual worlds (Table 2.5)

Constructionism	Perceived educational affordances	
Construct personally meaningful artefacts	Creation of persistent objects	Construction
Actively explore, test and extend understanding		Programming
Opportunity to programme		Persistence
Shareable artefact		
<i>Bricolage</i>	Flexibility	
<i>In-situ</i>	Embodied social presence	
‘Invisible’ technology	Immersion	
Collaborating on constructions	Collaborative learning	

As previously stated, constructionism emphasises the role of constructing personally meaningful and shareable artefacts by learners in order for them to actively explore, test and extend their understanding. This process can be supported by the creation of persistent objects in NGO-VWs, such as *Second Life* and *Active Worlds*. As shown in Table 3.2, this key perceived educational affordance comprises three parts, each of which aligns with a feature of constructionism.

Construction and programming clearly align to the construction of personally meaningful artefacts and the opportunity to programme, described by Hoyles et al. (2002) as an important aspect of constructionism. As part of a constructionist learning experience, learners construct

shareable artefacts. It is suggested that persistence allows the artefact to be shared without requiring users to be online simultaneously.

The flexibility of *Second Life* provides learners not only with the opportunity to engage in the learning experience at any time or place (Robertson & Kipar, 2010), but also the opportunity to construct, reconstruct and start afresh any artefact. This provides the learner an opportunity to engage in *bricolage* (Papert, 1991), which in turn may also support the exploration, testing and extending of the learner's understanding,

An embodied social presence may support a sense of *in-situ* construction. This may be particularly likely when collaborating on constructions within *Second Life* when learners are not co-located. In this context, the artefact is constructed, shared and discussed within the NGO-VW, supporting knowledge construction.

Learners who experience immersion in the NGO-VW are potentially more likely to consider the computer and NGO-VW as 'invisible'. This may be particularly likely from the level of engrossment, at which point controls are described as becoming invisible (Brown & Cairns, 2004).

Finally, by leveraging collaborative learning, Resnick's (1996) third form of distributed constructionism, collaborating on constructions, should be achieved. It is anticipated that this may be particularly powerful when learners are not co-located, through a sense of *in-situ* construction.

3.5.2 Design principles

The previous section described the design of SLurtles which provide learners with a programmable low-floor construction tool to support the construction of persistent, personally meaningful and shareable artefacts. However SLurtles are tools and not a learning experience.

Drawing on the alignment of pedagogy and technology, a set of design principles to guide the design of constructionist learning experiences in NGO-VWs was developed. These are further broken down into generic features which should be apparent regardless of context and those which are context dependent. Table 3.3 provides an overview of the design principles which are discussed below and highlighted in bold. The generic and context specific features are identified and marked in the text in italics.

Table 3.3 Alignment of pedagogy, technology and design principles

Constructionism	Perceived educational affordances		Design principles
Construct personally meaningful artefacts Actively explore, test and extend understanding	Creation of persistent objects	Construction	Task based on the use of SLurtles to construct an artefact
Opportunity to programme		Programming	
Shareable artefact		Persistence	
<i>Bricolage</i>	Flexibility		Time to engage
<i>In-situ</i>	Embodied social presence		Learning space
'Invisible' technology	Immersion		Familiarisation with technology
Collaborating on constructions	Collaborative learning		Opportunity to collaborate

By programming SLurtles to construct persistent objects, learners can engage in the construction of personally meaningful artefacts as they explore, test and extend their understanding. To facilitate this, learners need to be given carefully chosen **tasks** which require the construction of objects. The *form* of these tasks and whether they are open (e.g. create something interesting) or closed (e.g. create a square) requires careful consideration and will be dependent on the context of the learning experience. The task may also affect the *variety of SLurtle blocks* made available to learners. For example, if the learning task is closed, providing learners with only one type of SLurtle may be preferred.

The flexibility of NGO-VWs should support learners to engage in a process of *bricolage* as they construct their learning artefacts. However *bricolage* requires the development of ideas and the opportunity to redesign artefacts. Providing learners with sufficient **time to engage** in this process should support their active engagement in exploring, testing and extending their understanding through programming SLurtles to create objects. The amount of time will depend on the intended *learning outcomes* and *time available* which are context specific.

In order to leverage the sense of embodied social presence to support a sense of *in-situ* construction, the in-world location of learners needs to be considered. The **learning space** may need to be public, semi-private or private and may this depend on the form of assessment used. For example the learning space may have clear boundaries preventing access but allowing learners to view the artefacts of others. To support the construction of personally meaningful artefacts Scratch and Turtle provide learners with a blank 'canvas' in which to create their artefacts. When first purchased, an island in *Second Life* can provide learners with a similar

blank canvas as a *featureless island*, or *multiple discrete learning spaces* can be created. The form that the discrete learning spaces take will depend on whether they are to be *public, semi-public or private*. It is important to note the distinction between making sections of an island publicly accessible to those that can access the island and making the whole island public to all *Second Life* users. In the design of SLurtle-based learning experiences reference is made to the former, while ethical considerations for research (discussed in Chapter 4) may refer to both.

As discussed in the previous chapter, learners who experience engrossment and engagement in NGO-VWs are more likely to consider the computer and NGO-VW interface as 'invisible'. However learners need to be provided opportunities to become **familiar with the technology** before they can experience immersion (Brown & Cairns, 2004). This may include *pre-teaching of skills, engagement in other in-world learning experiences and independent or collaborative opportunities to practice skills*. Once they are familiar with the technology learners should have overcome initial barriers and become immersed in the environment.

By leveraging the features of NGO-VWs which have been identified in the literature as supporting collaborative learning, such as the avatar and communication tools, it should be possible to provide learners with the **opportunity to collaborate**. However, whether a constructionist learning experience needs to be collaborative or not depends on the learning context. As highlighted in Chapter 2, distributed constructionism focuses on collaboration in three forms: discussing, sharing and building artefacts. The discussion of artefacts may be supported through the use of avatars and communication tools, while the persistent and flexible nature of NGO-VWs should support the sharing of artefacts. Social interactions may be of particular importance to distributed learners. In this context, if learning spaces are private an informal shared space in-world may be made available to learners to socialise. Although a constructionist learning experience does not need to be *collaborative or support socialising*, if these are not desired in the learning context, it may be questionable as to whether a NGO-VW is the correct technology for the context.

Table 3.4 presents an overview of the design principles and the generic and context specific features described above. The first column identifies the design principles, the second presents the generic features that remain the same across contexts and the third column shows features that may vary depending on the learning context. It should be noted that designed learning experiences will vary greatly depending on context and learning goals. The following section provides two sample learning experience designs which illustrate this point and illustrate how the design principles can be implemented in different contexts.

Table 3.4 Guiding design principles and features.

Design principle	Generic feature	Context specific features
Task based on the use of SLurtles	Create an artefact using SLurtles	Task form: Open/closed task
		The variety of SLurtle blocks available
Time to engage	Time to engage in the task and process of <i>bricolage</i>	Learning outcomes
		Time available
Learning space	Blank canvas	Island space/multiple discrete spaces
		Public/semi-public/private
Familiarisation with technology	Opportunities to engage in technology specific skills such as avatar movement.	Pre-teaching of skills, engagement in other in-world learning experiences and independent or collaborative opportunities to practice skills
Opportunity to collaborate	The learning experience should support collaboration and/or socialising.	Informal shared space

3.5.3 Applying the design principles

In order to design a learning experience it is necessary to have an understanding of the learning context. While the generic features of the design principles will remain the same, the variable features will be affected by a number of factors. This section briefly presents how the learning context affected the design decisions made in two learning scenarios, with each design principle highlighted in bold.

3.5.3.1 Primary school maths

The first learning context was a series of 60 minute primary school maths lessons in which 16 students aged 10 years old used SLurtles to develop an understanding of shape. This learning experience was implemented as part of a Masters research dissertation (Devlin, 2012).

Learners had prior experience of using the technology as this learning experience was one of a series in-world. Therefore the students were **familiar with the technology** before this learning experience. Each lesson focused on a different **task**, scaffolding learners’ exploration of 2D and 3D shapes which concluded with each group of learners creating a house by programming the SLurtles. Due to the context, only SLurtles that created cuboid shapes were used.

In order to achieve the learning outcomes, learners engaged in the learning activity for an average of 55 minutes per lesson over eleven lessons, providing them with sufficient **time to engage**, achieve the learning outcomes and extend their understanding by undertaking more

complex, self directed tasks. As there was no formal assessment as part of this lesson, the **learning space** was a public island space, on an access controlled *OpenSim* server, allowing learners to use all of the available space and communicate with each other in-world (Figure 3.11). As learners were able to **collaborate** face-to-face an informal shared space was not necessary.

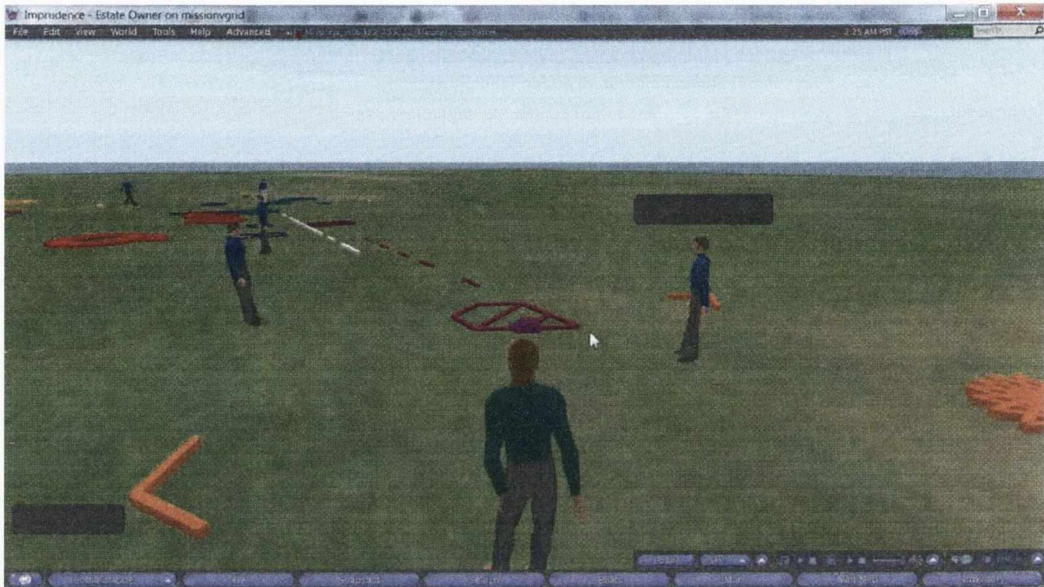


Figure 3.11 Screenshot of learners participating in the construction of shapes (Devlin, 2012)

3.5.3.2 Computer programming outreach

The second context is a programming workshop over three-and-a-half consecutive days during normal school hours with 25, 15-16 year old students at Bridge21 (Conneely et al., 2012). This implementation was designed in conjunction with the staff at Bridge21 for future implementation.

At Bridge21 students work in face-to-face teams of four or five to complete project based activities using technology (Tangney et al., 2010), providing an **opportunity to collaborate**. Based on the context, **tasks** would be open ended projects allowing the learners to create artefacts that are meaningful to the group. As such a wide variety of SLurtle blocks would be made available.

In Bridge21, each group has its own physical space with two computers in a shared room. This setting is an important feature of the Bridge21 model of learning, thus the in-world **learning space** would need to mimic this environment providing each group with a discrete learning space. Each space would be public allowing groups to visit each others' spaces as per the Bridge21 physical learning space.

Opportunities to gain **familiarisation with the technology** would be provided through engagement in other in-world activities rather than pre-teaching, as the focus of learning technical skills in this context, is within teams rather than from a teacher or other adult. Following these activities, learners would be provided with **time to engage** in the task for the remainder of their time at Bridge21, allowing them to return to the project and develop it over several days.

3.5.4 Learning experience implemented in this thesis

In this thesis, a learning experience was designed as part of a module for post-graduate learners on a taught Masters in technology and learning. The course is taken over two years part-time to support the participation of practicing teachers and other professionals. The degree course is underpinned by communal constructivism (Holmes, et al., 2001) and focuses on technology mediated transformative learning experiences (Mezirow, 1996). While the course content has changed over time it broadly introduces learners to pedagogical theories, various technologies, critical reflection, collaboration, design principles and research.

The module for which the learning experience was designed is worth 10 ECTS credits and has no formal pre-requisites. Teaching and learning activities centre around a mixture of formal lectures which are kept to a minimum, practical sessions and workshops. The aim of the module is to raise awareness and develop understanding of a number of innovative technologies used in the area of technology and learning through engaging in concrete experiences with these technologies. The full module descriptor including intended learning outcomes is provided in Appendix B and the learning experience was designed to meet the aims, learning outcomes and assessment described.

A typical cohort of 25 learners would be divided between those working in formal education and those involved in various roles in the workplace including instructional designers and trainers. Applicants to the course are expected to hold an upper second class honours degree or better. However the educational background can vary significantly with some past graduates of the course holding a PhD.

For the purpose of this research, a group of 24 and a group of 26 learners participated in a learning experience over four and six weeks respectively. The two implementations took place one year apart. The intended outcomes were for learners to experience a constructionist learning activity and gain an understanding of programming, as described in Appendix C which presents the formal description of the activity, marking scheme, submission and demonstration of the assignment as made available to the students. Both groups participated on the same

Second Life island, *Insula Docta TCD*, an access controlled island which only provided access to learners.

The learning experience was designed with the course team. The main lecturer on the module is experienced in the implementation of constructionist learning experiences. However as he had no previous experience of *Second Life*, the learning experience was designed in keeping with previous constructionist activities that he had run on the course which involved learners engaging with *Lego Mindstorms* kits to create an interactive robot.

A workshop provided a brief face-to-face introduction to SLurtles and S4SL, after which learners were set an **open task** to complete as part of their course assessment. The task required each group to create an interactive installation, programming SLurtles to create the installation and using S4SL to programme the installation to be interactive. Thus a wide variety of SLurtles were provided for learners to use.

Learners worked in pairs where possible and were **expected to collaborate**. However, as the learners are required to only attend the institution part-time, an opportunity to collaborate at distance was important. They were allowed to meet face-to-face, meet only online or a combination of these depending on their personal preference. In the first implementation learners had **four weeks to engage** with the learning experience and in the second **six weeks to engage**. This time was determined by the wider course timetable. At the end, the learners were required to present their installation and reflections on the experience to the class.

As the learners' artefacts were to be assessed as part of an accredited course, each pair was provided with a discrete **learning space** with clear boundaries. Each pair was provided with a 40 x 40 metre platform (Figure 3.12) on the island, in which they were required to create their installation. Each platform was identical with partially transparent walls allowing learners to look into each other's spaces whilst clearly demarcating the group space and preventing the avatars from falling off the edge of the platform. A walkway connected each group's space for those who preferred to walk rather than fly between spaces. To support **collaboration and socialisation** with the wider group each learning space was public to island members, providing all learners with the opportunity to access each others' spaces. Thus learners were provided with a publicly accessible, discrete learning space within an access controlled island.

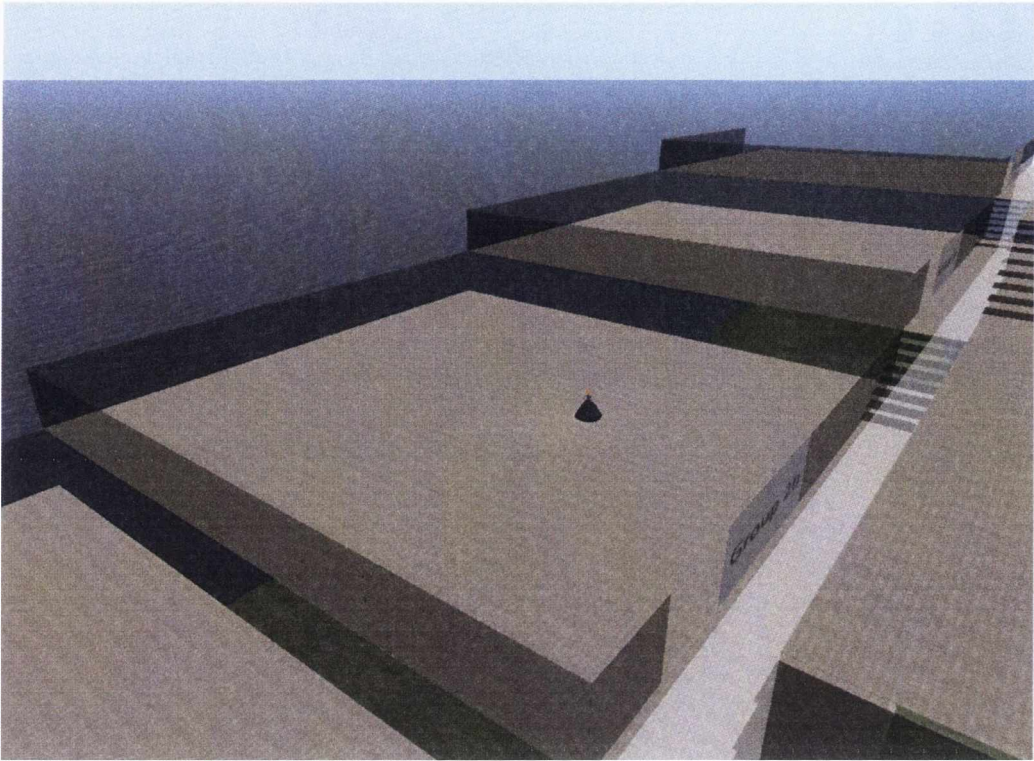


Figure 3.12 Blank platform with avatar.

Prior to taking part in the learning experience, as part of their course, learners participated in a five hour in-world introduction to *Second Life* as a teaching and learning environment. This consisted of: a short power-point presentation; the practicing of basic skills such as navigation and communication through a series of tasks culminating in a scavenger hunt across several islands; the exploration of discrete learning experiences; and a final text-based group discussion on the constraints and potential of NGO-VWs for teaching and learning. Through these activities learners had been given an opportunity to **familiarise themselves with the technology** prior to the commencement of the learning experience.

3.6 Conclusion

Following the constructionist tradition, SLurtles have been created to provide learners with a programmable low-floor, high-ceiling and wide-wall construction tool. SLurtles are designed to facilitate the design of constructionist learning experiences in NGO-VWs, overcoming the high-floor barrier to engagement presented by in-world construction tools.

Leveraging the perceived educational affordances of the technology to provide an opportunity for the features of the pedagogy to emerge, guidelines for the design of SLurtle-based constructionist learning experiences have also been developed. Implementing these guidelines

a learning experience has been designed for the purpose of addressing the primary research aim:

To explore constructionism in action in non-goal orientated virtual worlds

However, it is not possible to anticipate whether the design of SLurtles or the learning experience would be successful. Therefore they need to be explored in action through a pilot study in addition to the proposed alignment of pedagogy and technology. Thus two secondary aims for the first implementation of a SLurtle-based constructionist learning experience are to:

- Explore SLurtles in action with learners
- Explore the learning experience in action with learners

Underpinning the design of SLurtles are the broad constructionist principles of low-floor (easy to use), high-ceiling (powerfully expressive) and wide-walls (support the creation of a variety of artefacts): concepts central in the design of constructionist tools for learning. Considering Norman's (1999) distinction between designed and perceived affordances, while designed for, these affordances may not emerge when SLurtles are used by learners. While a block programmed to be persistent, will be persistent, SLurtles may not be easy to use and the complexity of constructions may be constrained. Similarly, while aiming not to limit the types of constructions which learners could make, this may not be perceived to be true by the learner. Thus, these design concepts are examined through the following research and sub-questions:

- Do SLurtles provide learners with a pedagogical tool with which to engage in constructionist learning in virtual worlds?
 - Do SLurtles provide learners with a low-floor construction tool?
 - Do SLurtles provide learners with a high-ceiling construction tool?
 - Do SLurtles provide learners with a wide-wall construction tool?
 - How do learners use SLurtles as part of a constructionist learning experience?

Similarly, while designed to provide learners with a constructionist learning experience by leveraging the perceived educational affordances, this may not emerge when implemented with learners. Therefore the following research questions are posed:

- Are learners able to engage in constructionist learning?
- Are the perceived educational affordances utilised by learners to support their engagement?

Chapter 4 presents the research approach taken to explore SLurtles and the learning experience in action. This is followed in Chapter 5 with the first implementation of a SLurtle-based constructionist learning activity in order to address the primary and secondary research aims.

4 Methodology

4.1 Introduction

Chapter 2 highlighted the limited amount of research into the use of constructionism to underpin learning experiences in NGO-VWs. Existing literature fails to clearly describe how the pedagogy is used to underpin the design of learning experiences and presents no findings that enhance our understanding of constructionism in action with learners in NGO-VWs. There is also no consideration of the features and perceived educational affordances of NGO-VWs that are not present in other constructionist learning environments. Therefore the primary aim of the research presented in this thesis is:

To explore constructionism in action in non-goal orientated virtual worlds

In order to engage in constructionist activities, learners require easy to use tools. This allows them to focus on the learning goals rather than learning how to use the tools. However as Dickey (2005b), Sanchez (2009b) and Cheal (2009) have noted, construction and programming tools in NGO-VWs present learners with a high-barrier to overcome before they can engage in learning activities. While S4SL (Rosenbaum, 2008) provides an external low-floor programming tool for *Second Life*, there was no low-floor construction tool prior to this research. To address this, Chapter 3 presented the design of SLurtles and SLurtle-based constructionist learning experiences, introducing two secondary research aims:

- Explore SLurtles in action with learners
- Explore the learning experience in action with learners

Due to the paucity of literature on constructionism in NGO-VWs, it is also necessary to identify areas for future research in order to provide greater depth of understanding. Additionally as collecting data in NGO-VWs presents a number of challenges and opportunities it is necessary to refine data collection in the NGO-VW. Thus two additional secondary aims are introduced:

- Refine in-world data collection
- Generate research questions for future research

To accomplish these aims the following six requirements of the research arise:

1. Pilot SLurtles with authentic learners
2. Create a rich description of the learning experience
3. Explore learners' perceptions

4. Identify pertinent factors
5. Pilot in-world data collection approaches
6. Generate research questions

To achieve these requirements, this chapter presents the rationale for the methodology, research method and ethical approach taken in this thesis. Section 4.2 presents four **methodological approaches** and considers both the role of educational research and the researcher's own philosophical perspective in identifying an appropriate methodology for this study. Interpretive research is identified as the methodological approach most in-line with the role of educational research, the perspective of the researcher and the requirements of the research.

Section 4.3 identifies case studies as the most appropriate **research method**. The differing approaches to conducting case studies presented by two authors, Robert Yin and Robert Stake, are outlined, identifying an exploratory case study followed by an instrumental case study as the best approach to achieve the aims of the research. As case studies lack routine procedures (Yin, 2009), the remainder of this section then focuses on how the two case studies are implemented.

Finally, section 4.4 presents the **ethical considerations** emerging from the chosen research method. With limited literature on the ethical considerations of conducting research in NGO-VWs, this study adopts a teleological approach to address the key ethical concerns of informed consent, privacy protection and identity.

4.2 Methodology

This section begins by framing the research presented in this thesis within the sphere of educational research. This is followed by a summary of five methodological approaches identified as potentially relevant for this study; positivist, postpositivist, interpretive, critical and feminist. There are several approaches which are not discussed, such as queer theory and postmodernism, as their objectives are outside the scope of this research.

Within the sphere of social science, and especially within education, it is necessary to consider the researchers' own understanding of knowledge, its ontological basis and its methodological implications (Hitchcock & Hughes, 1995). It is possible that the researcher's understanding will change over the course of the study and may necessitate a re-examination of methodological choices and in turn data collection procedures. This is briefly presented and combined in the discussion with the requirements of the research to present the rationale for selecting a broadly interpretivist approach for this research.

4.2.1 Educational research

As stated by Merriam (1998), within positivist research, education is considered the object under investigation, in interpretive research it is a process and within critical research it is a social institution. However it is perhaps the role of educational research that is most important. To understand this it is first necessary to understand what the term ‘education’ encompasses. Bassey (1999) provides a framework definition of education, stating that “education is:

- First, the experience and nurture of personal and social development towards worthwhile living;
- Second, the acquisition, development, transmission, conservation, discovery and renewal of worthwhile culture” (p.38)

Figure 4.1 illustrates Hargreave’s (1997) model of the influence of educational research on the practice of teaching (as cited in Bassey, 1999). The strongest influence it has is on evidence-based knowledge of teaching which can inform a teacher’s craft knowledge of teaching. Whether it is the positivist generalisation which is implemented across an education system or a teacher’s own evaluation of an interpretive study and whether it could be generalised to their own circumstance, educational research can influence the practice of teaching.

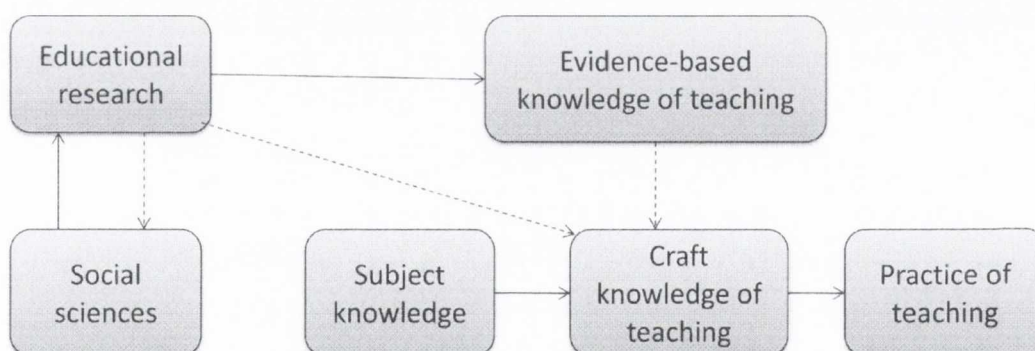


Figure 4.1 Hargreaves’ (1997) model of the relationship between educational research and teaching.

4.2.2 Five methodological approaches

4.2.2.1 Reductionist approaches: Positivist and postpositivist research

Reductionist approaches to research focus on identifying the interactions between the parts that make the whole. The emphasis on cause-and-effect relationships requires the researcher to identify and control the variables within their research context. Within positivist educational research, research methods from the natural sciences can be applied: using existing theory to derive a hypothesis; collecting quantitative data; following statistical analysis; and expressing

findings as generalisations applicable to the wider population (Cohen, Manion & Morrison, 2007).

The same emphasis on systematic steps, rigour and validity, applied to qualitative data analysis may result in the researcher's approach being described as postpositivist. Postpositivist researchers apply similar techniques to qualitative data as positivists do to quantitative data. Although this data is collected from multiple perspectives, it is treated in a reductionist manner, systematically analysed, with an emphasis on cause-and-effect, and results are seen as generalisable to the wider population (Creswell, 2007).

Positivist and postpositivist approaches differ in their ontology and epistemology. Positivist research aims to study and understand reality, while in postpositivist research reality can never be fully understood and only approximated (Hatch, 2002). The positivist view that only quantifiable and observable actions are relevant and that analysis of data from a sample can be generalised up to the population does not address the variety of human responses to environmental situations and assumes a deterministic view of human nature. The postpositivist approach to qualitative data may be criticised due to its reductionist nature but it provides an emphasis on rigour and validity which is critiqued as absent in many other approaches to qualitative data (Bassey, 1999).

4.2.2.2 Interpretive research

Interpretive research is often used as an umbrella term which encompasses several approaches to qualitative research, including critical research and feminist research discussed below. Interpretivist approaches to research reject the reductionist approach of positivist and postpositivist research, preferring to explore and describe the complexity of the subjective experience (Creswell, 2007). However within interpretive research, it is not merely the actions of learners which are observed that inform the researcher's understanding, there is also a need to understand the idea, intention, motivation and beliefs behind those actions (Bartlett, 1991). To gain this understanding a variety of data may be collected including interviews and documents. Meanings are viewed as being negotiated through an individual's interactions with others as well as their cultural and historical background, therefore the researcher uses open-ended questioning and positions themselves within the research, acknowledging the influence their own background has on their interpretations of data. However the varying contexts in which research may be conducted and lack of variable control may prevent a simple semantic analysis of responses and may therefore require pragmatic consideration.

As Carr and Kemmis (1986) note, the interpretive paradigm cannot account for the social, cultural and political context of the individual, which may distort self-understanding and

therefore affect their responses. Nor can it account for those participants who consciously (or sub-consciously) provide misleading information. It is also important to be aware that the researcher themselves has their own construct of being and knowledge and this may bias their interpretation of data. While there are critiques of the rigour and relevance of interpretive research, Guba (1981) presents credibility, transferability, dependability and confirmability in interpretive research as corresponding approaches to positivist internal validity, generalisability, reliability and objectivity.

4.2.2.3 Critical research (Advocacy/participatory)

Strongly influenced by the work of Jürgen Habermas, the epistemological assumption of critical research is that technical knowledge, which may emerge from positivist research, and practical knowledge, emerging from interpretive research, are legitimate forms of knowledge but inadequate. 'Emancipatory' knowledge emerges through reflection on power relations in the political and ideological context (Carr & Kemmis, 1986). It is through emancipatory knowledge that the transformation of society, the aim of critical research, can take place.

There are a number of approaches to critical research. Some researchers follow participatory and action research strategies, others the reflective, theoretical and practical approach of ideology critique (Cohen, Manion & Morrison, 2007). Rejecting the notion of 'truth' within the positivist paradigm, critical researchers' view a traditional, interpreted reality as insufficient as it neglects to account for the potential distortion of the interpretation process (Carr & Kemmis, 1986).

However critical research has a deliberately political agenda and an interest in shaping behaviours (Cohen, Manion & Morrison, 2007). Political agendas may bias the research questions asked and the interpretations made. As described by Carr & Kemmis (1986), interpretive approaches are limited by relying on participants' self-understanding and researchers' interpretations of these, as they do not account for the social, cultural and political influences on those understandings. However the process of critique and the expression of emancipatory knowledge needs to be mediated through language which is value laden and therefore open to individual interpretation which can be distorted by social, cultural and political context. It may therefore be difficult to ensure an undistorted representation.

4.2.2.4 Feminist research

As a female researcher it is relevant to understand and examine feminist research as an interpretivist approach. Feminist research gives particular value to the female perspective and seeks to empower women in a male dominated world which oppresses women. It raises concerns about the use of male constructed theories, male assigned meanings to language, the

ability of men to analyse the experiences of women, dominance of the researcher over the participant and the participant as beneficiary of the research (Ezzy, 2002; Cohen, Manion & Morrison, 2007). These concerns may be of interest to the social science researcher, particularly in NGO-VWs where gender may be explored in different ways, for example a male discovering how they are treated as a female avatar (Francino & Guiller, 2011).

Feminist research focuses on particular questions relating to the affect of gender on meaning and this may be seen as too narrow a focus within educational research (Cohen, Manion & Morrison, 2007). It does however highlight issues of power relations and the use of language within the research process. As with critical research, feminist research aims to produce critiques which challenge power imbalances (Hatch, 2002).

4.2.3 Personal Statement

The methodological approach to be chosen depends on a number of factors, not least of which should be the researcher's own understanding of existence and reality (ontological assumptions), knowledge and its limitations (epistemology) and human nature and its relationship with its environment. Burrell and Morgan (1979) identify these as the assumptions which inform the researcher's methodological approach.

I acknowledge that both my current and past experiences will have had a significant impact on my ontological and epistemological assumptions as well as those on human nature: being located within a computer science department whilst conducting this research; my background in linguistics; experience as a practicing teacher; as well as my general life experiences. I identify my own assumptions as broadly in line with the subjective conception of social science as described by Cohen, Manion and Morrison (2007). I take a pragmatic approach, believing that there is no privileged route to knowledge and the route chosen should be based on both the researcher's own philosophical perspective and aims of the research. I believe educational research should be both relevant to the context in which it is conducted and to wider communities of researchers and educators. I view language, whether thoughts, written or vocal, as shaping our lived experience and influencing our actions. I also consider dialogue to be formative in developing understanding. Due to the nature of language (semantics versus pragmatics) and bias of the researcher, it may be difficult to report a study without either making value judgements or allowing the reader to do so. Without language we cannot begin to understand the individual mind, motivations and emotions, yet language is insufficient to accurately describe the individual's experience of life.

4.2.4 Discussion

Considering the aims and requirements of the research, together with the previous statements on educational research and the researcher’s own ontological assumptions and epistemology, the research undertaken in this thesis adopts a broadly interpretivist methodology. Table 4.1 presents an overview of the research aims and requirements in relation to the five methodological approaches presented: positivist, postpositivist, interpretivist, critical and feminist. Green denotes those research aims or requirements which could be met by the methodological approaches. Amber indicates those that could be met but would be limited by the confines of the approach, for example feminist research could identify pertinent factors but these would always be linked to gender.

Table 4.1 Overview of alignment between methodological approaches and research aims and requirements.

	Methodological approach				
	Positivist	Post-positivist	Interpretivist	Critical	Feminist
Research aims					
Explore SLurtles					
Explore the learning experience					
Refine in-world data collection					
Generate questions					
Research requirements					
Pilot SLurtles					
Rich description					
Perceptions of learners					
Identify pertinent factors					
Pilot research methods					
Generate research questions					

In considering the aims and requirements of the research, reductionist approaches emphasise the relationship between cause and effect. Although this could provide an approach to validate the alignment of pedagogy and technology, it would be necessary to identify all variables. However a natural educational setting is a complex context in which it is not possible to identify all variables. Whilst there are some overt variables such as age, gender or time on the activity which can easily be identified, there are many which the research cannot identify or quantify.

One of the greatest mediators in social interactions is language and is therefore a powerful tool that can be used to mediate understanding between participant and researcher, providing the researcher with some level of access to the participant’s knowledge. Thus, interpretive

approaches, in which the meaning of an experience is negotiated, provide the methodological approach most in line with the researcher's own beliefs. However neither critical nor feminist approaches meet the requirements or aims of this study. While the educational context of this research perhaps suggests that an implicit aim of this research may be to change or transform practice, this is not an explicit aim of this study. Equally, this researcher does not aim to empower women nor focus on the female perspective. However feminist approaches do highlight issues of power relationships which are strongly rooted in language and this has ethical implications when obtaining informed consent, considered later in this chapter in section 4.4 on ethics.

While the positivist and post-positivist focus on generalisable theories of human behaviour are attractive to many researchers, they do not account for individual cases which do not fit the theory (Guba & Lincoln, 1994). Therefore generalisations may be insufficient when focusing on a specific case. It may also be argued that a purely interpretive approach which rejects generalisation does not consider how the findings of an individual study can be developed into what Bassey (1999) terms 'fuzzy generalisations', which suggest that something may or may not be found in similar contexts.

It is necessary to be aware of and make explicit the choices that have been made in identification of a methodological approach (Creswell, 2007). Each approach influences the researcher, including the interpretations that will be made (Denzin & Lincoln, 2008). Based on the requirements of the research and with consideration of the researcher's own ontological and epistemological understandings, the research undertaken in this thesis adopts a broadly interpretivist methodology. Considering Hargreaves' (1997) model of the relationship between educational research and practice, the individual interpretation and generalisation of findings to other contexts is considered to be important. However the personal views of the researcher in 4.2.3 influence the approach adopted in this thesis with regard to generalisation, aligning more closely with the generation of fuzzy generalisations by the researcher. This issue is returned to in the discussion of the research method.

4.3 Research method

4.3.1 Choosing between three methods

Research methods are distinct from methodology as 'methods' pertains to the tools and methodology to how these tools are interpreted. Within educational research there are a wide range of research methods that may be applied within an interpretivist approach (Cohen, Manion and Morrison, 2007). Of these three research methods were considered as potentially appropriate for this study: grounded theory; action research; and case study.

Grounded theory provides researchers with an approach which aims to produce a mid-range theory of the phenomena under study. Rather than beginning a study with a predefined and tested theory, grounded theory is a method for developing a theory which is generated from data (Strauss and Corbin, 1994). The reasoning behind this is that implicit theories reside within data. As such the researcher remains open to emergent codes and categories throughout the process. Data collection and analysis are systematic, take place simultaneously and involve theoretical sampling. Grounded theory methods, such as the constant comparative approach to data analysis may be appropriated within other interpretive methods. Grounded theory is also linked to the positivist tradition (Charmaz, 2005). However, unlike positivist approaches, pre-existing theory does not inform initial hypotheses which lead to data collection, although the processes which result in theoretical sampling use theory emerging from the data.

Action research is typically associated with critical research and is common in educational research which aims to improve current practices by changing them (Bassey, 1999). Involving both researcher and participants in a collaborative enquiry, action research aims to provide understanding of particularly complex social phenomena and, through a process of change, improve the current social situation by empowering the participants (Cohen, Manion and Morrison, 2007). This typically occurs through a series of case studies in a cycle of planning, implementation, observation and reflection.

Similarly to grounded theory and action research, case studies are situated within a real-life context, where an understanding of the phenomenon is linked to its context (Yin, 2009). Unlike grounded theory, theory is developed from the existing literature prior to data collection. Theory, emerging from the literature, impacts the type of case study chosen; the cases to be studied; analysis of data; and interpretation of findings (Yin, 2003; 2009). Observations, interviews and documents provide the most common data sources for a case study. As with action research, the approaches for analysing are eclectic and vary depending on the intended outcomes of the study. The final outcome of a case study should be a rich description of the case. However there may be additional intentions of the researcher to interpret, evaluate and build theory.

Considering each of these methods, the six requirements (outlined in the introduction to this chapter) and the researcher's own beliefs, the case study is the chosen research method for this thesis. This is done whilst acknowledging the eclectic nature of case study methods. For example, while the research reported in this thesis involves two case studies, involving reflection and planning between implementations, action research is not the most appropriate method as the research does not aim to improve existing practices by changing them, although

this may be a future goal. The constant comparative approach to data analysis, a grounded theory method, provides an opportunity to openly code data to identify emergent issues which may be supportive in addressing the first two aims of this study. However the emphasis placed on the researcher by grounded theory to collect and analyse data without preconceptions does not fit with the researcher's own beliefs about the limitations of the role of the researcher as interpreter. Equally this study is based on the proposed alignment between the features of constructionist pedagogy and the perceived educational affordances of NGO-VWs and thus the study is based on a theoretical proposition. Therefore the case study method is used whilst appropriating from other methods as required.

The following sub-sections present and justify the use of exploratory and instrumental case study methods in this thesis. This is followed by a detailed discussion of the various aspects of the case study method, structured to follow the temporal sequence of a case study: research questions; identifying the case; data collection; data analysis; validity; reliability; and generalisation. Finally to summarise, section 4.3.9 presents an overview and justification of the approaches taken in each of the case studies.

4.3.2 Case study approaches

Case studies explore a phenomenon situated within a bounded real-life context (Yin, 2009), resulting in a rich description of the case. However several authors suggest different approaches to defining the case, reasons for conducting a case study and the intended outcomes of the research, which in turn impact the data collection and analysis approaches. In addition, case studies can be used in positivist, critical and interpretive research and hence Merriam (1998) describes case studies as lacking clear definition and description. Two prominent authors on the case study method significantly influence the approaches taken within this study, Robert Stake and Robert Yin. Both authors present multiple types of case study, each with its own aims and approaches

Stake (1995) presents three types of case studies; intrinsic, instrumental and collective. Intrinsic case studies are undertaken to understand a case of inherent interest to the researcher. The purpose of the study is to understand the case rather than to test a hypothesis or build theory, although it does not prohibit this outcome (Stake, 2005).

Instrumental case studies are single cases used to advance the existing understanding of an issue and to improve generalisations (Stake, 2005). While a description of the case is presented it is not the focus of the study.

Finally the collective study uses multiple cases to improve the understanding and potential theorising of the researcher (Stake, 2005). Stake's collective case study is similar in purpose to the use of multiple cases by Yin, providing an opportunity to improve external validity, reliability and generalisation of findings (Miles & Huberman, 1994).

Yin's (2003) six forms of case study can be considered as three types; exploratory, descriptive and explanatory, with each type having the potential to be conducted with single or multiple cases. Exploratory case studies are used to generate and refine research questions and hypotheses when there is a dearth of existing literature and theory in the area (Yin, 2009). While this type of case study can also be used for piloting, the results of the study may be of substantial interest to the field, identifying and elaborating on key concepts in an otherwise broad field (Yin, 2003). However subsequent studies conducted on the improved understanding provided by the exploratory case cannot incorporate the original exploratory data, thus preventing 'bleed' from the exploratory study (Yin, 2003).

Descriptive case studies focus on producing a rich description of the case under investigation. Descriptive case studies may be considered to be very similar to intrinsic case studies as they do not aim to test hypotheses or build theory and it is an interest in the case that fuels the investigation. However theory does have a role in the descriptive case study, which Stake does not consider in the intrinsic case study. Theory guides what is in or out of scope and how the case should be investigated (Yin, 2003). While it is not the aim of this research to study intrinsically interesting cases, it is the aim of all case studies to produce a rich description of the case being investigated.

Explanatory case studies aim to explain how and why events within a case occur, considering cause-effect relationships. Yin (2009) states that case studies cannot directly address the identification of causal relationships, by the nature of the method, as there are a wide variety of variables which could impact a case. Explanatory case studies use theory informed research questions to focus the study. While some of the variables may be identified in previous studies, it is the complex context of the case that is of interest to the case study researcher.

In this thesis an exploratory case study is implemented to achieve the primary research aim, followed by an instrumental case study to delve into specific issues. Each of the approaches to conducting case studies presented above was considered for use in this thesis. While they share similar outcomes, such as creating a case description, there are significant differences between the approaches. It was therefore important to identify the type of case study most appropriate to achieve the aims of the research presented in this thesis.

To achieve the primary aim, four secondary aims of the research have been identified: explore SLurtles; explore the learning experience; refine data collection in-world; and generate research questions for future research. The exploratory case study approach is closely aligned to these aims and is implemented in Chapter 5. Exploratory case studies are used to generate hypotheses and research questions when no pre-existing theory exists, or to isolate the hypotheses to be examined in a subsequent study when existing theory and literature is broad or non-specific. At the same time they can be used to pilot aspects of the study including SLurtles and data collection tools. While the use of an exploratory case study provides an opportunity to achieve the primary aim of the research, by implementing a second case study a greater depth of understanding can be achieved.

Having identified areas for future research through the first case study, the second case study provides an opportunity to explore some of these areas in greater depth. These are researched through an instrumental case study. Instrumental case studies provide an opportunity to advance existing understanding based on a single case. As the research questions of the second case study aim to uncover factors, a second exploratory study was considered, as this approach allows the researcher to remain open to emergent findings. However with the theoretical underpinning of the research having been established in the first case study, these need to be investigated and exploratory case studies may be too inductive. By comparison explanatory case studies may be too deductive at this stage without a clear understanding of the factors involved. In this study participant numbers are also limited which further reduces the effectiveness of explanatory case studies. With limited opportunities to implement following the first case study, the use of multiple or collective case studies is prohibitive. Single intrinsic and descriptive case studies are excluded as they aim to provide a rich description which is specific to the case and not expected to be generalised. Unlike intrinsic and descriptive case studies, the findings of instrumental case studies may be generalised. As such they provide a closer fit with Hargreave's (1997) model of the relationship between educational research and teaching, referred to earlier (4.2.1). Therefore, in order to improve understanding of the emergent findings of the exploratory case study, an instrumental case study is implemented.

It is important to note that the cases in the exploratory and instrumental case studies are different bounded systems with common features. As a result, evidence may emerge from the instrumental case study which refutes the findings of the exploratory case study. However, the data from these two case studies cannot be mixed as the first is a pilot.

4.3.3 Identifying the case: A bounded system

Stake (2005) describes a case as a “specific, unique, bounded system” (p. 445), focusing on objects rather than processes, people rather than events, specifics rather than generalities. Stake (2005) refers to the bounds of a case study, identifying what is in and out of the bounds of the case, with some features which are outside of the bounds of the case remaining relevant to the context of the case. This is in contrast to Merriam’s (1998) broader definition of case studies as focusing on situations, events, programmes or phenomenon. Yin (2009) describes case studies as enquiries within a real-life context, where an understanding of the phenomenon is linked to its context.

Stake (1995) suggests that both ‘typical’ and ‘unusual’ cases may be appropriate. The case should maximise what can be learnt within the limited time available, provide ease of access for the researcher and include willing participants (Stake, 1995). Yin (2003) notes the important role of theory, existing literature and intended outcomes in the identification of cases to study. Using exemplary cases requires *a priori* understanding of what constitutes an exemplary case, similarly the use of extreme or unusual cases requires an understanding of what is ‘typical’.

Within this thesis both exploratory and instrumental case studies follow Stake’s approach, identifying a case which can maximise what can be learnt in the limited time available. Due to the nature of existing theory and literature underpinning this research, at time of selection it would not be possible to identify whether the cases were typical or unusual.

4.3.4 Data collection

Several authors note that researchers, often the primary data collection instrument, are provided with little training and guidance in the data collection techniques necessary for case study research and that these techniques lack formal definition (Merriam, 1998; Yin, 2009). This section addresses this problem by presenting several approaches to data collection and considers the implications of conducting these within a NGO-VW.

Bassey (1999) emphasises the need for ‘sufficient data’; enough for exploration, interpretation and testing for trustworthiness but not so much that there is insufficient time for the data to be successfully explored. Stake (1995) presents three main approaches to data collection: interviews, observations, and using documents. However, Yin (2009) lists six sources of data: documents, archival records, interviews, direct observation, participant-observation, and physical artefacts. The approaches to data collection used in this study are discussed below, followed by a discussion on the implications of conducting data collection within a NGO-VW.

4.3.4.1 Interviews

Interviews provide researchers with a particularly powerful research tool as a means to get 'inside a person's head' (Tuckman, 1994) in order to understand their subjective experience. Stake (1995) states that interviews should be targeted and influenced by the interviewer and not follow the whim of the interviewee as this "may tell us quite a bit about the interviewee but so often not what we need to know about what the interviewee has observed" (p.66). Stake (1995) focuses on using the 'issues' or research questions to guide the interview and does not recommend the use of audio recordings, but rather memory and notes so a quick report can be written capturing the essence of the interview for verification by the interviewee shortly following the interview.

Yin (2009) however notes that audio recordings can provide a more accurate account of the interview. Unlike Stake's notes and memory, audio recordings and transcription provide the researcher with an opportunity to return to and immerse themselves within the dialogue at a latter point in time, allowing issues to emerge from the data. While an audio recorded interview prevents data being lost or introduced by a researcher, inaccuracies and bias may yet emerge due to the interviewee's own poor memory, biases and articulation of responses (Yin, 2009). Responses may also be influenced by the articulation of a question by the researcher and the interviewee wishing to please the interviewer (Yin, 2009).

There are five main characteristics of interviews: purpose, type, form, medium and location. Within a research study there are three distinct purposes for choosing to conduct interviews (Cohen, Manion, & Morrison, 2000). Firstly, and most commonly, the purpose of a research interview can be to collect information pertinent to the broader objectives of the study. Secondly the interview purpose can be to validate, refute or amend hypotheses. Finally the research interview can be used in conjunction with other data collection instruments to develop nascent understandings or delve further into emergent aspects of the phenomena under study.

The purpose of the interview then guides the selection of the interview type. The literature in this area presents differing views on interview types (Cohen et al., 2000), however the most common typology is that arranged along the continuum of *structure*, from the structured (or standardised) interview to the unstructured or open interview which relies solely on open questions allowing the participant to form their own response (Creswell, 2002; Cohen, Manion & Morrison, 2007). The structured interview is a quantitative instrument consisting of closed questions with a fixed choice of responses and provides standardised, comparable and quantitative data (Cresswell, 2002; Cohen, Manion & Morrison, 2007). Highly structured and

standardised interviews may also be conducted as surveys (Yin, 2009), resulting in quantitative and possibly qualitative data as part of an embedded case study design. Further along the continuum is the semi-structured interview which combines closed and open questions in order to gather both quantitative and qualitative data. Finally the unstructured or open interview relies solely on open questions allowing the participant to form their own response. Of these there are two types of open interviews: those with pre-formed questions which act as a guide for the interviewer (focused interviews); and those which are led by the responses of the interviewee, in which the researcher has few pre-set questions (non-directive interviews) (Cohen, Manion & Morrison, 2007).

Both Yin (2009) and Stake (1995) show preference towards 'focused' interviews, with the aim of gaining descriptions, linkages and explanations as perceived by the interviewee. Yin (2009) notes that there are several types or 'levels' of questions that can be asked within a case study. Those most appropriate to interviews include level 1, questions targeted at specific interviewees, and level 2, questions about the specific case.

Convergent interviewing (Dick, 1998) is an approach to interviewing which moves from very open questions to increasingly structured questions with each subsequent interview. Between interviews there is a period of analysis and interpretation of the interview, followed by preparation of questions for the next interview. Each interview is conducted with a different participant. The aim of convergent interviewing is to build theory through the refinement of interview questions, converging on the issues (Rao & Perry, 2003). While this approach is described as a method, as it incorporates an approach to analysis and has its own stated aims, rather than a data collection technique, it may be possible to embed convergent interviewing techniques within case studies. However this approach would require a significant amount of time devoted to analysis between each interview, with the result that the final participant to be interviewed would be more dislocated by time from the original events within the case than the first participant interviewed. To reduce the time between interviews, text-based interviews could be conducted in-world as they contain less text on average and provide a ready-made transcript (Girvan & Savage, 2011).

One-to-one interviews are the most prominent form of interview (Kvale & Brinkmann, 2009) and are popular in educational research (Creswell, 2002). Although time consuming, a one-to-one interview allows the researcher to gather a personal perspective from the participant without fear of ridicule or the impact of group dynamics. While group interviews also gather information from individual participants the focus tends to be on the shared understanding of

multiple participants (Creswell, 2002). As such, group interviews can be seen to represent aspects of a knowledge construction event (Kvale & Brinkmann, 2009).

Whether conducting one-to-one or group interviews, there are several communication mediums through which the interview can take place. Traditionally interviews are conducted face-to-face or in some cases via telephone. However, advances in computer mediated communication tools and environments have opened up the possibility of conducting interviews through synchronous and asynchronous text-based communication using tools such as electronic mail and instant messaging. Alternative voice-based communication tools include voice over IP (VOIP) and video conferencing.

The final feature to be considered is that of location. As previously mentioned, interviews traditionally take place face-to-face with both interviewer and interviewee in the same location. However telephone interviews provide an opportunity for interviewer and interviewee to be at a distance from one another. The location of the interview will depend on the purpose of the interview, whether in the research setting (in context) such as a classroom or out of context in a private office. Thus, the traditional interview location may be face-to-face or at distance and in context or out of context. In addition, NGO-VWs provide researchers with another choice, whether to conduct interviews in-world or out-of-world (as discussed in 4.3.5).

Table 4.2 presents an overview of the interviews used in this research which are similar across the two case studies. Non-directive open interviews are used in the first case study as they support the broad exploratory nature of the research, allowing the researcher to ask questions based on the responses of the interviewees. Focused open interviews are used in the second case study. As this case study is focused by specific research questions, the interview questions need to reflect this, however the aim is not to collect quantitative data from the interview and therefore the open focused interview approach is used.

Table 4.2 Overview of interviews conducted in each case study

	Exploratory	Instrumental
Recording	Audio	Audio
Purpose	Develop understanding	Develop understanding
Type	Open, non-directive	Open, focused
Form	One-to-one	One-to-one
Medium	Face-to-face and VOIP	Face-to-face
Location	Face-to-face and in-world in context	Face-to-face

Both face-to-face and in-world interviews are conducted in the exploratory case study but only face-to-face interviews in the instrumental case study. Both were offered to participants in both case studies, however participants in the instrumental case study only chose face-to-face interviews. The implications of conducting interviews in-world is discussed below (4.3.5).

4.3.4.2 Observations

Unlike Yin, Stake (1995) shows preference towards observations over interviews, noting that observations are usually less controlled by the researcher than interviews. Stake (1995) states that pre-identified (*etic*), rather than emergent (*emic*) issues or research questions should be used to direct observations. The observation should provide an accurate description of events (Stake, 1995). Stake (1995) notes that there can be both quantitative and qualitative observations with quantitative focusing on aggregating coded data over several observations, while qualitative observations focus on producing a description of the case.

Yin (2009) describes two forms of observation: direct observation, both formal and informal, as a passive observer; and participant-observation, taking an active role in the case. Direct observation may include the use of a highly structured observation protocol to count the occurrences of certain behaviours, as well as informal and unstructured observations taken at various points, including during interviews.

The distinction Yin makes between direct and participant-observation is the role of the researcher within the case. During direct observation the researcher is a passive observer, however within participant observation the researcher may have a variety of roles and may participate in the action. As participant-observer the researcher may gain additional access to cases, which would otherwise be unavailable, as well as the opportunity to manipulate events (Yin, 2009). However, the researcher may introduce biases through support of the group being studied and may also be unable to perform both observation and participation roles simultaneously.

In this thesis a selection of participant-observations take place in the second case study as the researcher visited groups in-world to discuss questions that they had. However the first case study takes the opportunity to use participants' chat logs as a substitute to traditional observation. To critically appraise their use, the following research question is included in the first case study to focus the refinement of the research methods:

- Do chat logs provide an adequate means of data collection?

As shown in the findings of the exploratory case study (Chapter 5), chat logs were not adequate for data collection. Therefore in-world participant observation was used in the second case

study. It should be noted that both forms of observation provided a nearest substitute to observing the participants face-to-face. Table 4.3 provides an overview of the use of observation in the two case studies, further discussed in the section below on data collection in NGO-VWs (4.3.5).

Table 4.3 Overview of observations conducted in each case study

	Exploratory	Instrumental
Form of observation	Chat-logs	In-world participant observation

4.3.4.3 Documents and archival records

Yin (2009) describes documents as a source of corroboratory data, rather than a primary data source. Documents may provide records of an event the researcher could not directly observe (Stake, 1995) and are unobtrusive (Creswell, 2003). However, documents are not without bias and are written with an intended audience in mind (Yin, 2009). The intentions of such documents should be recorded and considered during analysis.

Creswell (2003) presents the use of audiovisual materials such as photographs, video and art objects as a source of data collection, separate to documents and physical artefacts. He considers that these, much like documents, are unobtrusive methods for data collection, however they can be more difficult to interpret. In this study, participants created individual and group reflections for course assessment (Table 4.4). As these documents are written for assessment purposes they are likely to be biased and written with those conducting the assessment in mind. While not directly comparable to documents, or each other, audiovisual materials were created by some participants for the same purpose. As such these data sources are treated in a similar way to the documents.

Table 4.4 Overview of documents collected in each case study

	Exploratory	Instrumental
Documents	Individual and group reflections	Individual reflections

Although Yin (2009) describes documents as a source of data which, unlike interviews or observations, are not an outcome of the case study, the reflection documents collected in this research were. They were created and submitted for assessment purposes and were generated as a result of the learning experience at the heart of the case. It is important to note that the

researcher was not involved in assessment on the course and this was made clear to participants, as highlighted in the following section on ethics (4.4).

4.3.4.4 Physical artefacts

Yin (2009) defines physical artefacts for data collection purposes as “a physical or cultural artefact – a technological device, a tool or instrument, a work of art, or some other physical evidence” (p.113). Despite this, the example he presents is a computer printout of the date and type of work done on a computer and the amount of time it took, which may be considered by others to be a document.

For the purposes of this study an artefact is a physical or ‘virtual’ object(s) created by a person as the result of a learning activity. These learning artefacts, although created within the bounded system, may not directly provide us with information about the events within the case, unlike documents which may record the process through which the artefact was created or used. They may however provide insight into the outcomes of the learning process for the participant.

In the exploratory case study, the artefacts learners created as part of their course were recorded using *FRAPS*, a screen capture software optimised for use in three-dimensional gaming environments. This provides an opportunity to capture the researcher moving around and interacting with learners’ artefacts. Screenshots are also used to capture images of completed artefacts as well as those under construction. These recordings were made as the artefacts were removed from the learning environment shortly after they were created, thus without these recordings there would be no evidence of these artefacts existence. Although available in the second case study, artefacts were not recorded as they did not provide evidence which would help to answer the research questions. This is summarised in Table 4.5 below.

Table 4.5 Overview of physical artefacts collected in each case study

	Exploratory	Instrumental
Physical artefacts	Constructions recorded	-

4.3.5 Data collection in virtual worlds

While educators are challenged by the opportunities and constraints of NGO-VWs (Jarmon, 2009), researchers also need to consider both opportunities and obstacles to conducting educational research in NGO-VWs (Moschini, 2008). With an increasing literature on educational research in NGO-VWs, it is perhaps surprising that there is not a relative increase in

the number of reported interviews and observations conducted in-world. Whether this is due to methodological or contextual restrictions is unclear. Thus, this section considers how to conduct interviews and observations within a NGO-VW, as well as artefact and document collection.

The exploratory case study provides an opportunity to pilot and refine data collection techniques to achieve the fourth aim: Refine in-world data collection. The understandings gained in this case study direct the data collection procedures in the following instrumental case study. It is important to note that in addition to the consideration of the opportunities, constraints, specific techniques and implications of conducting data collection in-world, there are additional ethical concerns that may need to be addressed. These include whether to use voice or text, using public or private communication channels, informed consent, privacy protection and the identity of the participant. These issues are discussed in the following section on ethics (4.4).

4.3.5.1 Interviews

Unlike other online technologies, NGO-VWs provide researchers with a range of opportunities to conduct interviews through features such as avatars, camera tools and a variety of communication modes. For example, Minocha, Tran & Reeves (2010) identified potential participants through serendipitous encounters with their avatars in selected locations throughout *Second Life* and thus selected participants based on their avatar profile information. Having selected a participant they used in-world communication tools to initiate a conversation and invited them to participate in an interview there and then or at a later time.

Moschini (2008) notes that learning experiences which take place in a NGO-VW may be evaluated using real-world, online and in-world tools. Hew & Cheung's (2010) review of the literature on educational research in NGO-VWs, conducted in 2008, identified only five studies that reported the use of interviews, none of which reported using NGO-VWs to conduct the interviews. Since 2008 there has been an increase in the number of articles published on the use of NGO-VWs in education and with that an increase in the number of studies using interviews. The literature review (Chapter 2) identified 208 articles published or made available as pre-print by July 2011, on educational research in NGO-VWs. Of these, 54 described the use of interviews for data collection. These are broken down by interview location in Table 4.6. Both face-to-face and in-world interviews were reported with equal frequency and of those conducted in-world, both text and VOIP were used, as shown in Table 4.7. It should be noted that some articles reported more than one approach to conducting interviews.

Table 4.6 Breakdown by location of 54 articles reporting the use of interviews for data collection

Face-to-face	In-world	Unclear
15	15	39

Table 4.7 Breakdown by medium of 15 articles reporting the use of in-world interviews.

Text	VOIP	Unknown
5	2	9

While face-to-face interviews are currently the dominant medium in the literature on educational research in NGO-VWs, there are a number of advantages to conducting interviews in-world. This approach allows not only access to participants otherwise unavailable but provides opportunity for the interview to be conducted in the learning context allowing both interviewer and interviewee to identify, share and demonstrate objects and activities during the interview. This may also provide researchers with an opportunity to engage in a modified form of stimulated recall in which the researcher identifies a specific object in the environment and participants would be asked to describe their thought processes whilst engaging with it during the learning experience.

In addition to conducting the interviews in the research context, text-based interviews may also provide the interviewer with a number of opportunities unavailable in traditional face-to-face interviews, such as: back-up recordings created by participants; ready-made transcripts; and the opportunity to note-take and scroll through the interview transcript during the interview. However the medium may be perceived to be slow (Cheal, 2009), thus discouraging participation.

Based on their experience of conducting interviews in-world, Minocha et al. (2010) provide the only notable description of techniques for researchers. They focus on logistics such as maximum length of an interview, codes of practice, developing researcher identity and interview locations for conducting interviews in-world. However they do not discuss any barriers encountered during their data collection.

The constraints encountered when employing in-world data collection are likely to vary depending on contextual factors including researcher experience. For example, Kirriemuir (2007) used in-world text interviews to follow-up questionnaires. He found that these interviews provided little additional information, however he noted that this was likely to be

constrained by his then lack of experience of interviewing in-world, technical problems and the long time to type questions and responses. Time was also a constraint identified by Vasileiou and Paraskeva (2010), who found that conducting the same structured interview in-world took almost twice as long by comparison to a telephone interview. However, Knorr et al. (2011) suggest that in-world interviews increase efficiency.

Whether participants have sufficient experience of using NGO-VW tools such as avatars should also be considered. Knorr et al. (2011) found that during VOIP-based interviews, despite prompting, there was no interaction between interviewer and interviewee avatars and participants did not initiate any movement. However the participants involved in the study had no previous experience of NGO-VWs. It is therefore unsurprising that one participant described "Having a person standing in the middle of the NGO-VW with no real purpose was a little strange" (p19). To be able to effectively compare and conduct face-to-face and in-world interviews it may be necessary for both interviewer and interviewee to be comfortable with the medium.

Researchers need to develop techniques to minimise the constraints and leverage the opportunities. For example, during group interviews, participants may engage in back-channel conversations through local-chat, IM or VOIP. These conversations may be distracting to participants and result in a lack of engagement with the interview. However it may be possible for an interviewer, with permission, to collect this as an additional data set.

The type of data collected may have additional implications for data analysis. For example where a participant requests to take part in the interview through text rather than VOIP, is the data equally valid? Does it provide the same depth? Dependent on the data analysis approach, if text-based interviews provide less depth it may be worthwhile conducting them first, analysing them for emergent codes and themes, then using VOIP or face-to-face interviews to explore these in depth.

4.3.5.2 Observation

As with interviews, the literature reviewed provides only limited advice on conducting observations in NGO-VWs. Observations conducted within a NGO-VW may be limited by a number of factors and considered to provide a nearest substitute to observing the participant in the physical world. While it is possible to observe the location of participants and record their public communication with each other, it is difficult to observe their 'out-of-world' or physical actions, such as note taking and use of other computer applications, as well as some in-world actions, for example editing an object. Software such as *Fraps* or *Camtasia* could be used by the participant to record their on-screen actions, however these recordings can create

prohibitively large files. Additionally, as NGO-VWs provide learners with an 'always on' environment, accessible at any time of day, it would be impossible for the researcher to observe all actions of an individual participant without video. Equally it would be difficult to observe multiple learners in different locations on a single island.

Consequently, the first case study explores the use of chat logs as an alternative to traditional observations. Chat logs record, with timestamps, all text-based messages sent and received by an individual avatar. This includes the receiving of objects from other avatars. This can provide the researcher with a rich source of data, with every conversation recorded, however it lacks the location and movement of the avatar. Chat logs are stored on the participant's computer, as such if they change computer or change preferences, for example, data may be lost. In addition participants may edit the text files created before handing them over to the researcher.

Logfiles, identified by Clarke and Dede (2007) as a potentially useful data set, may provide another alternative to traditional observation. However these are unavailable to researchers using hosted platforms such as *Second Life*, although they may be utilised in studies using purpose built goal-orientated virtual worlds as per the *River City* project or when implementing a privately hosted *OpenSim* grid. Without logfiles, neither in-world observations, nor chat logs can provide a complete picture of participants' actions during a research study; however they do provide a viable substitute.

4.3.5.3 Documents and artefacts

Documents and artefacts created within a NGO-VW are persistent, however the researcher may be dependent on an asset registry which they do not have access to and cannot back-up. This is similar to the problem reported by Allison et al. (2010) regarding learner assessment in-world.

For research purposes, documents and artefacts may need to be kept for extended periods of time. To address this, screen capture tools may be used to record documents and artefacts. This provides an opportunity to record the data within the context it was created and to later review the data without accessing the NGO-VW. This may be particularly important when the researcher is using a hosted NGO-VW, as described earlier in section 4.3.4.4.

Recordings are however limited and generate a form of artefact themselves. For example when recording an artefact created in the NGO-VW, data is limited by camera position and how the user interacts with the artefact. For this reason recorded artefacts are used for validation rather than as a primary data set in analysis.

4.3.6 Data analysis

Analysis of data begins by attributing meaning to the first impressions of data collected (Stake, 1995). Through analysis data are 'pulled apart', giving meaning to the parts and exploring how they are related (Stake, 1995). Stake (1995) notes that it may not be possible, or even necessary, to analyse all data to the same depth. The case and issues should remain the focus of the analysis, although analysis may drift out and return to the focus several times. However, Yin (2009) stresses the need to explore all evidence collected, which should be presented separately to any interpretation. Together with the consideration of rival interpretations, use of *a priori* knowledge and a focus on the research questions, this provides an opportunity for 'high-quality' analysis (Yin, 2009).

Due to the variety of approaches available for the analysis of case study data, Yin (2009) states that the choice of analytic technique will depend on the researcher's "own style of rigorous empirical thinking, along with the sufficient presentation of evidence and careful consideration of alternative interpretations" (p.127). The analytic strategy needs first to be identified before the specific techniques can be chosen (Yin, 2009), however some techniques are more appropriate for certain types of case study than others and multiple strategies and techniques may be appropriate within the one study. Yin (2009) presents four general strategies which underlie the analytic techniques he proposes: relying on theoretical propositions; developing a case description, which may help to identify causal links to be further analysed; combining qualitative and quantitative data, with qualitative remaining central to the study; and examining rival explanations.

Stake (1995) presents two primary approaches to data analysis: categorical aggregation and direct interpretation. While presenting categorical aggregation of several instances as a quantitative data analysis method for both qualitative and quantitative data, Stake (1995) describes it as a 'distraction' from understanding the case, which is of primary concern to the case study researcher. However, categorical aggregation may be appropriate for instrumental or explanatory case studies, which are focused on a specific aspect of the case rather than the complexity of the whole (Stake, 1995). Alternatively direct interpretation of the specific instance may be most appropriate, particularly when it occurs only once (Stake, 1995). Both of these approaches require the identification of patterns in data and identification of correspondence between patterns and certain conditions (Stake, 1995), which may emerge from the data (*emic*) or are drawn from the research questions (*etic*). To identify patterns, data is coded with both *etic* and *emic* codes (Stake, 1995) and through categorical aggregation and direct interpretation an understanding of the case is developed. However, the aggregation of

codes will not in itself answer the ‘how’ and ‘why’ research questions at the heart of a case study (Yin, 2009).

As previously discussed, theory plays a role in each of the case studies conducted as part of this research. Initial theoretical propositions about the alignment of constructionism and the perceived educational affordances of NGO-VWs are used to frame the first case study, however they are not refined. As such, developing a case description is particularly appropriate for the exploratory phase of this research. This approach can support the identification of causal links (Yin, 2009) and in turn the generation of research questions for the instrumental case study.

Based on the generated research questions the main focus of the second case study is on theoretical propositions, however it also generates a case description. Table 4.8 presents an overview of the analytic strategies, their primary or secondary importance and the approaches to data analysis which are discussed below.

Table 4.8 Overview of data analysis in each case study

	Exploratory	Instrumental
Primary analytic strategy	Case description	Theoretical propositions
Secondary analytic strategy	Theoretical propositions	Case description
Data analysis approach	Constant comparative	Content analysis

Prior to this higher level analysis, an approach is needed to break apart the data and interpret the parts before rebuilding into an informed description of the case. However, neither Yin nor Stake present a detailed description of how this might be achieved. One such approach is coding, a general qualitative approach (Miles & Huberman, 1994; Creswell, 2003) through which patterns, as described by both Yin and Stake, may emerge. *Etic* codes are decided *a priori* from the research questions and theoretical propositions, while *emic* codes emerge from the data and are usually *in vivo*.

To provide a structure to the data analysis, the research in this thesis follows the constant comparative analysis in the exploratory case study and uses content analysis to provide a framework for the analysis of data in the instrumental case study. It is important to note that to prevent ‘bleed’ (Yin, 2003) between the exploratory and instrumental case study, data from the two studies are not analysed together. A third approach, semiotic analysis, was also considered as it focuses on the representation of meaning through codes. Semiotic analysis takes into consideration the role of the reader as active interpreter of the meaning of a text.

However in the analysis of written and verbal texts it does not provide a clear method to follow. Nor does it support the aims of the case studies.

4.3.6.1 Case 1: Constant comparative analysis

Constant comparative analysis is a method for analysing qualitative data in which the data is reduced into *emic* codes which retain much of the richness of the original data and are not aggregated. Beginning with the open coding of the first source a large number of codes are generated and with the coding of each subsequent source the emergent codes, and later categories, are compared and refined. This approach is used in the first case study as it allows the researcher to remain open to emergent codes and develop a rich case description. The results of this analysis can also be used to develop an initial understanding of the theoretical propositions of the alignment between constructionism and the perceived educational affordances of NGO-VWs, SLurtles and the design of the learning experience.

Detailed analysis begins by assigning codes to a word, phrase or larger section of text, however it is worth noting that it is not the words but the meaning which is important (Miles & Huberman, 1994). Codes may be both descriptive and interpretive (Miles & Huberman, 1994), however it is not enough to consider the semantic meaning of words but to consider the pragmatic meaning, as a word or phrase within a certain context may hold a certain meaning but not in another. As Ricoeur (2004) notes, interpretation is “the work of thought which consists in deciphering the hidden meaning in the apparent meaning, in unfolding the levels of meaning implied in the literal meaning” (p. 12) and as Miles and Huberman (1994) note, the choice of words used by an individual may be as important as the words they did not choose to use.

Constant comparative analysis is described by Merriam (1998) as compatible with inductive research, which includes exploratory case studies. Although developed as part of grounded theory (Glaser & Strauss, 1967), the constant comparative approach is widely acknowledged as suitable for data analysis which does not aim to build substantive theory. As the constant comparative approach relies on the analysis of language and the research requirements stated a need to understand the perceptions of the learners, data analysis primarily focuses on the interviews conducted with participants. Learners’ reflections provide a second source of data generated by the participants. However, as noted in sub-section 4.3.4.3 earlier, these are a source of corroboratory data and used for validation purposes only.

In the exploratory case study, prior to analysis the data was prepared and read, sensitising the researcher to the data (Creswell, 2003). Data analysis then began with the open coding of the first interview. Through analysis of subsequent interviews and comparison with the interviews

already analysed, new codes emerged, some codes became redundant and dimensions began to develop (Creswell, 2003; Cohen, Manion & Morrison, 2007). Due to the high volume of codes that are generated through such a process, *NVivo8* was used to support the data analysis.

Following the apparent saturation of codes (Glaser and Strauss, 1967), categories and sub-categories were developed from the original codes through an iterative process which aimed to produce efficient categories (Merriam, 1998), reflecting the purpose of the research: exhaustive, mutually exclusive, sensitising and conceptually congruent. Within this case study this approach was applied to the identification of categories and sub-categories. Overall, Creswell (2003) suggests that there should be between five and seven categories or themes within a study and are the major findings of the study. Together with the codes, these are used to create a description of the case.

4.3.6.2 Case 2: Content analysis

In the second case study Krippendorff's (2004) approach to content analysis is used to provide a framework with which to scaffold the data analysis process. Content analysis is an approach to the analysis of textual data and involves both qualitative and quantitative processes. Analysis aims to answer a research question and therefore inferences drawn during the process of analysis are targeted at theoretical propositions. The technique aims to generate inferences which can be both replicated and validated by other researchers.

Content analysis is particularly useful when the researcher is unable to directly observe an event. In the context of the research undertaken in this thesis, observation is limited to the observation of avatars and recording communication in the NGO-VW. As such, the researcher is unable to directly observe the participants. Thus, it is necessary for the researcher to draw inferences about the phenomena. Following the exploratory case study, two research questions emerged which were investigated in the subsequent instrumental case study. As instrumental case studies aim to develop understanding, content analysis provides an opportunity to investigate the research questions, considering multiple factors, different interpretations and the context, without direct observation of the phenomena.

Krippendorff (2004) describes six components of content analysis: unitising, sampling, coding, reducing, inferring and narrating. While Cohen, Manion and Morrison (2007) broaden this to eleven steps they encompass similar aspects adding stages such as defining the research question. This study follows the approach described by Krippendorff (2004).

Unitising involves defining the units of analysis, including sampling units, coding units and context units. To support the inclusion of context in data analysis, this research uses *NVivo8*

software, described in the following section. The selection of texts to be analysed is referred to as 'sampling', however in this study as the quantity of data is limited, all available data are analysed. While Carley and Palmquist (1992) note that content analysis can be automated, such processes do not consider the context of the data.

Codes may be both descriptive and interpretive (Miles & Huberman, 1994), decided in advance or emergent (Creswell, 2003). As the research questions emerged from the exploratory case study, the codes and categories identified in that study are used as an *a priori* set for initial coding of the data. However content analysis allows the researcher to consider emerging codes and to refine the initial set of codes. Typically this would be followed by a coding comparison as content analysis relies on the interpretation of texts and two researchers may interpret the same data in different ways. One reason for this is that there is no single, identifiable, describable and stable meaning of a unit of text. In addition, as codes are text-based, they may be misunderstood by others applying the codes. Although not possible in the research described in this thesis, to support validation in principle (Krippendorff, 2004), the codes used in the analysis as well as notes used in the coding template are reported as part of the case study.

Once coded the data is further reduced to simplify and manage the data for quantitative analysis. Quantitative data analysis can take a number of forms, however this study focuses on the use of frequencies and cross-tabulation (Cohen, Manion and Morrison, 2007) as the most appropriate approaches for the research aims and the data available. At this point Cohen, Manion and Morrison (2007) describe the summarising of the results of the quantitative analyses before drawing inferences from the resulting data.

Krippendorff (2004) described the inferences made by content analysts as *abductive*. Unlike deductive inferences which infer particulars from generalisations and inductive inferences which over-extend generalisations to a population, abductive inferences are described as relating one set of particulars to another. For example, inferring the barriers encountered by learners from their reflections onto the learning experience. As such this approach is particularly well suited to case study research which does not aim to generalise beyond the case or infer particulars about the case from generalisations. Justification, in the form of an analytical construct, is required to support an abductive claim about the data and this claim requires a qualifying statement, which should be evident in the narration of the answer to the research question (Krippendorff, 2004).

The analysis process used in this case study broadly follows Krippendorff's (2004) approach to content analysis: unitising, sampling, coding, reducing, inferring and narrating. An additional

stage which would not typically occur in content analysis was introduced in this study, that of validation. It should be possible to validate inferences through observation (Krippendorff, 2004), however this is not common practice in content analysis. This case study provided an opportunity to collect participant-observations in-world and the participant's reflections. As the reflections were created for assessment purposes they were treated as a secondary data source and therefore suitable for triangulation along with participant-observations. This supplementary data is unitised, sampled, coded and reduced following the same techniques applied to the primary data set. It is then compared to the primary data analysis results and used to develop inferences.

As previously stated, Krippendorff's (2004) approach to content analysis is used as a framework to scaffold the data analysis process in the second case study. Due to the opportunistic sampling method, insufficient data was available to apply standard statistical tests such as *chi-square*. Thus it is unknown whether the results of the reduction phase are the outcome of chance or not. As the inferences drawn from these results are drawn from a single case study at most they could only be generalised to similar groups of learners participating in a similar learning experience. However it is not the aim of case study research to generalise beyond the case.

While this approach is reductionist, it also requires interpretation of the original data in coding and interpretation of the quantitative results in relation to the context of the case. Therefore it may be considered to sit between post-positive and interpretivist approaches. Content analysis provides systematisation of the analysis process which is appealing to a novice researcher and difficult to achieve in interpretivist approaches. However this can be at the cost of a rich case description. Therefore there is a tension between the approach chosen and the methodological underpinning of the study.

Despite the limitations of content analysis in the context of this study, it provides a relatively clear process to follow which can be used to achieve the aims of the second case study. Although a fairly well defined process, in practice, as a qualitative technique it retains some of the 'messiness' inherent in qualitative data analysis (Hatch, 2002). Unlike open coding, used in the coding comparison in the first case study, content analysis provides the researcher with an opportunity to focus on a particular area of interest, thus potentially improving the efficiency of the data analysis process, whilst remaining open to emergent codes (Krippendorff, 2004). As such content analysis provides an approach, congruent with the aims of this case study, with which to frame the data analysis process and within the timeframe available.

4.3.6.3 The use of software in data analysis

Yin (2009) and Creswell (2003) note that software may be useful when analysing large quantities of qualitative data, acting as a reliable tool to assist in the coding of data. However, it is the researcher that must interpret the meaning, remaining central within the data analysis process. It is important to note that the use of software does not dictate the research method or process of analysis to be used but rather provides a supporting tool within the process.

The largest challenge of using software to assist analysis identified by Yin (2009) is the wide range of evidence collected in case studies which must all be converted into a textual form. Miles and Huberman (1994) describe data analysis approaches expecting the researcher to be dealing with text based data only. However tools such as NVivo 8, which was used in the current study, can incorporate photographs, video and audio with or without transcripts for analysis. Software can also support rapid analytic manipulation of evidence (Miles and Huberman, 1994) as well as searching and exploring patterns of data and ideas (Richards, 1999).

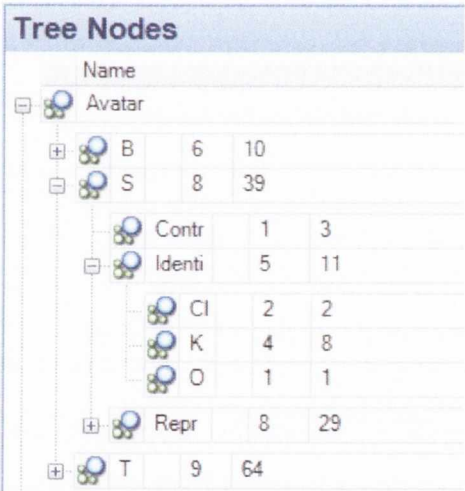


Figure 4.2 Screenshot from NVivo8 showing the use of trees

NVivo 8 provides the researcher with a range of tools to support data analysis. Sections of text can be coded at pre-defined or emergent codes and relationships between codes are supported in the use of 'trees' (Figure 4.2). To support the inclusion of context, coding which is focused on individual words can quickly be expanded to include the surrounding context. The initial stages of constant comparative analysis involve the use of memos which are supported and searchable within the software. Analysis conducted by two researchers can also be tested for inter-rater reliability through conducting a Kappa coefficient. Analytical tools such as matrixing can support cross-tabulation during content analysis, whilst text searches can focus on individual words or a string in pre-determined sources. Finally, the software allows the researcher to quickly identify each section of text coded at a specific node, with links to the text in context.

While there is a range of other tools available to the researcher in this software, these are the main ones used in this study. Examples of their use are given within the report of the first case study in the following chapter.

4.3.7 Validity and reliability

Bassey (1999) states that both reliability and validity are problematic in case study research. For example, as they are postpositivist measures, external validity looks to the population to validate the sample. However Yin (2009) suggests that both validity and reliability are important within empirical social research, presenting four tests of quality: construct validity, internal validity, external validity and reliability. Yin (2009) presents 'case study tactics' to be used at multiple junctures within the case study research. To test for construct validity, presented by Yin (2009) as the most challenging test, multiple sources of data should be collected with a chain of evidence established and initial drafts of the final report should be reviewed by participants. Internal validity occurs at the point of data analysis through pattern matching, explanation building and exploring rival explanations, as discussed in the previous section on data analysis. External validity relates to generalisability which is further discussed in the following section.

Reliability requires that the same procedures could be repeated to gain the same results by another researcher conducting the same case study (Yin, 2009). However, as Yin notes, this does not mean that the results could be replicated by doing another case study. Instead, through the use and reporting of a case study protocol another researcher could follow the process of the study accurately.

Unlike Yin, Creswell (2003) suggests validity, rather than reliability, is a strength of qualitative research, presenting eight primary approaches to validity: triangulation, member-checking, rich description, clarify researcher bias, presenting negative or discrepant information, spending prolonged time in the field, peer debriefing and the use of an external auditor. The first four approaches are considered the most appropriate for this study as time and resources were unavailable to conduct the latter four. Together with Yin's approach to reliability, the four approaches were applied to both case studies (Table 4.9).

Table 4.9 Overview of validity and reliability approaches in each case study

Exploratory	Instrumental
Reporting of case study protocol	Reporting of case study protocol
Triangulation	Triangulation
Member-checking/peer-validation	Member-checking/peer-validation
Rich, thick description	Rich, thick description
Acknowledge researcher bias	Acknowledge researcher bias

Creswell, (2003) identifies triangulation as the most commonly used approach to validity and is similar to Yin’s (2009) test for construct validity. Stake (2005) describes triangulation as providing an opportunity to identify the different realities or ways in which the case is seen, using multiple perceptions to clarify and verify. Stake’s description of triangulation focuses on data source, described by Denzin (1984) as the most common of four forms of triangulation strategy. Other forms of triangulation include: investigator, when using two or more researchers; theory; and method, including within-method triangulation and between-method triangulation (Denzin, 1984). Through triangulation there may be evidence of corroboration between sources, as well as inconsistencies and conflict (Miles & Huberman, 1994). As such it forms part of the rationale for collecting data from multiple sources.

Member checking provides an opportunity for participants to review and comment on written drafts of findings when no further data will be gathered from them (Stake, 1995). The participant may suggest alternative language which may or may not be used in the final report (Stake, 1995). An additional approach to enhance internal validity proposed by Meriam (1998) is that of peer examination. Similar to member checking, in this approach knowledgeable colleagues are asked to review and comment on the findings as they emerge.

The use of a rich description suggested by Creswell (2003) to increase validity appears within this study as part of the description of each case, required by the nature of the case study approach. Finally, biases can compound each other and the introduction of the researcher with their biases, values and assumptions can affect the actions of participants within the case (Miles and Huberman, 1994). While Miles and Huberman (1994) present a number of approaches to avoid, identify and remove bias affecting the research, including the use of triangulation, it is the view of this researcher that these effects can never be completely negated. Therefore it is acknowledged that the personal values, assumptions and biases that the researcher brings to their role as primary data collection and analysis instrument, will influence the results of the research.

4.3.8 Generalisation of findings

Opposing views are held by authors with regards to the generalisation of qualitative and, more specifically, case study research. For example Stenhouse (1985, cited in Bassey 1999) argues that the case study should be able to stand on its own, without generalisation, through good reporting. Stake (1995) supports this argument by stating that the primary intention of case study research is to understand the specific case rather than to understand what this case can tell us about other cases. However Bassey (1999), presenting Atkinson and Delemont's (1985) critique of case studies, notes their concern that "if studies are not explicitly developed into more general frameworks, then they will be doomed to remain isolated one-off affairs, with no sense of cumulative knowledge or developing theoretical insight" (p.39). One approach to address Atkinson and Delemont's critique would be to conduct a metasynthesis (Downe, 2008), however this is conducted on previously reported studies and would not be appropriate for this study.

There are several approaches to generalisation. Yin (2009) suggests the use of multiple case studies which can also be used to support external validity. Yet Yin (2009) views the goal of generalisation from case study research to be towards theory and not population. Stake (1995) describes both generalisations that can be made within a case through observing repeated actions and beyond the specific case to the wider population. He also importantly notes that these are the researchers' assertions through their own interpretation of the data and that alternative interpretations should also be sought. In keeping with this, Bassey (1999) describes the generation of 'fuzzy generalisations' from empirical research to suggest that "something *may* happen, but without any measure of its probability" (p.46).

Stake (1981 in Merriam, 1998) also suggests that generalisations may be made by the reader and not the author of the report as the reader brings with them their own understanding and experience. If generalisations are made by the reader to their own circumstance, this could be used to inform their knowledge of teaching and in turn their practice as suggested in Hargreave's (1997) model (see Figure 4.1 earlier). However these generalisations may be biased by the process of interpreting the written word. As such findings need to be presented clearly and may justify a researcher drawing fuzzy generalisations.

Returning to the earlier sections of this chapter, which identified the methodology and methods used in this study, as opposed to experimental research, case studies revel in the complexity of multi-faceted and sometimes competing factors for the explanation of a phenomenon. Whilst a suggested weakness of case studies is the ability to generalise from them, they can be viewed

as more 'relevant' or 'real' to the general reality that people live, than any experiment might produce and control.

Considering the personal views of the researcher in 4.2.3, the approach adopted in this thesis with regard to generalisation is to present fuzzy generalisations developed by the researcher which may be relevant to other researchers and educators. It is acknowledged that these generalisations are limited by the nature of interpretive research and that it is the same researcher drawing generalisations as interpreting the raw data. Therefore despite rigour of analysis these generalisations are likely to be biased. They are also limited to similar cases.

4.3.9 Summary

This section has outlined the key concerns regarding choice of research methods used in this thesis. To achieve the aims and requirements of the research outlined in 4.1, two case studies are undertaken and described in the following chapters. Below is an overview of the research methods followed in each of the studies (Table 4.10).

Table 4.10 Overview of each case study

	Exploratory	Instrumental
Data collection		
• Interviews		
1. Recording	Audio	Audio
2. Purpose	Develop understanding	Develop understanding
3. Type	Open non-directive	Open focused
4. Form	One-to-one	One-to-one
5. Medium	Face-to-face and VOIP	Face-to-face
6. Location	Face-to-face and in-world in context	Face-to-face
• Observation	Chat-logs	In-world participant observation
• Documents	Individual and group reflections	Individual reflections
• Physical artefacts	Constructions recorded	-
Data analysis		
• Primary analytic strategy	Case description	Theoretical propositions
• Secondary analytic strategy	Theoretical propositions	Case description
• Data analysis approach	Constant comparative	Content analysis
Reliability	Report case study protocol	Report case study protocol
Validity	Triangulation Member-checking/peer-validation Rich, thick description Acknowledge researcher bias	Triangulation Member-checking/peer-validation Rich, thick description Acknowledge researcher bias
Generalisation	To case	To case

4.3.9.1 Exploratory case study

The first study (Chapter 5) presents an exploratory case study which aims to:

- Explore SLurtles in action with learners
- Explore the learning experience in action with learners
- Generate research questions for future research
- Refine in-world data collection

The exploratory study uses non-directive open interviews conducted one-to-one with participants either in-world or face-to-face as the primary source of data. Of the 24 participants, an opportunistic sample of 14 took part in the interviews. This sample included participants only accessible to the researcher through the NGO-VW. While the mix of medium and location may influence the data collected, this approach is used to increase participation in

the research. Following Stake's (1995) approach, interviews are considered in both case studies as the strongest approach to understanding the multiple views and realities of a case, however analysis focuses on the lived experience of the individual within the case.

As described in 4.3.6, the constant comparative analysis uses these interviews as the primary source of data. While it was not possible in this study to conduct a second coding of the data by a second independent researcher, to increase validity the researcher returned to the first sources coded, re-coding them and conducting a coding comparison to identify anomalies in coding which were then examined across sources. Data collected from learners' reflections, chat logs and in-world artefacts, generated during the learning experience (described in Chapter 5), provide corroboratory data used in triangulation. Following this, member checking and peer examination were conducted to increase construct validity.

Following the initial constant comparative analysis, higher-level analysis aims to develop a rich case description based on the categories and sub-categories which emerged. This description, presented in the findings, in combination with analysis of the theoretical proposition of technology and pedagogy alignment were then used to generate and refine the research questions used in the second case study. Analysis of the theoretical propositions follows the rich case description, using the researcher generated codes as an additional corroboratory data set.

4.3.9.2 Instrumental case study

The second study (Chapter 6), an instrumental case study, aims to answer two research questions which were generated from the first case study. As with the exploratory case study, the instrumental case study uses interviews as the primary source of data. In this study interviews are conducted one-to-one and face-to-face, as it was convenient for participants to meet the researcher face-to-face rather than in-world. Of the 26 participants that took part in the learning experience, an opportunistic sample of 9 took part in the interviews. While these interviews were open the questions were focused by the researcher in order to draw out responses relevant to the study's research questions.

Within both case studies the researcher is also a participant within each case, designing and facilitating the learning experiences at the heart of each case. As a result, this study adopts participant-observation, using unstructured observations to produce descriptions. It is accepted that the dual role limits the observations that may be made, however it is through the participant role that access to both cases is gained.

As described in 4.3.6, data was analysed following the content analysis approach described by Krippendorff (2004). This provides a combination of qualitative and quantitative analysis, with

the qualitative remaining central to the study. Again, interviews were the primary data source with learners' reflections and participant-observations providing corroboratory data for triangulation. Higher-level analysis then focused on the theoretical propositions of the research questions, developing a case description and considering rival explanations.

4.4 Ethics

The existing ethical standards followed by educational researchers provide the starting point for all researchers in NGO-VWs and other popular digital technologies. However there are ethical issues that have emerged in online educational research and these continue to be relevant in the online virtual world environment. In addition, the combination of features within NGO-VWs raise new ethical concerns which the current literature on educational research in NGO-VWs fails to address in any depth. Consequently, issues such as obtaining informed consent, privacy protection and identity need to be considered in terms of the features of the specific technology.

This section considers these traditional ethical concerns in the non-traditional NGO-VW environment. Beginning with a discussion of the pertinent philosophical perspectives, these guide the approach to gaining informed consent, privacy protection and identity discussed in this section. This is concluded with an overview of the ethical approach taken in the research reported in this thesis.

4.4.1 Philosophical perspectives

There is a range of philosophical traditions of argumentation within ethics. Each paradigm is characterised by a shift in ethical concern and focus, often in reaction to infamous research studies. This section briefly outlines those perspectives which are relevant to the ethical dilemmas presented in the following section.

Following research events during World War II, researcher paternalism was the only protection offered to a research participant (Emanuel & Grady, 2006). This was underpinned by utilitarianism which views the individual participant as the passive subject of research and focuses on the social value and 'good' that could be done for the population.

In the early 1970s, following a series of scandals which highlighted unethical practices, regulatory protectionism emerged in the United States and Europe. This approach is underpinned by both utilitarian and deontological approaches. Regulatory protectionism introduced the Institutional Review Board (IRB) and individual informed consent in order to protect the vulnerable participant. From this the ethical principles of respect, justice, and

beneficence emerged, which underpin the ethical requirements of informed consent, participant selection and risk analysis (Emmanuel & Grady, 2006).

Deontological approaches provide rule-based policies and may prove particularly attractive for the novice researcher. Many researchers appreciate such policies as they can guide their interactions with participants (Roth, 2004). However such policies are formed over time and are thus most effective in established research contexts (Kanuka & Anderson, 2007). In contrast, teleological approaches, such as ethical relativism, provide an evolving approach to ethical issues, requiring the researcher to be reflective and adjust their approaches in response to their observations and reflections (Kanuka & Anderson, 2007). Thus the focus remains on the researcher to identify the potential effects or consequences of the research. To support the researcher following a teleological approach, Roth (2004) emphasises the role of members of the community. However the community referred to is the research community which forms the ethical review panel and not the community at the heart of the study which is discussed in the following sections.

Viewing protectionism as discriminatory, the participant access paradigm emerged in the mid-1980s, focusing on individual autonomy and providing opportunity for participants to assess the risk and benefits of a study for themselves (Emmanuel & Grady, 2006). Marked particularly by medical research interventions, it also has a role in educational research whereby a research intervention by its nature should not be harmful and may instead provide an opportunity. Individual autonomy in deciding whether to take part in research highlights the need for detailed informed consent procedures.

The final shift has seen a focus on the community to be researched, underpinned by communitarianism and discourse ethics. Rather than just focusing on the social value over the rights of the individual, the community partnership paradigm considers the participant as an active member of the research process as well as part of a wider community. While potentially only appropriate to a small sub-section of research studies, and most often discussed only in terms of medical research, this approach may be particularly appropriate to research which recruits participants from within a specific community, when research is conducted within a community setting and when a community may benefit or be harmed by the results of such research. It is important to note that this is an emergent, teleological approach to defining the research procedures and may not result in consensus. It does not exclude the researcher from following the approaches of the other paradigms and as an emergent approach is particularly appropriate for use in emerging and not yet fully formed popular digital technologies, such as NGO-VWs.

4.4.2 Informed consent

Under regulatory protectionism, informed consent became, and continues to be, one of the most important ethical practices in research involving humans. While in the physical classroom a researcher can easily distribute and collect informed consent forms and the completion of an online questionnaire may imply consent, many researchers in the field of online research have noted that gaining informed consent to the standards required by ethical review bodies is a particularly difficult and at times seemingly impossible process (Kanuka & Anderson, 2007).

This is not a problem particular to NGO-VWs but to online research in general. Frankel and Siang (1999) report that in online research there are three main issues with regard to informed consent: whether informed consent is necessary; how it can be obtained; and how it can be validated.

4.4.2.1 The need for informed consent

There are four principal factors to consider when deciding on whether informed consent is required in NGO-VW research: whether a space is public or private; if data collection will be covert or overt; the nature of the research undertaken; and the expectations of individuals and communities.

4.4.2.1.1 Public versus private space.

Whether a space is public or private is one of the main factors when deciding on the need for informed consent. Within the context of NGO-VWs, a dichotomy of public and private space is a false one. Instead it is a continuum with blurred boundaries which has significant implications for informed consent. As a result there are many ethical questions that may be asked of the public/private space boundary, such as: What defines private versus public NGO-VW space? Is it sufficient to consider whether or not an island is access controlled? How do we approach islands which have both open and access controlled areas? If an avatar moves from one area to another does their expectation of privacy change? Does the educator or researcher have an obligation to warn students, participants and others when they cross invisible boundaries? If a conversation takes place in an access controlled area but can be 'over-heard' in a publicly accessible area, can it be recorded without informed consent?

Within *Second Life*, for example, there are five main types of space on the public-private continuum (Table 4.11): private, access controlled islands; islands with mixed access controls; community based islands with no access control; publicly accessible, privately rented space; and publicly accessible islands. *Second Life* 'islands' may be privately owned or attached to the publicly accessible 'main grid'. The research location is an active choice made by the researcher and therefore the ethical approaches applied need to be justified.

Table 4.11 The public-private continuum of space in *Second Life*.

Type	Example	Access	Informed consent?
Private islands	Company islands with access limited to employees.	Controlled	Yes
Mixed access controlled islands	University campus generally accessible with teaching and learning space only accessible to specific avatars enrolled on the course.	Mixed	Possibly in public spaces. Yes in private spaces
Publicly accessible community islands	Islands provided for specific groups of users with a common interest.	Open	Possibly
Public islands with privately rented spaces	A shop or other building on land rented from the owner of an island. No access control.	Open	Possibly
Public islands	A <i>Second Life</i> island attached to the main grid with no access controls	Open	Possibly

Private island owners, or those assigned by the owner, can control access to the island, or part thereof, through access lists and group membership. Private islands may be particularly appealing to educators wishing to ensure that only users who are members of their course or programme can access the space. Owners and estate managers for whom all boundaries on an island are invisible are sometimes referred to as GodKings. They can go anywhere, do anything and are the gatekeepers for the island. Researchers in this position need to be particularly aware that with great power comes great responsibility and this power should not be used to coerce participation in research, nor does it negate the need for informed consent in these private spaces.

Some islands in *Second Life* have both publicly accessible and access controlled spaces. While this demarcation of space is evident to a user without access rights, by visual marker, it can perceptually be invisible to a user with access permission. For example, some higher education institutions use their islands for both marketing and teaching purposes. Such environments can also blur the boundary between a public, community and private space. Both experienced and novice users, whether learners or researchers, may not be aware that they are crossing boundaries between the public and private spaces when they have full access to both. Data collection tools, whether chat loggers in-world or video capture on the researcher's desktop do not observe these boundaries whether visible or invisible to the researcher. Hence the

researcher needs to exercise great care in the use of such spaces, making themselves aware of invisible boundaries and the need for corresponding changes in practice.

Participants need to be informed when they are in an access controlled area as it may provide them with a greater sense of privacy and safety. It may also be appropriate to provide learners with reminders when they are leaving private areas and entering publicly accessible areas of an island as these boundaries may not be clear.

Public spaces in NGO-VWs may be considered to be synonymous with the main shopping street of any town. Herring (1996), an early researcher of MUDs, states that actions that take place in public environments can be observed without the informed consent of participants or notification of the presence of the researcher. This approach has been used by Bakardjieva and Feenberg (2000) in their research into online communities so as to not affect behaviour. However within public spaces data collection tools must be open and not concealed.

4.4.2.1.2 Data collection.

As McKee and Porter (2009) state, the form of data collection and degree of interaction the researcher has with participants will impact the research ethics applied. When conducting research in any virtual world space, including public spaces, informed consent is required when using covert data collection tools. Such tools include the use of 'bots, visitor counters, chat logging tools and screen capture software. The researcher's avatar can also be considered to be a covert data collection tool as there may be no indication that the person behind the avatar is a researcher or is writing observational notes. One solution to this may be to openly label the avatar as a researcher who is observing others in the space. Signs and 'bots may also be used to alert avatars to the presence and actions of the researcher (Lin et al., 2010).

While informed consent may be gained from participants, tools such as chat loggers and screen capture can also record messages sent from non-participants. For example, in a public space an avatar may approach a group of participants and begin a conversation. In this situation the researcher may be able to simply remove the non-participant's contribution. However this interaction may have elicited responses from participants which the researcher wishes to record. Where removing the non-participant's data may result in a loss of context it may be necessary to seek out that avatar and gain their informed consent to include their comments. In this situation it is useful when screen capture or text logging tools record avatar names. Another situation to consider is when using screen capture any messages sent to the researcher's avatar will also be recorded. Whether this message is sent from an individual, private or public group will inform the researcher's actions.

4.4.2.1.3 Nature of research.

While naturalistic observation in a public setting with openly declared data collection tools may not require informed consent, observation of learners in a public space, engaging in an activity which is the result of an intervention as part of a research study, would require informed consent, as there may be risks as well as benefits which would not have existed in that space without the intervention of the researcher.

4.4.2.1.4 Individual and community expectations.

Publicly accessible, privately owned spaces, such as cafes or general buildings, may be located on rented land which forms part of a public space. This form of space may be treated by some in the same way as the public space. However in such spaces the person paying for the space may feel entitled to a greater level of privacy as may the person visiting such a space. The reason for this may be due to the application of real-world schema of privately owned spaces. For example members of a study group meeting at a local coffee shop may expect greater levels of privacy than when walking along the street. Therefore it would be appropriate to ask permission from a 'gatekeeper', such as the owner or lease holder of a space, to use the space for research purposes.

Similarly, publicly accessible spaces run for the benefit of a specific community of learners requires careful consideration of the need for informed consent in addition to other ethical dilemmas. As with any publicly accessible space, a community space may be seen as 'fair game' for a researcher to collect data in. They are publicly accessible and as such can allow the researcher to easily enter a social environment. However much like listservs and forums for specific communities (Kanuka & Anderson, 2007), community spaces in NGO-VWs may be seen to lie between the public-private dichotomy.

Eysenbach and Till (2001) note that "the perception of privacy depends on an individual group's norms and codes, target audience, and aim" (p.1104). Although public, some community islands within NGO-VWs provide notecards to avatars that enter the space, informing them of the community standards. As part of such information there may be explicit statements regarding expectations of privacy and the right to record conversations. However researchers cannot expect all such spaces to provide information to visitors and a lack of such information cannot be taken as *carte blanche* for research activity.

Owners of such spaces may provide a point of contact and clarification as to the perceived level of privacy. However privacy issues for a community may run beyond the concerns of the individual to the community as a whole. As such there may be a need to involve the wider

community with regard to the aims, procedures and expected outcomes of the study. One approach to this is the community partnership approach.

Finally, some service providers publish community standards which all users must abide by. For example, within *Second Life* users agree not to remotely monitor or publish conversations without the permission of the avatars being recorded. As Moschini (2010) notes, quantitative data such as origin and behaviour of avatars can be collected through use of in-world tracking systems and 'spying devices' which can record the conversations and movements of avatars whilst the researcher is offline. While she states that these may infringe community standards and ethical codes, it can be argued that regardless of the public or private nature of a space, covert data collection tools can only be used with the express permission of the avatar being studied. Similarly to traditional educational research ethics, a researcher cannot leave an automated device recording conversations in their absence without informed consent and quoted conversations may not be published without consent.

4.4.2.2 Obtaining informed consent

Obtaining informed consent is comprised of three parts: presenting all relevant information to participants; ensuring participants understand the information; and obtaining voluntary agreement to participate (Frankel & Siang, 1999). These can present new opportunities and challenges for researchers and participants in NGO-VWs.

Within a NGO-VW there may be a wide range of opportunities to present the information to potential participants, such as posters at the research site, notecards passed directly to participants from the researcher or through 'bots which distribute information about the research to nearby avatars through notecards, text-based chat or other modes of communication (e.g. Lin et al., 2010). Another may be to provide such information to avatars on entry or 'teleportation' to an island through similar forms of communication. However it should be noted that some users may regard such messages as 'spam' and choose to ignore them. In this situation it is debatable as to whether the researcher has fulfilled their ethical obligation to inform users of their presence and intentions.

In addition, ethical review committees may, as standard, require online researchers to present information on a publicly accessible website. Within the NGO-VW participants may be directed to this website, however opening a web browser may result in a loss of immersion. To resolve this issue, the same information may be presented both on a website and in-world, with the in-world information providing the website address.

NGO-VWs as research sites can provide new benefits for participants and researchers when ensuring that they understand the information they have been presented with. Online research may provide a 'level field' for communication between participant and researcher (Bakardjieva & Feenberg, 2000). By providing the participant with means, via avatar and in-world communication tools, to easily initiate contact with the researcher, the traditionally perceived power imbalance favouring the researcher may begin to be addressed. An avatar, which can easily be linked to the researcher's real-life identity, may be used to hold presentations about the research and discuss avatar-to-avatar any questions a participant may have. This may also introduce a more level relationship between researcher and participant, in comparison to email based communication.

Obtaining consent in traditional educational research involving observation and interviews requires the participant's name and signature on a consent form. However, NGO-VW residents are not always willing to provide their real life names, preferring to use their avatar name only when in-world. While it may be appropriate to accept the typed name of an avatar on a consent notecard in *Second Life* which can be traced to the avatar (if created by the consenting avatar), this has implications when validating informed consent.

4.4.2.3 Validating informed consent

Validating informed consent requires the researcher to verify that the person giving informed consent is not from a vulnerable population and that they are who they say they are. Kanuka and Anderson (2007) describe this as a particularly problematic process when conducted entirely online, however they note that despite this educational researchers tend to accept unsecured consent forms unless participants may be considered to have an incentive to misrepresent themselves. Those researchers who accept unverified consent should be aware that they risk recruiting participants from vulnerable populations (Frankel & Siang, 1999) and that participants may misrepresent important demographic information (Turtle, 1997).

Within NGO-VWs, residents may be reluctant to provide their real-life names. Avatars provide the virtual world resident with an embodiment and identity within the NGO-VW which they may not wish to link to their real-life identity. While many view the avatar as an anonymous figure, they may only provide pseudo-anonymity. For example an online search of the researcher's *Second Life* avatar name (Sleepy Littlething) can link real-life and virtual world identities.

To assist with validating informed consent, some studies may ask participants to provide both their avatar and real-life names for the purpose of validation. However participants may be unwilling to provide their real-life identity. With no financial incentive, a substantial time

commitment and requirement to collaborate with others throughout the process it may be that on assessment of the specific circumstances that the associated risks of accidentally recruiting vulnerable participants would be low and thus appropriate to proceed with the study.

4.4.2.4 Risk and benefits

The potential risks and benefits of taking part in a particular research study must be made clear to research participants in order to gain informed consent. Grimes et al. (2009) pay particular attention to the nature and possible forms of 'harm' within NGO-VWs. However as Bosk and de Vries (2004) note, it may not be possible to inform participants of all the risks and benefits. Similarly to their observations on ethnographic studies, few educational researchers believe that the educational activities participants are to be involved in are risky. In such situations there is a return to researcher paternalism in the form of good will. It is this Kantian focus on good will which allows educational researchers to introduce new learning experiences to learners and study the effects of such an intervention.

A good will alone is good in all circumstances and in that sense is an absolute or unconditional good. . . . a good will continues to have its own unique goodness even where, by some misfortune, it is unable to produce the results at which it aims. (Kant, 2005, p.8)

Whilst acknowledging that as researchers and as educators we may falter in the means, it is the end and the aims which must be entrenched in good will. We must do all that we can to maximise the benefits and minimise the risks.

4.4.3 Privacy protection

As Bosk and de Vries (2004) note it is easy to promise confidentiality and anonymity to research participants but in some situations this may be difficult in practice.

We can do nothing to prohibit a sufficiently determined reader from trying to decode the text ...from identifying himself or herself, or prevent an institution from coming forward and saying, "We are 'made-up-ville'". (p. 254)

As previously discussed, avatar names provide only pseudo-anonymity, thus the use of avatars names in publication is not sufficient to protect privacy. In addition, Grimes et al. (2009) state that many residents invest considerable time in growing the reputation of an avatar. Thus publication of an avatar name may be equally harmful to the participant as publishing their real-life name.

Expectations of privacy protection may also vary dependent on the real-life geographic location of participants. Ess (2002) notes that there are different legal provisions for privacy in the

United States and European Union. Therefore, what provision should a researcher in Australia provide to participants resident across Europe, using *Second Life* which is bound by US law? The approach taken in this research is to apply the most conservative protection to all participant information, thus reducing the risk to all participants, meeting and possibly exceeding their own expectations.

4.4.4 Identity

Related to both informed consent and privacy protection is the issue of identity. As described above, while it may be possible to link avatars with real-life persons through a simple online search, the pseudo-anonymous nature of avatars can prevent researchers confirming the identity of research participants. This double edged ethical sword of identity is further complicated by the common practice of users creating multiple avatars, known as 'alts'.

'Alts' may be the second or third (or more) avatar of a single user and serve a variety of purposes. When a 'professional' avatar can easily be linked to a real-life person, 'alts' allow the user to go *incognito* and may be used by educators, learners, researchers and research participants.

The (potential) use of 'alts' by researchers raises the issue of deception. As per traditional educational research ethics, limited deception may be permissible on the grounds that there are no alternative approaches, that there is minimal risk to participants and that participants will be fully informed as to the deceit as soon as possible in debriefing. However the researcher needs to ensure that they will be able to debrief the entire community affected by the deceit and, as noted by Frankel and Siang (1999), online communities may be in a constant state of flux. In addition individual participants may leave the NGO-VW for extended periods of time or permanently.

The (potential) use of 'alts' by participants may also hold serious implications for the validity and reliability of research results. For example a study which had an open call for participants through the *Second Life* educators (SLED) mailing list asked participants to complete an in-world survey. To encourage potential participants a financial incentive for taking part was offered in return for the time taken to complete the survey. Researchers need to consider that due to such financial incentives and through the use of 'alts', the same real-life person may participate in the same survey multiple times. If 10 people did this using just three avatars each, they would account for 30 responses and may significantly skew results.

While this may be a concern for other data collection methods including interviews and observations, qualitative data analysis tends to avoid aggregation of data and uses techniques

such as triangulation and member checking to increase validity. Despite this, it is difficult to ensure that each avatar that takes part in a learning activity and is involved in data collection, is controlled by a unique individual.

4.4.5 Discussion

The previous sub-sections have presented some of the broad research concerns applicable to any research domain involving human participants and considered them in the context of educational research in NGO-VWs. The unique combination of features and perceived educational affordances of NGO-VWs has resulted in new educational opportunities and new ethical considerations and concerns.

The research in this thesis is designed in-line with the ethical guidelines, standards and good research practice published by the British Educational Research Association (2004), the American Educational Research Association (2000), Trinity College Dublin (2009) and follows the ethics protocol of the School of Computer Science and Statistics, Trinity College Dublin. The ethical principles which underpin this are: respect, justice, beneficence and non-maleficence.

The learning experience took place on the *Second Life* island '*Insula Docta*'. The researcher was able to limit access to the island to learners and instructors on the course, as such informed consent was necessary from all participants before data could be collected. Any learner not wishing to participate in the research had any information relating to them removed from the data, as described in the participant information sheet. All participants regularly met together and this provided the researcher with the opportunity to gain and validate informed consent in a face-to-face setting. The participant information sheet (Appendix B) outlined potential benefits and risks to participants and an opportunity to discuss these was provided at the meeting. There were five areas of risk identified by the researcher: time; audio recordings; image recordings; the use of chat logs; power imbalance and assessment on the course.

To ensure that research activities did not negatively impact participation on the course, those activities supplemental to the module requirements were optional for those that had chosen to participate in the research. In addition they were scheduled according to the participants' availability outside of the course.

All interviews were audio recorded and following transcription were assigned participant codes. Similarly any still or video images recorded in the NGO-VW were edited to remove avatar names with transcriptions coded. All data is stored in compliance with the Data Protection Act (1988 and 2003). In order to record in-world data the researcher's avatar displayed information that recordings were taking place.

Chat logs had to be recorded by each participant on their own computer. As such this places the participant in the position of power. Following the first case study participants were asked to submit these logs to the researcher, thus allowing the participants to decide what data will and will not be passed to the researchers. However this approach had a negative impact on the data collected, as discussed in the first case study (Chapter 5) and chat logs were not recorded in the second case study.

All participants took part in the learning experience as part of an assessed course and as such particular attention was paid to potential power imbalances. To address this, participants were informed that their participation would have no impact, either positive or negative on their assessment on the course and that they were free to leave the study at any time. Only the researcher, who is not an instructor on the module, would have access to raw data such as interview transcripts, except for data also submitted for assessment such as the learners' reflections. This data was coded to remove any personal information including names. Marks awarded as part of the course requirement were not collected.

To ensure privacy protection, the decision was taken within this study to code rather than anonymise data, with both participant and avatar names coded in the data. The ethical implication is that it remains possible to link data with an identifiable person (Pauwels, 2007), however this provided the opportunity to identify both supporting and negating data across data sources for an individual participant, thus strengthening data analysis.

Finally, to address issues of identity, each learner was provided with access to *Insula Docta* for only one avatar and 'alts' were not used by the researcher or instructors. While it was impossible to guarantee that the person controlling the avatar was the participant that had signed the informed consent form, this approach reduced risks to participants and added validity to the research. Personal information was stored in accordance with the Data Protection Act (1988 and 2003).

4.5 Conclusion

This chapter has discussed and justified the use of the interpretive case study methods in this research. While there are a number of approaches to conducting case studies, through careful consideration of the aims and requirements of the research an initial exploratory case study followed by an instrumental case study were identified as most appropriate. Data collection and analysis focus on the subjective experience of the individual within the learning experience, using one-to-one open interviews as the primary data source. Corroboratory data for validation is collected from a range of sources including documents and artefacts prepared by participants for the purpose of assessment. Participant chat logs are trialled as a substitute to traditional

observation in the first case study; however the second case study uses in-world participant observation. While there are a wide range of possible approaches to data analysis, the constant comparative approach and content analysis have been chosen to meet the aims of the first and second case studies respectively. Finally ethical concerns when conducting research in-world have been discussed and the approach followed in this thesis has been outlined.

The following chapters present the implementation, findings and discussion of each case study. Chapter 5 reports on the exploratory case study and through an instrumental case study, Chapter 6 examines two emergent areas of interest which may impact the design of constructionist learning experiences in NGO-VWs.

5 Case 1: Exploratory case study

5.1 Introduction

Learning experiences in NGO-VWs lack pedagogical underpinning (Savin-Baden et al., 2011).

One reason for this may be the lack of clear guidelines with which to design learning experiences (Vrellis et al., 2010). To address these points, this thesis implements an approach to the identification and implementation of pedagogies with which to underpin learning experiences in NGO-VWs.

Following this approach constructionism has been identified in this thesis as an appropriate pedagogy (Chapter 2), yet few studies report the use of constructionist learning experiences in NGO-VWs. Beyond the alignment proposed in Chapter 2, there is no current understanding about how the features and perceived educational affordances of the technology may support or enhance constructionist learning as learners engage in a purpose designed learning experience. Therefore, the primary aim of the research presented in this thesis is:

To explore constructionism in action in non-goal orientated virtual worlds

Constructionist theory emphasises the importance of learners engaging in the construction of personally meaningful and shareable artefacts. However the inbuilt construction tools in NGO-VWs present the novice with a high-floor barrier to overcome before they can engage in the learning activity. To address this, a low-floor construction tool was required and Chapter 3 presented the design of SLurtles as low-floor programmable construction tools for use in *Second Life*. Following the approach to the identification and implementation of pedagogies for use in NGO-VWs, guidelines for the design of SLurtle-based constructionist learning experiences were also derived. From these guidelines, the constructionist learning experience implemented in this research was designed, as presented towards the end of Chapter 3.

As described in Chapter 4, two case studies are implemented in this thesis. The first, presented in this chapter, is an exploratory case study which aims to explore SLurtles and the learning experience in action with a group of post-graduate learners. Due to the lack of literature on constructionism in NGO-VWs, this study also aims to generate research questions which could be explored in subsequent studies. Finally, as in-world data collection procedures are implemented for the first time, this study provides an opportunity to refine them in advance of the second case study.

This chapter presents a detailed description of the first case study beginning with the research aims, context of the learning experience and data collection. The primary analytic strategy, described in Chapter 4, is to develop a rich description of the case which is achieved through the constant comparative analysis, presented in detail in section 5.5 of this chapter. The codes and categories are then used as an additional data set with which to engage in the secondary analysis of the theoretical propositions. Throughout this chapter codes are formatted **bold**. Following the section on data analysis, the findings are presented.

Finally, the discussion considers the findings of both the primary and secondary analysis of the data in relation to each of the aims of the study and associated research questions. SLurtles are found to provide learners with an empowering low-floor, high-ceiling and wide-wall construction tool with which learners were able to engage in the construction of personally meaningful and shareable 3D artefacts as part of a constructionist learning experience in the NGO-VW. While the findings broadly support the proposed alignment of pedagogy and technology; there are some aspects which require further study.

5.2 Research aims and questions

The main aim of exploratory case studies is to generate and refine research questions when there is a dearth of existing literature and theory in the area (Yin, 2009). However they also provide an opportunity to pilot aspects of the study. Thus this case study has four research aims:

- Explore SLurtles in action with learners
- Explore the learning experience in action with learners
- Refine in-world data collection
- Generate research questions for future research

Beginning with SLurtles, as highlighted in Chapter 3, it is not possible to anticipate whether all design concepts behind SLurtles would be successful during implementation with learners. Underpinning the design of SLurtles are the concepts of a low-floor (easy to use), high-ceiling (powerfully expressive) and wide-walls (support the creation of a variety of artefacts), concepts central in the design of constructionist tools for learning. While it is possible to programme an object to be persistent when created by SLurtles, there is no way to be sure that SLurtles provide learners with a low-floor, high ceiling and wide wall tool until used by learners. Therefore, while maintaining the broad exploratory aim, the following research and sub-questions are used to focus discussion of the findings:

- Do SLurtles provide learners with a pedagogical tool with which to engage in constructionist learning in virtual worlds?
 - Do SLurtles provide learners with a low-floor construction tool?
 - Do SLurtles provide learners with a high-ceiling construction tool?
 - Do SLurtles provide learners with a wide-wall construction tool?
 - How do learners use SLurtles as part of a constructionist learning experience?

Similarly to SLurtles, while the learning experience is designed to leverage the perceived educational affordances and provide opportunity for the features of the pedagogy to emerge, this may not be the case in practice. At this stage it is not possible to assign causal relationships between pedagogy and technology, therefore a broad exploration of each is undertaken, within the context this learning experience. While the aim is to explore the learning experience in action, the following research questions are used to focus the theoretical analysis and discussion of the findings:

- Are learners able to engage in constructionist learning?
 - Do the features of constructionism emerge during the learning experience?
- Are the perceived educational affordances utilised by learners to support their engagement?

As highlighted in Chapter 4, NGO-VWs provide opportunities to utilise various approaches to data collection. Due to external limitations, direct observation of participants was not feasible. Similarly the technical overhead and time required made it impossible to record participants' avatars in-world. Therefore chat logs have been proposed as a substitute. However there is no evidence of this data collection technique being used in other studies. Therefore it is necessary to pilot the approach and the following research question is posed to focus the refinement of the in-world observations as there are no existing guidelines on the use of chat logs for observations:

- Do chat logs provide an adequate means of data collection?

The answers to each of these research questions will be pertinent to the final aim of the case study which is to generate research questions for future studies. An improved understanding of the alignment between pedagogy and technology as well as SLurtles as a low-floor construction tool will guide the development of research questions for subsequent studies.

5.3 Context

As described in Chapter 3, a group of 24 learners participated in the SLurtle-based constructionist learning experience over four weeks, as part of a post-graduate course in

technology and learning. The intended outcomes were for learners to (1) experience a constructionist learning activity; and to a lesser extent (2) gain an understanding of programming. All 24 learners agreed to participate in the research study, of which 19 self reported as having little or no previous programming experience. Only four had experience of using *Second Life* before the course. An overview of the participants is provided in Appendix E.

12 groups of 2 were formed and where possible (in 5 of the 12 groups) non-programmers were paired with programmers at the request of the module co-ordinator. All groups participated on the same *Second Life* island, *Insula Docta TCD*, an access controlled island which only provided access to participants, as highlighted in Chapter 4. The learning task required each group to programme SLurtles to create an installation and use S4SL to make the installation interactive. A full description of the learning experience is presented in the Design Chapter (Chapter 3). At the end of the four weeks the learners were required to present their installation and reflections on the experience to the class and submit them for assessment as part of the course requirement.

5.4 Data Collection

Following a request for participants, all 24 members of the course gave permission for data to be recorded. Figure 5.1 illustrates the data collection activities during and following the learning experience.

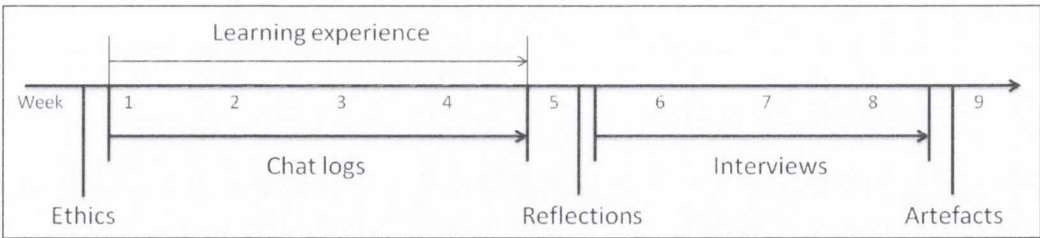


Figure 5.1 Data collection over time

Interviews provided the primary source of data for analysis. Of the 24 participants, an opportunistic sample of 14 took part in non-directive open interviews conducted in either *Second Life* or face-to-face. An overview of the 14 participants is provided in Appendix E. Interviews in *Second Life* were conducted through voice at the learners' installation space. Face-to-face interviews took place in a private office space without access to *Second Life*. Each interview lasted between 30 and 80 minutes. Audio recordings of the interviews were transcribed and names were coded rather than anonymised (as discussed in Chapter 4). The transcripts were then imported into NVivo8 in preparation for data analysis.

Participants were requested to record their chat logs over the four weeks of the learning experience and send the automatically generated text files to the researcher after the learning experience. Following the learning experience they provided the researcher with the group and individual reflections they had created for the course as well as access to their artefacts. Artefacts, while providing no evidence of the process, demonstrate the final outcome of the learning experience for each group and may be referred to in interviews and reflections. These were recorded using the screen capture software *FRAPS*. As learners' reflections were created for the purpose of assessment, they are likely to be biased. Data generated from these three sources were coded to remove names and imported into *NVivo8*, except for the video files as the file sizes were prohibitively large. Table 5.1 presents an overview of the quantity of data collected.

Table 5.1 Summary of data collected

Data	Potentially available	Total collected
Chat logs	24	5
Individual Reflections	24	24
Group Reflections	12	11
Interviews	24	14
Artefacts	12	12

5.5 Data Analysis

Qualitative data analysis is a messy process (Hatch, 2002). This section presents a detailed description of the data analysis undertaken in this case study to clarify the actuality. Figure 5.2 presents an overview of the data analysis process, linking each phase to the research aims.

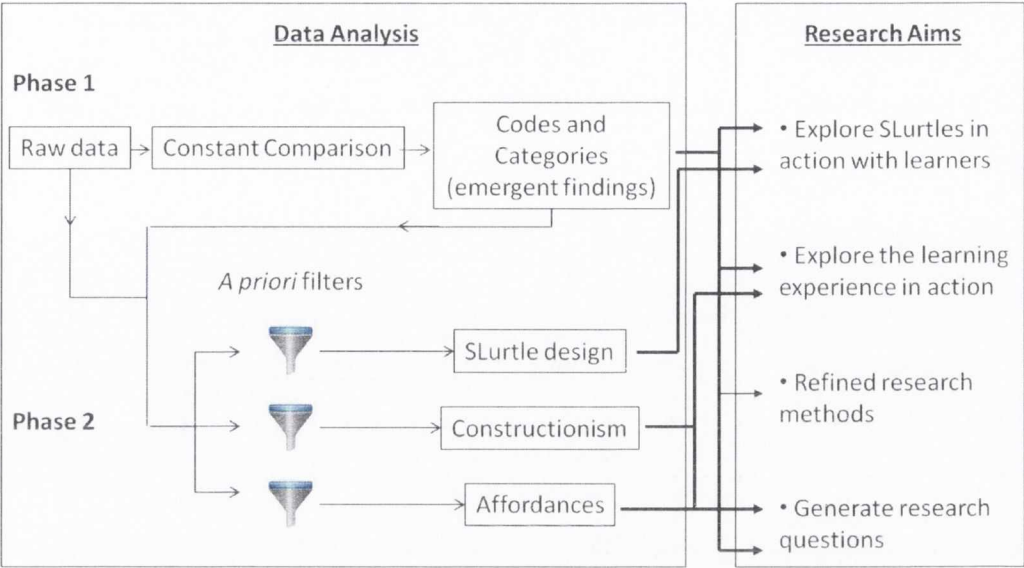


Figure 5.2 Overview of data analysis process linked to the research aims.

The first phase focuses on the case description. As highlighted in Chapter 4, the primary analytic strategy is to develop a rich case description using the constant comparative approach, allowing the researcher to remain open to emergent findings. The findings of the constant comparative analysis should address each of the four research aims.

The second phase focuses on the theoretical propositions which underpin the design of SLurtles and the learning experience. This is achieved through the use of *a priori* codes derived from the theoretical propositions, which act as filters to analyse both data and emergent findings. This analysis allows the research questions to be answered and supports the generation of research questions for the subsequent instrumental case study.

5.5.1 Phase 1: Emergent codes

Figure 5.3 provides an overview of the first phase of the data analysis process. While Chapter 4 justifies the use of constant comparative analysis in this case study and describes several of the stages involved, it does not attempt to portray the non-linear and often messy reality of the analysis process. This section addresses this by fleshing out each stage of the process as it was conducted, through detailed description and the use of screenshots.

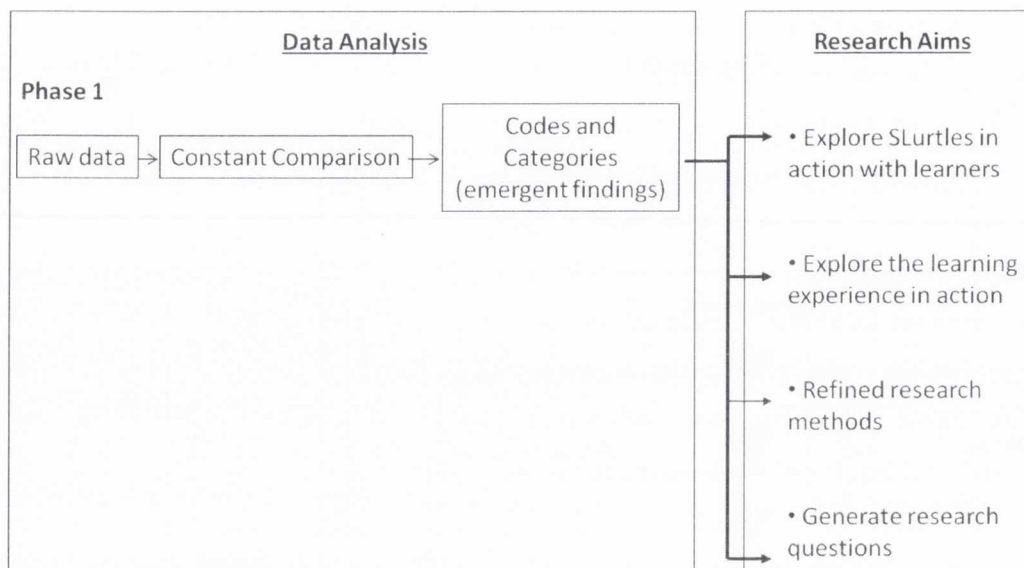


Figure 5.3 Overview of data analysis: Phase 1

Beginning with initial coding, emergent findings shaped the flow of data analysis including the use of internal coding and relational analysis. Rather than following a sequential approach, codes and initial categories were often returned to and re-examined in light of these additional stages, providing the researcher with an opportunity to consider rival theories (Figure 5.4). For example, following the coding of the first interview, tentative categories were developed, however as the number of emergent codes grew it became clear that these categories would not be efficient with many codes fitting in more than one category. Similarly the relational analysis highlighted possible coding properties and dimensions, requiring a return to coding. The use of researcher memos was ongoing throughout the data analysis process feeding into each stage.

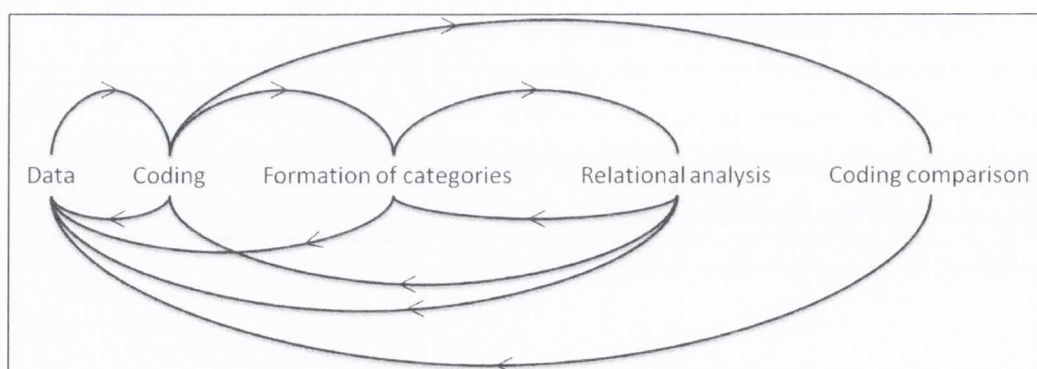


Figure 5.4 The messy process of data analysis

Each stage of analysis occurred at a different level of abstraction as illustrated in Figure 5.5. Member checking, peer validation and triangulation followed these stages and resulted in a return to codes and reconsideration of categories.

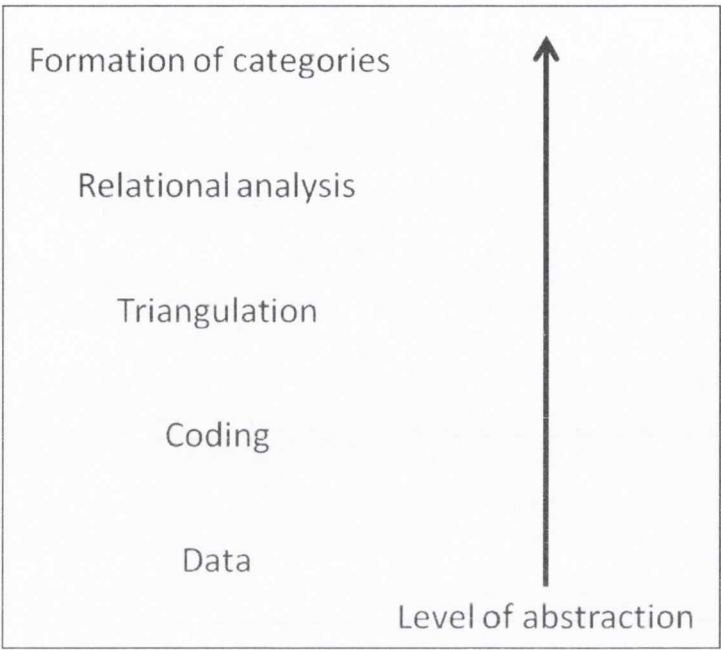


Figure 5.5 Illustration of the increasing levels of abstraction away from the data during data analysis.

The following sub-sections describe the process in detail, illustrating how each stage impacted the others, resulting in some stages being repeated several times. At the end of the analysis process a set of emergent categories and their codes had been generated (Appendix C). These were used to develop a rich description of the case which is presented in the following section on findings (5.6).

5.5.1.1 Generation of initial codes and tentative categories

Data analysis began with the open coding of the first interview. As described in Chapter 4, following an initial read through of all the data to sensitise the researcher, detailed analysis began by assigning emergent codes to phrases in the text. Analysis of the first interview transcript (1a1) resulted in 74 codes. Analysis of the second interview (1a2) generated 25 new codes.

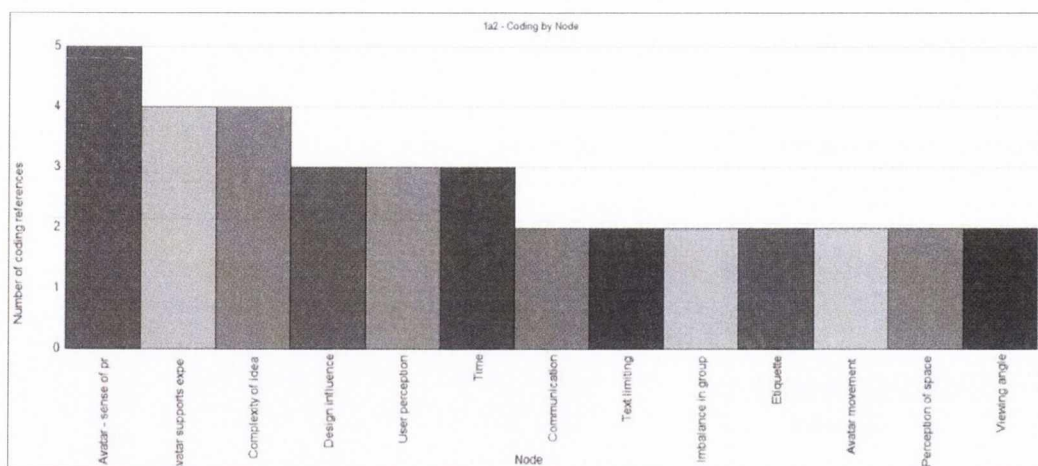


Figure 5.6 Most common codes in interview 1a2

Following analysis of the first two interviews almost 100 codes had been generated. To begin to explore this data, *NVivo8* was used to generate an initial quantitative overview of codes, graphing codes by the number of references for each interview (for example, Figure 5.6). A list of the most commonly used codes across the two sources (Table 5.2) and a list of codes used in both sources (Table 5.3) was also generated.

Table 5.2 Most common codes across interviews 1a1 and 1a2

Name	Sources	References
Influence of looking at other groups' work	1	11
SL constraint	2	9
Time	2	8
Abstract-concrete	1	8
Design influence	2	8
Viewing angle	2	7
Looking at other groups' work	1	6
Regret	1	6
Develop idea	1	6
SLurtle limitation	1	6
Avatar - sense of presence	2	6
Outsider perceptions	1	5
Motivation	1	5

Table 5.3 Codes used in both 1a1 and 1a2

Name	Sources	References
Idea	2	2
Time	2	8
Overcoming limitations	2	3
Viewing angle	2	7
Perception of space	2	4
User experience	2	2
User perception	2	4
Design influence	2	8
SL constraint	2	9
SL skills	2	2
Communication	2	3
Online collaboration	2	2
Avatar movement	2	3
Avatar supports socialisation	2	3

With 99 codes generated from analysis of the two interviews, these graphs and tables provided a visual indication of the codes used most frequently. This provided a starting point for the initial identification of categories which developed over several iterations as more interviews were analysed. The initial outcome of this process was a model of codes from the two interviews which included 13 tentative categories:

- Role of avatar
- Communication
- Collaboration/Group work
- Design/Idea
- The individual within the group
- Thinking/Learning
- Overcoming problems
- Building
- SLurtle
- *Second Life*
- S4SL
- Programming
- Making public

It is worth noting that several codes remained outside the categories at this point in the analysis: **engaging, time, regret, viewing angle, perception of space, interaction with space** and **motivation**.

From these tentative categories it appeared that ‘making public’ would emerge as a major category. This referred to the participants’ awareness that they were creating artefacts in a

public space. It also appeared that ‘*Second Life*’, ‘*SLurtle*’ and ‘*S4SL*’ would become sub-categories under a broader category of ‘tools’, as they were each used as tools during the learning experience.

Analysis of subsequent interviews resulted in a total of 226 codes (Table 5.2), although some were removed through the reduction of codes, described in the following sub-section (5.5.1.2). Coding of the sixth interview (3a1) resulted in only 10 new codes and it was noted that each was only coded once within the text, suggesting that saturation of new codes may be occurring. This appeared to be confirmed through analysis of the seventh interview (5b1). Although two new codes were initially generated during analysis of this interview, further examination of the codes found that these codes overlapped with existing codes.

Table 5.4 Number of codes added per interview

Interview	New codes	Cumulative total codes
1a1	74	74
1a2	25	99
1b1	20	119
2b1	63	189
2a1	27	216
3a1	10	226
5b1	0	226

Having coded and formed initial categories from the data along with the reduction of codes, a coding comparison was conducted (described in 5.5.1.4). The aim of this was to recode the first two interviews in light of the additional 127 codes which had emerged to examine the internal validity of the coding.

Following the coding comparison and reduction of codes, a final set of codes was created (Appendix C). At this point the remaining codes were moved from ‘Free Nodes’ to ‘Tree Nodes’ within *NVivo8*, where they were placed within a hierarchical tree structure of categories and sub-categories. This aided the analysis of the remaining seven interviews. While the researcher remained open to new codes throughout analysis of the final set of interviews, none emerged.

5.5.1.2 Reduction of codes

The process of reducing codes was used several times throughout the data analysis. It was often prompted by unexpected results, for example the generation of a particularly large number of codes, described below, or a memo which prompted the re-examination of codes within categories as described in the following sub-section (5.5.1.3). A lengthy process of code reduction was conducted following the coding comparison described in detail in sub-section

5.5.1.4. The coding comparison focused on the original data assigned to each code and lead to the greatest reduction of codes over the course of the data analysis.

The fourth interview to be coded (2b1) initially resulted in 63 new codes (Table 5.4). Such a large number of new codes at this point was unexpected and so the researcher engaged in an initial process of identifying overlap and potential redundancy between codes. This began by allocating the new codes to the existing tentative categories. This was achieved with the use of a visual model in NVivo8 (Figure 5.7). This highlighted several possible overlapping codes. For example, **SLurtle – personification** and **personification** were identified as repetitive codes and the sections of transcript coded at these were merged into **SLurtle – personification**. Another outcome of this modelling was to identify that **external tool** and **external tools** had been created as well as **tools**. The first two codes were merged and the references coded at the remaining two codes were compared. This check confirmed that the remaining two codes **external tools** and **tools** were distinct but that some of the references in **tools** should have been coded at **external tools** and these were changed.

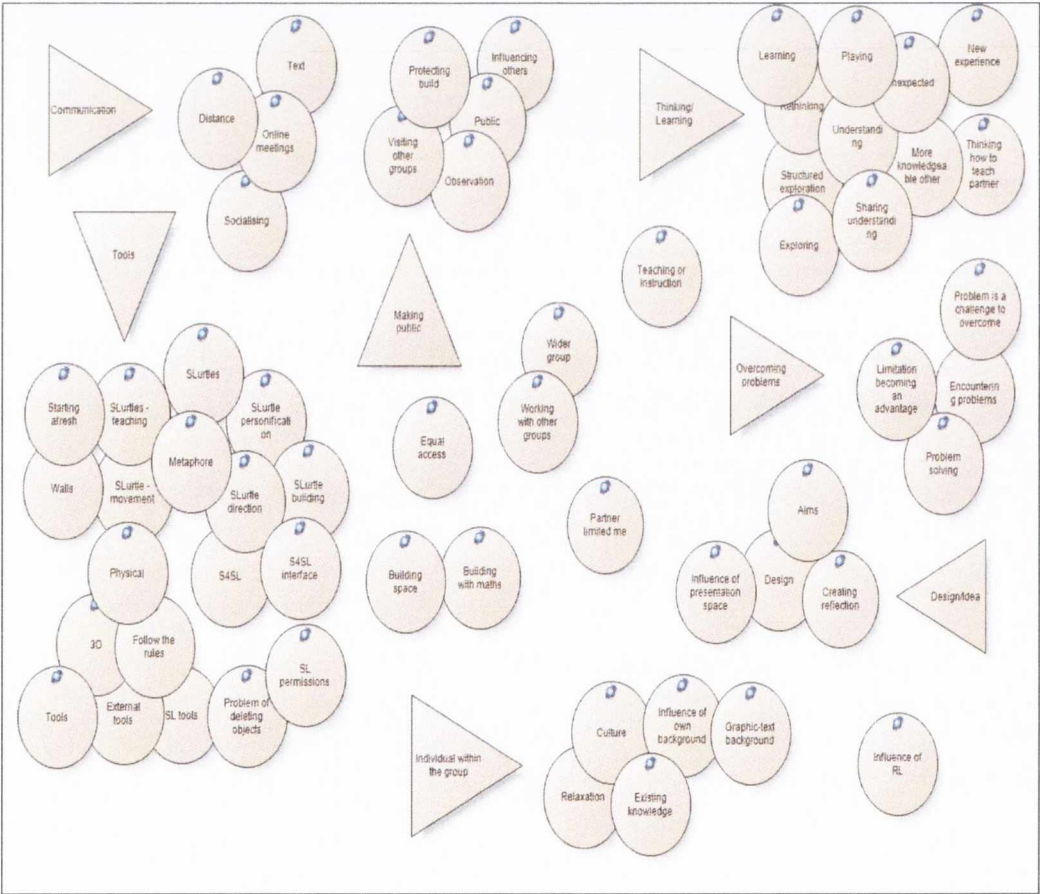


Figure 5.7 Model of codes generated by interview 2b1.

NVivo8 proved to be a powerful tool throughout data analysis. At this stage it supported the visual modelling of new codes generated in interview 2b1 as shown in Figure 5.7, in which codes are in circles and categories are in triangles pointing towards related codes. Modelling of new codes under the tentative categories confirmed that these categories were strong but also highlighted that there were codes which remained outside these categories.

5.5.1.3 Memos

As part of the process of generating tentative categories and adding new codes to the initial model, memos were created in *NVivo8* to record the researcher's thoughts. For example, Figure 5.8 shows a memo created whilst adding new codes which had emerged from interview 1b1 to the initial model.

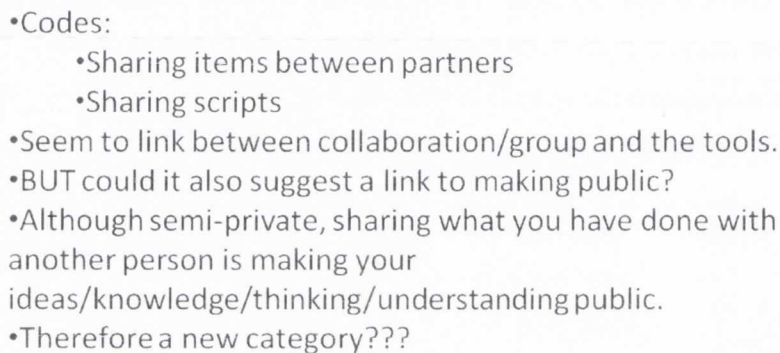
- 
- Codes:
 - Sharing items between partners
 - Sharing scripts
 - Seem to link between collaboration/group and the tools.
 - BUT could it also suggest a link to making public?
 - Although semi-private, sharing what you have done with another person is making your ideas/knowledge/thinking/understanding public.
 - Therefore a new category???

Figure 5.8 Sample memo

As a result of this memo the researcher began to explore the potential relationship between the categories 'making public' and 'collaboration/group work'. While there were no codes which were linked to both categories at this point in the data analysis, a possible link between categories was explored in subsequent analysis of the data and creation of categories. In this a parent-child relationship was considered with either category a sub-category of the other. However it became clear that there was insufficient data to support this hypothesis and they were treated as unrelated categories in the findings.

Another example is captured in the memo shown in Figure 5.9. As previously discussed, analysis of the fourth interview (2b1) resulted in 63 new codes. Following this analysis, these codes were examined to identify replication and overlap between new and existing codes through modelling the codes within the tentative categories (as described earlier in 5.5.1.2). Through this process a supporting memo was generated (Figure 5.9).

- Category: Making public
 - Supported by features of SL:
 - Avatars - seeing others around and in space
 - Visiting other spaces
 - 3D
 - immersion
 - Sense of presence
 - Potential category of 'sense of space'
 - Drives:
 - Design
 - Collaboration
 - Thinking process
 - Affects
 - The nature of sharing
 - Not just between two people or when one person chooses to share with another.

Figure 5.9 Memo which led to relational analysis of codes

This memo resulted in the re-examination of the selection of codes linked to the category ‘making public’ and eventually lead to the category becoming a sub-category of ‘learning environment and design’. It also prompted a relational analysis of these codes (described in 5.5.1.5) which led to the introduction of some axial codes.

5.5.1.4 Coding comparison

New codes emerged and others became redundant throughout the data analysis process. Once the seventh interview had been conducted a very different set of codes had been generated than those that had emerged during analysis of the first interview. Consequently a coding comparison was conducted to test the internal validity of coding. As no other researcher was available to conduct a second coding of the data, the researcher returned to the first interview and coded it again.

In NVivo8 the researcher logged in with a new identifier (KK, originally CG) and was able to openly code the first data set without seeing the first set of coding. Once this was completed a coding comparison query was run in the software which compared the coding between CG (the first coding) and KK (the second coding).

Table 5.5 shows a sample of the results generated in NVivo8. The column titled ‘Kappa’ shows the Cohen’s Kappa coefficient for each code, which provides a statistical measure of agreement or error between two researchers coding the same text (Gwet, 2008). The next column aggregates the percentage of agreement between coders. This is broken down in the following

two columns into either both rater A and B (CG and KK) coded the same text at that code, or neither rater coded the text at that code. The final three columns of the table are similar but for disagreement, when one rater coded the text at that code but the other rater did not.

Table 5.5 Sample of coding comparison results

Code	Kappa	Agreement (%)	A and B (%)	Not A and Not B (%)	Disagreement (%)	A and Not B (%)	B and Not A (%)
Avatar supports building	0.9954	99.99	0.87	99.12	0.01	0.01	0
Avatar supports socialising	1	100	1.4	98.6	0	0	0
Develop idea	0.3578	96.85	0.94	95.91	3.15	1.64	1.51
Idea	0.0252	94.24	0.08	94.16	5.76	0	5.76
Learning beyond programming	0.8611	99.19	2.16	96.58	0.81	0.76	0.06
SL constraint	0.6853	96.33	4.38	91.95	3.67	0.83	2.84

Unlike percentage agreement, the Kappa coefficient takes chance occurrence into account; hence a high percentage agreement does not indicate a high Kappa. For example, **idea** has a 94.24% agreement between coders, however the Kappa is low (0.0252). As can be seen in Table 5.5, both CG and KK consistently applied the code to only 0.08% of the total text, while KK applied the code to an additional 5.76% of the text. As this is unlikely to have occurred by chance, the Kappa coefficient is low. Conversely, **avatar supports building** has both a high percentage agreement (99.99%) and a high Kapap (0.9954), as shown in Table 5.5. Although the code was consistently applied to only 0.87% of the text, there was only 0.01% disagreement.

62% of all codes had a Kappa between 0.5 and 1, which Landis and Koch (1977) suggest demonstrates a moderate to almost perfect agreement when applying these codes between the beginning and end of the first seven interviews. Table 5.6 sets out the divisions of agreement based on the Kappa statistic described by Landis and Koch (1977). Although Landis

and Koch (1977) acknowledge that these divisions are arbitrary, they support the understanding of the statistical outcome of the analysis.

Table 5.6 Interpretation of Kappa statistics by Landis and Koch (1977).

Kappa Statistic	Strength of Agreement
<0.00	Poor
0.00-0.20	Slight
0.20-0.40	Fair
0.40-0.60	Moderate
0.60-0.80	Substantial
0.80-1	Almost perfect

The Kappa result indicated which codes had been used reliably within the interview. For example, the code **avatar supports socialising** had a Kappa of 1 indicating that the code was applied by the researcher to the same section of text at the start of the data analysis process and at the end. Thus this code was used reliably. By comparison, the code **develop idea** had a Kappa of 0.3578, suggesting that this code was applied quite differently from the start of the analysis to the end. With such codes the breakdown of percentage agreement and disagreement between CG and KK was used to re-examine the researcher’s coding. As per the reduction of codes, the references within the text were returned to for re-examination.

While the coding comparison provided quantitative indicators of the reliability of the researcher’s use of codes throughout the coding process, it was necessary to follow this up by re-examining the references indicated by the agreements and disagreements within the interview. For example, the codes **avoiding building** and **text easy**, with Kappas of 0.3913 and 0.3683 respectively, were used by the researcher to code the same reference within the text but included a greater or lesser amount of surrounding context between coding sessions. This was identified by returning to the original references and examining the coding stripes for each reference by both raters. As indicated by the blue line in Figure 5.10, during initial coding the researcher selected a much smaller section of text to code at **avoiding building** than the later coding shown in orange. The reverse was true for **text easy** shown in Figure 5.11.

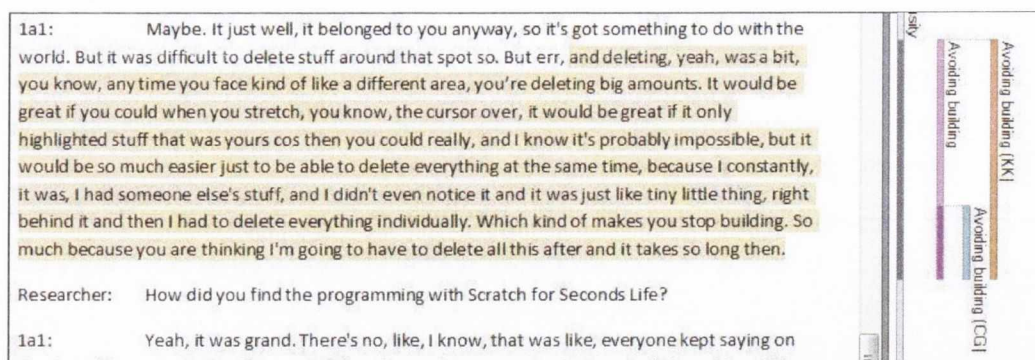


Figure 5.10 Snapshot of coding by CG and KK for the code avoid building

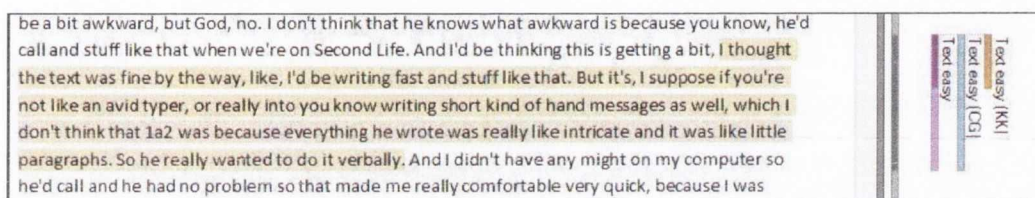


Figure 5.11 Snapshot of coding by CG and KK for the code text easy

Another possible reason for 38% of the codes having a Kappa between 0.5 and 0 is that codes which had emerged following the analysis of the first interview were more precise than the codes initially used. This was noted in a memo and prompted further investigation of overlap between codes, leading to further reduction of codes.

Finally there were some codes which needed careful reconsideration of how they were used. For example, **idea** had a particularly low Kappa (0.0252) and so the references coded were examined. Of the nine discrete references coded at **idea** by KK, only one had previously been coded by CG. Together with the results of Cohen's Kappa coefficient, this demonstrated that the use of this code had changed over time and therefore needed to be reapplied to all sources.

While Cohen's Kappa coefficient provides an indicator or reliability, it is not a sufficient test on its own. Thus, the statistical analysis prompted a qualitative assessment of the researcher's use of codes during the coding process. The coding comparison generated several memos about codes which were followed up by examining references and identifying overlap between codes resulting in a reduction of codes. Following this process of internal review, the final seven interviews were coded with an improved understanding of how each code should be applied.

5.5.1.5 Relational analysis

At several stages during the coding of data, the development of categories and generated memos highlighted potential relationships between codes. It was unexpected that the first case study would generate such clear potential relationships and so relational analysis was used to

explore these findings further. The following description is the analysis which occurred following the reduction of codes in which the codes **imbalance in group** and **perception of own ability compared to partner** were examined for overlap. **Imbalance in group** was coded in 6 interviews at 15 references, whilst **perception of own ability compared to partner** was coded in 5 interviews at 9 references. The references were examined to identify why each reference had been coded or not coded at each of the two codes. While the original analysis was confirmed and the codes remained separate, it was noted in a memo that they may be related. It was also noted that references to both balanced and imbalanced groups were coded at **Imbalance in group**. This resulted in the creation of a memo (Figure 5.12) and the code was renamed to **(im)balance in group**.

- So is this a continuum?
 - How does balance or imbalance within a group affect things?
 - Which things need to be (im)balanced?

Figure 5.12 Memo on code: imbalance in group

This memo prompted the exploration of how the **(im)balance in group** code related to other codes through a relational analysis. To support this process, *NVivo8* was used to quickly analyse all references assigned to each code and cross-reference these with the references coded at **(im)balance in group**, through the use of the ‘matrix’ query. The software also provided an opportunity to extend the coding to a wider selection of text, thus including a greater context within the **(im)balance in group** references and increasing the potential cross-references.

Following the aggregation of codes and references which were found to cross-over with **(im)balance in group**, each reference was examined within its wider context. On an interview-by-interview basis, each code identified in the matrix was listed and tentative associations between codes were drawn based on interpretation of the raw data. These were noted in memos, for example Figure 5.13. This memo records the initial links the researcher considered between codes in interview 2a1. The first point notes that when an imbalance was addressed by the group, communication and collaboration increased within the group. The second and third points link imbalance to **feeling of loneliness** and **working independently**.

- Imbalance -> change -> balance AND communication AND collaboration UP
- Imbalance -leads to-> feeling of loneliness
- Imbalance -leads to-> working independently (leads to loneliness?)

Figure 5.13 Memo created following the matrix of all codes with the code (im)balance in group

Once all the references for each interview had been completed and memos created, they were re-examined to identify and consider those that overlapped. Following this, several visual models were created to further develop the tentative links. These included one model by participant, part of which is shown in Figure 5.14; one examining those factors which resulted in imbalance (inputs) and those which were the result of imbalance (outputs) (Figure 5.15); and one which examined the changes that were made within groups to address the imbalance and the effects of these changes (Figure 5.16).

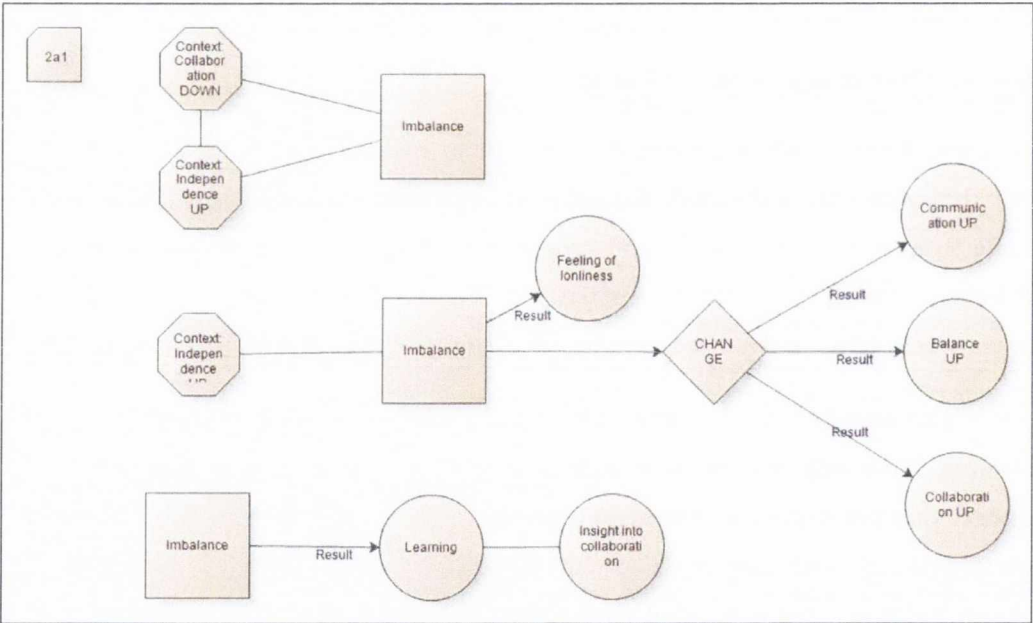


Figure 5.14 Model of 2a1 codes linked to (im)balance

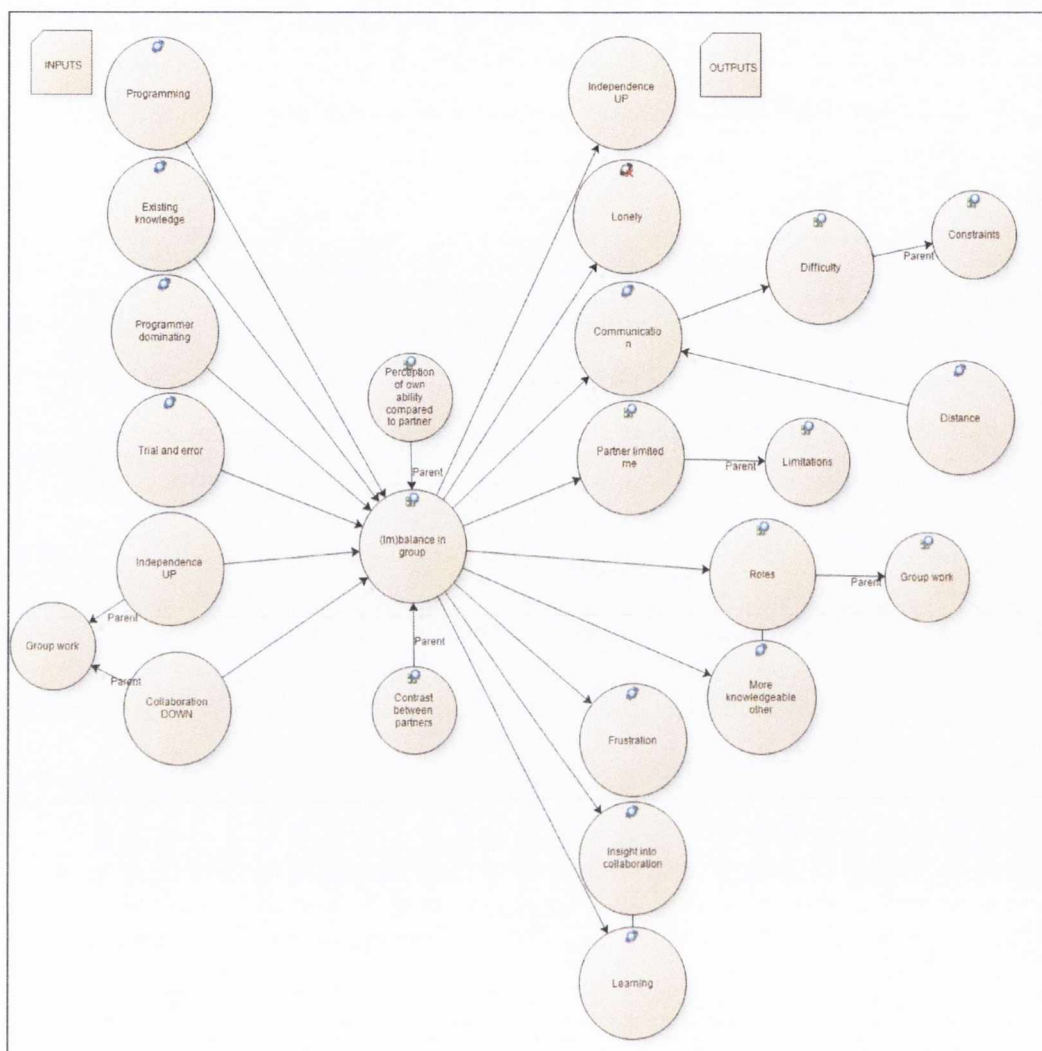


Figure 5.15 Model of codes linked to (im)balance, exploring inputs and outputs

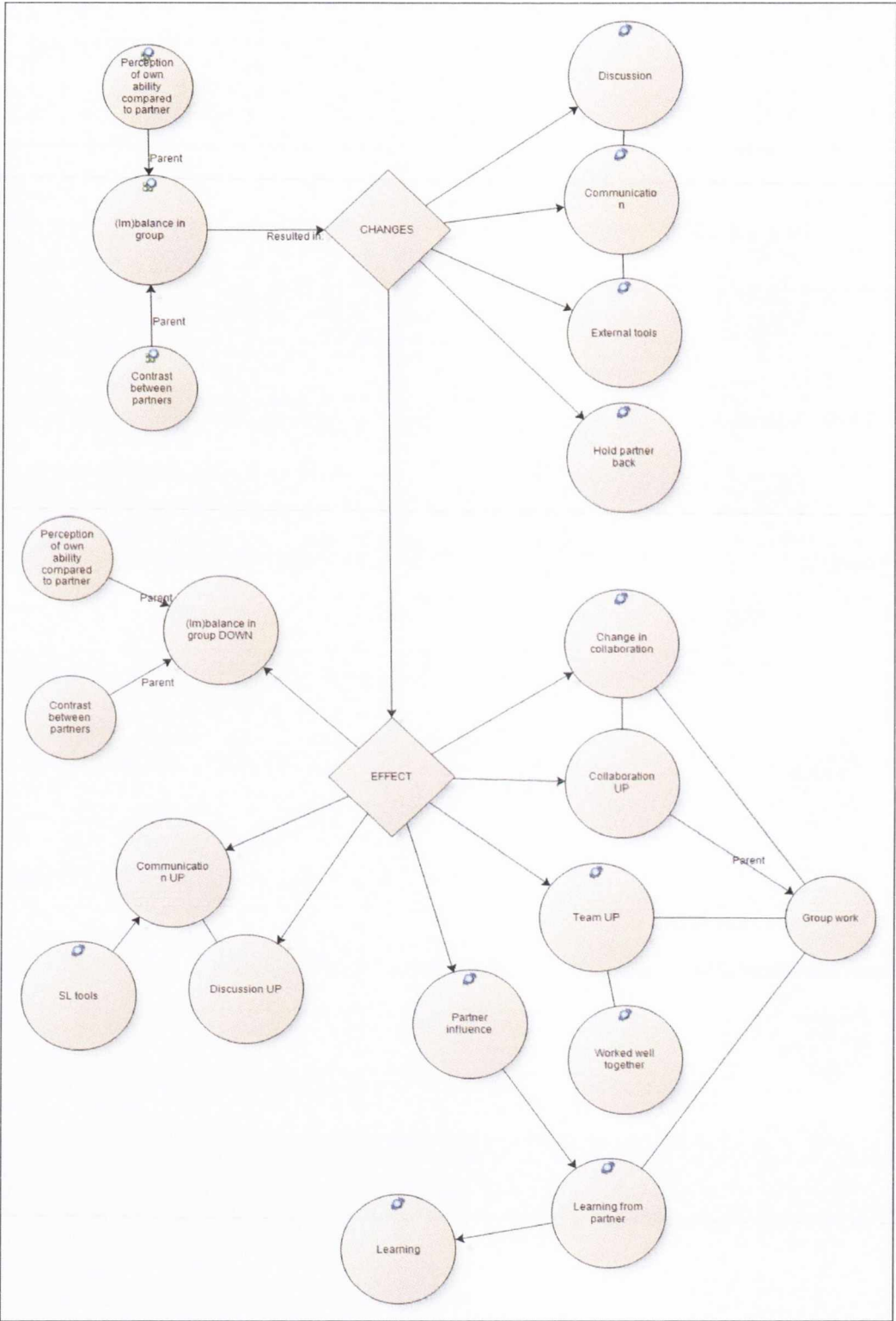


Figure 5.16 Model of codes linked to (im)balance, exploring changes and the effects of change

The results of this analysis were influential in the development of efficient categories, in which 'imbalance' became a sub-category of 'group work'. The findings of this analysis are discussed within the findings section of this chapter (section 5.6).

5.5.1.6 Creating efficient categories

Starting with the tentative categories generated at the start of the data analysis process, the creation of the final categories required several iterations, returning to and prompted by memos as well as the relational analyses. The aim was to create 'efficient categories', which Merriam (1998) describes as:

- Reflecting the purpose of the research
- Exhaustive
- Mutually exclusive
- Sensitising
- Conceptually congruent

The tentative categories generated following the coding of the first interview were neither exhaustive nor mutually exclusive as some codes fitted in more than one category and some in none. Thus categories were reconsidered, exploring alternative approaches to the division and categorisation of codes. Each proposed set of categories and sub-categories was presented for either member checking or peer validation. The aim was to create a final set of categories with high efficacy which were also valid to participants and peers.

While it was not possible to fulfil all the requirements of efficient categories, the final set of categories and sub-categories demonstrated strong internal validity through triangulation with other data sources. This process is discussed in detail in the following sub-section (5.5.1.7). The four categories are presented in detail in the findings section of this chapter (5.6) and are comprised of:

- Thinking
- Group Work
- Learning Environment and Design
- Learning

Two particularly problematic sets of codes related to the role of the avatar during the learning experience and a sense of constructing in a public space. These were both represented in strong categories ('role of avatar' and 'making public') during the early stages of analysis but this changed during the development of efficient categories. Within the final set of categories and sub-categories, codes relating to the use and role of avatars during the learning experience

were spread throughout each of the final five categories and were a particularly strong element within 'Learning environment and Design'. As a category or sub-category, 'role of avatars' was not a mutually exclusive category and nor was it conceptually congruent with other categories or sub-categories at the same level. However the codes could be split between the final set of categories. Consequently, the role of the avatar is considered to be a cross-category theme within the findings of this research study.

Several of the codes originally categorised as related to the sense of making in public were also associated with the tentative category 'design/idea'. Over time a new proposed category 'learning environment' emerged. The three proposed categories 'learning environment', 'design' and 'public' were considered to be strongly linked and of a similar level although some of the proposed sub-categories, for example 'motivation' were linked to more than one category. Through validation, it became clear that while 'public' remained a strong category it was a feature of, and thus a sub-category of, both 'learning environment' and 'design'. Figure 5.17 is a screenshot of an early model of the codes, sub-categories and categories created during the development of efficient categories. The inter-connectedness (shown by connecting lines) of the categories of 'learning environment' and 'design' with each other and the sub-category of 'public' reduces the efficiency of these categories and although unresolved, they remain within the findings as they were validated through both member checking and peer validation.

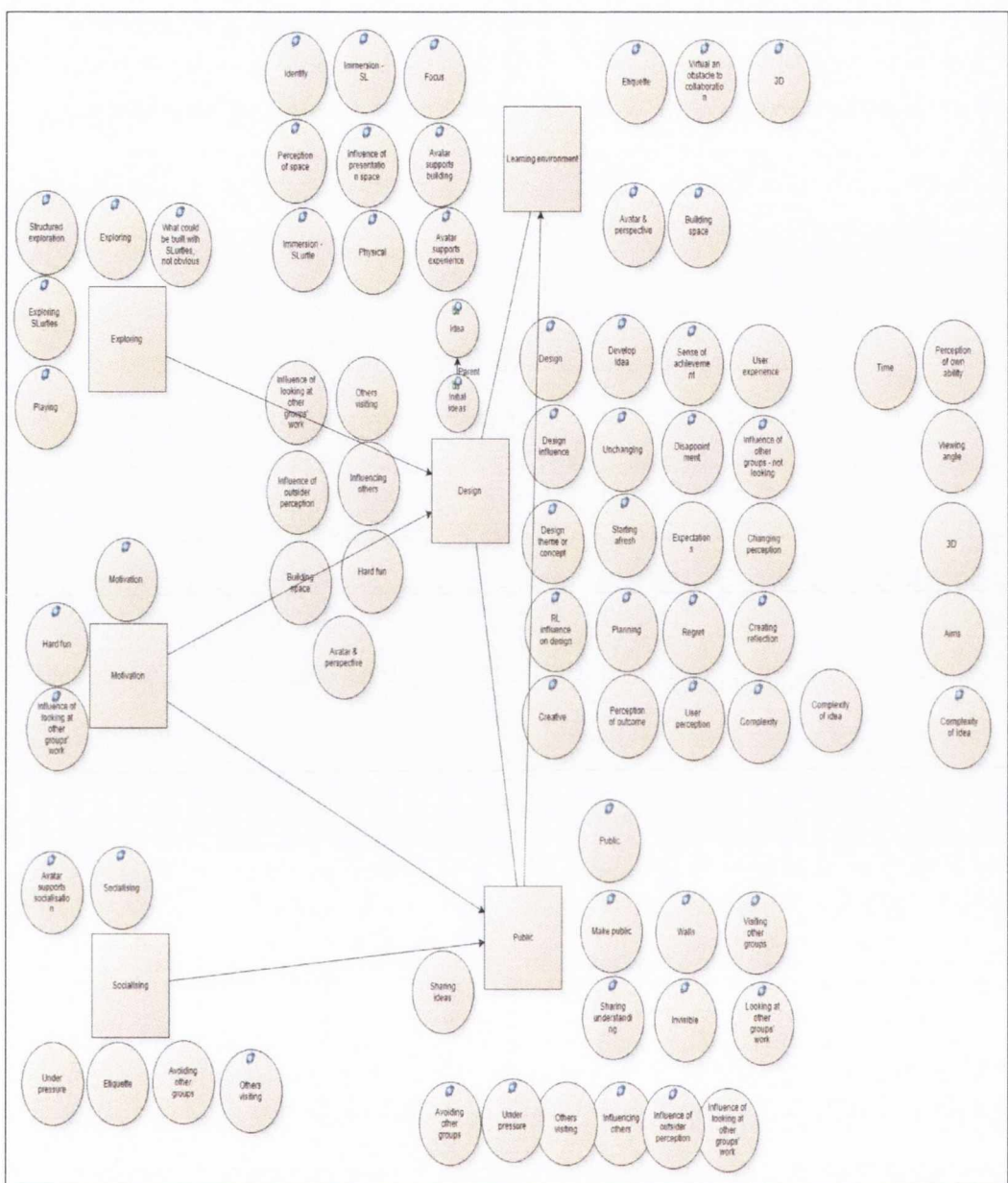


Figure 5.17 Screenshot of one section of the model of codes (in circles) and categories (in squares) during the development of efficient categories.

Appendix C presents the resulting final categories, sub-categories, minor themes and codes. The final five categories are discussed in detail in the following findings section of this chapter (5.6).

5.5.1.7 Internal validity

During the development of a final set of categories, two tests of internal validity were used on several occasions: member checking and peer validation. As discussed in Chapter 4, member checking involves participants in the review of draft findings when no further data will be

collected from them. Two participants who had taken part in the interviews agreed to individual meetings to discuss the proposed categories. At these meetings the categories were presented and the participants were asked if they provided an accurate reflection of the experience. Both agreed that the categories provided a good description of the main points of the learning experience. One noted that there was no mention of avatars at the category and sub-category level which surprised him and so it was agreed that the role of the avatar would be highlighted as a cross-category theme.

A similar process of peer validation took place with three of the researcher's colleagues. These discussions were particularly important in the final integration of 'learning environment' and 'design' as one category within which there were several sub-categories, as well as including 'public' as a sub-category.

Following the identification of codes and categories there were two phases of triangulation with other data. This began with exploring internal consistency between interviews and other data collected from each participant interviewed. Taking each participant in turn their chat logs, artefacts and individual reflections were coded using the final codes listed in Appendix C. Through this analysis only data which confirmed the findings was identified. In the second phase the process was extended to include all data sets from all participants. This process identified evidence which countered some of the final codes whilst other data supported the same codes. While the final categories and codes within them remained the same, as a result of this analysis, some codes were considered to be axial.

5.5.2 Phase 2: *A priori* codes

Following the generation of a final set of codes and categories, data analysis moved to the second phase. To analyse the data, *a priori* codes were drawn from the theoretical propositions underpinning the design of SLurtles and the learning experience:

- SLurtles
 - Low-floor
 - High-ceiling
 - Wide-walls
- Constructionism
 - Construct personally meaningful artefacts
 - Actively explore, test and extend understanding
 - Opportunity to programme
 - Shareable artefact
 - *Bricolage*
 - *In-situ*
 - 'Invisible' technology
 - Collaborating on constructions
- Perceived educational affordances
 - Creation of persistent objects
 - Construction
 - Programming
 - Persistence
 - Flexibility
 - Embodied social presence
 - Immersion
 - Collaborative learning

As illustrated in Figure 5.18 both raw data and the researcher generated codes and categories were analysed using the *a priori* codes as a filter to address three of the secondary research aims:

- Explore SLurtles in action with learners
- Explore the learning experience in action
- Generate research questions for future research

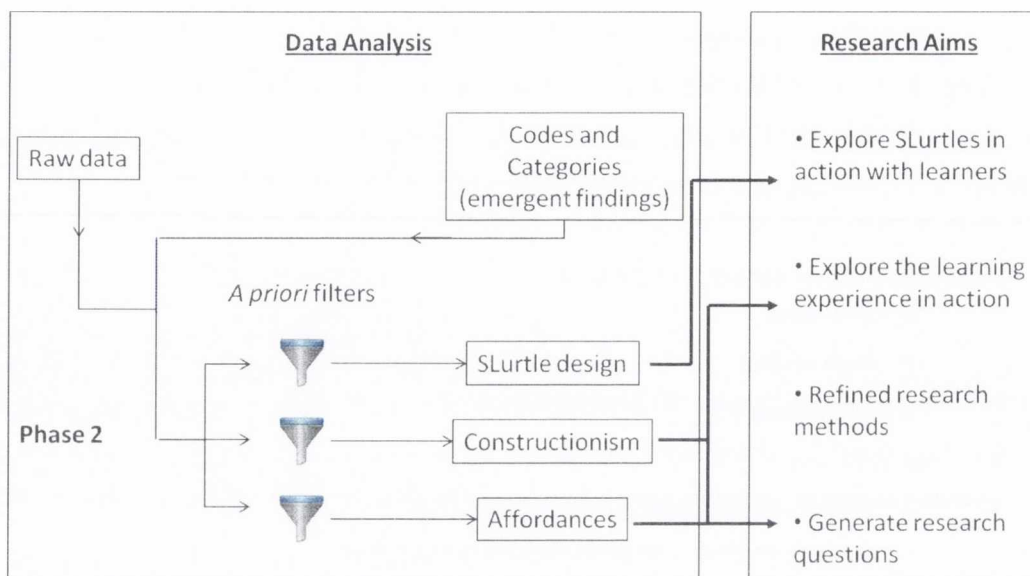


Figure 5.18 Phase 2 data analysis process

Over several iterations, each set of *a priori* codes was used as a filter to analyse both raw data and emergent findings from the constant comparative analysis. As per the first phase of data analysis, interviews were the primary source of data, followed by the corroboratory data sets and finally the codes and categories from the first phase were analysed.

Analysis began with the SLurtle design principles, followed by constructionism and perceived educational affordances underpinning the learning experience. All data sets were analysed for both supporting and refuting evidence. While this process required substantial time to complete, it was a simple linear process. Finally internal validity was examined by comparing across data sets in a process of triangulation. The findings are reported in 5.6.2.1 (SLurtle design), 5.6.2.2 (constructionism) and 5.6.2.3 (perceived educational affordances) in the following section.

5.6 Findings

This section presents the findings of the data analyses described in the previous section. While qualitative data analysis is a messy process, it produces rich findings. Each of the categories developed through the constant comparative analysis is presented with a detailed description of each sub-category, illustrated with codes and data. This is followed by the findings from the second phase of analysis on SLurtle design, constructionism and perceived educational affordances.

5.6.1 Phase 1: Categories and sub-categories

Through the open coding of interviews a wide variety of codes emerged and these were developed into four categories: ‘Thinking’, ‘Group Work’, ‘Learning Environment and Design’ and ‘Learning’. Each of these categories is presented in turn, exploring each of the sub-categories with evidence from the data to present a rich description of the learners’ experience.

5.6.1.1 Thinking

While ‘thinking’ refers to a range of activities undertaken by participants during the learning experience, two key sub-categories emerged during the data analysis: ‘Programming’ and ‘Barriers’. Programming was a key aspect of the learning experience and thus a lot of thinking activities described by participants relate to programming. Participants also described a number of barriers to their thinking, such as basic skills and the way in which SLurples created objects. While some of these barriers resulted in participants feeling limited or constrained during the learning experience, low barriers enabled learners to engage quickly with the learning experience.

Figure 5.19 presents an overview of the category and sub-categories which are discussed in detail below.

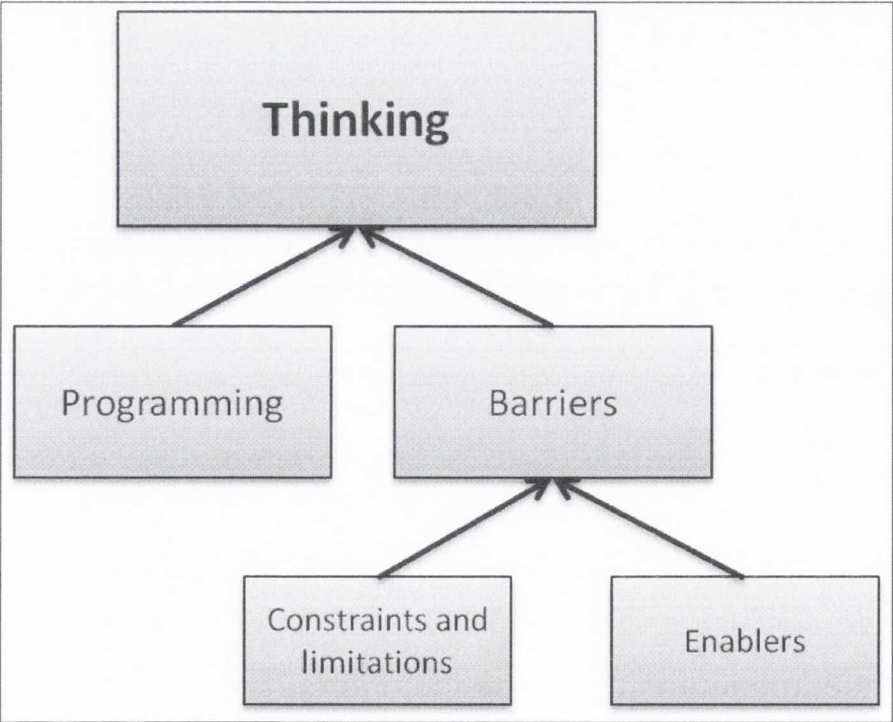


Figure 5.19 Representation of 'Thinking' category

Thinking

Participants described SLurtles as objects within the environment which supported their thought processes and this was achieved in a number of ways. A particularly strong code, which was also supported by both chat logs and reflections, was **SLurtle movement**. For example one participant described the importance of the SLurtle showing a clear direction of movement: *"I suppose because it was something visual to look at, and you knew what way he was facing, and that was important as well when you built something"*.

While the form of the SLurtle was important for learners, showing a clear direction of movement, one participant described the **SLurtle's appearance** as potentially constraining their thought processes: *"Like why not just use a paintbrush, or you know, something that would be more relevant ... I mean, turtles don't draw"*. However others described the **SLurtle's appearance** as supporting exploration and in turn creativity: *"If it's a SLurtle ... it forces you to ask, what can this thing do? And by being forced to ask, what can this thing do, you have to experiment, you have to play, and you also have to think he's that way up at the moment, could it be a different way up, and if he's this way up I can actually draw pictures on the wall"*.

One group created a bowling alley as part of their artefact. When clicked a ball would roll towards the pins, apparently knocking them over at which point a 'Strike!' message would appear. As described by one member of the group this artefact required a lot of **problem solving**: *"To actually figure all this out because it was, like, a fair bit of problem solving on it in terms of, like, one we couldn't figure out why the ball would not go down the full length ... and then we tried, erm, we tried commands with the pins, ... but that wouldn't work because the collide was with the pins and it wasn't with the ball. So that's why what we had to do was to simulate the actual ball hitting the pins. And you wouldn't notice when you're standing here, that it's actually just timed, erm, so when the ball would roughly be where the pins were, then they would knock over"*.

While some learners identified the use of **reflection** early on in their **problem solving**, for others it was a strategy they learnt to use over time: *"I wouldn't reflect at all, whereas I think 3a1 would be a much more a reflective person, and I think I got that from her. And then kind of reflected more myself."* Partners were also influential on learner's approaches to **problem solving**. Learners described their partner as supporting their thinking process when working on a problem together: *"sometimes you're thinking, you're just thinking down the wrong route, and somebody else, you know, can drag you back on it"*.

This **feedback** also helped learners to identify characteristics of the SLurtle they were previously unaware of: *"it comes out the middle, so he draws, we wanted to make it .1 wide. But he draws .05 on this side and .05 on that side"*. This resulted in several groups using **alternative approaches** such as pen and paper to plan their designs and programmes rather than rely on abstract conceptualisation from which to plan the programme: *"I did the math in my head and talked through it with 3a1 but we never got it right. We were actively experimenting but getting it wrong every time. Finally I took out two pens and a piece of graph paper and 3a1 did the same."*

While a number of participants noted using a **trial and error** approach, for example: *"most of the problem solving would have been done around erm, you know, the kind of trial-and-error, guess and test, erm, stuff"*, several learners identified that over the duration of the learning experience their approaches to **problem solving** changed, as described in one interview: *"Maybe I do it in a different way, but this taking a step back, looking at things how they work, how... and then thinking, what will we do now as a result of that and why didn't it work, or why did it work and that kind a way of thinking, that methodology of thinking is very good and it was effective"*.

Programming

Several participants described SLurtles as a focal point for their thinking about programming, beginning with their initial ideas, then exploring and testing them in action with the SLurtle. As one participant said, *"getting a SLurtle to build something based on his movement. That's the key thing"*. A process another participant described as *"cool"*.

SLurtles were described in both interviews and reflections as providing learners with an opportunity to observe and reflect on the scripts that they created. As part of the **problem solving** process, SLurtle action or inaction provided learners with **feedback** on the programmes they had created *"if it didn't respond in a way that you thought that it would respond, it was providing you with feedback, you know, telling you I do not respond this way"*. As noted in one reflection, this feedback supported learners as they reflected on the experience: *"The fact that I could get immediate feedback from watching the actions of the SLurtle allowed me to evaluate what the script was doing in comparison to what I wanted to happen. I found this visual feedback allowed for an accelerated understanding of what was happening within the script than if I had to think in the abstract as to what was happening"*. An example of this was found in another participants' reflection, which included the snapshot shown in Figure 5.20.



Figure 5.20 Observing programming errors

Interviews, chat logs and reflections provided evidence to suggest that SLurtles and the 3D environment allowed the more experienced programmers to easily explain abstract programming concepts to novices, such as 'loops', through the **SLurtle building concrete** examples which could be shown to a complete novice. In particular it allowed the novice to watch the SLurtle perform each step within the loop before beginning the next iteration of the loop. By observing the actions of SLurtles and the creation of SLurtle blocks, learners were able to reflect on their programmes, redesign and engage in active experimentation, thus they were engaged through the process of construction. There was evidence in the chat logs to show that in some groups that had both novice and experienced programmers, the novice programmers began to adopt the language of the experienced programmers to describe the actions of the SLurtle in terms of its programme:

"P1: he's gone mental"

And some time later:

"P1: he's obviously gone into an infinite loop"

Another participant described SLurtles and S4SL as providing an opportunity to engage in 3D modelling and programming without existing 3D graphics or programming experience. Thus for

the novice *"you're going from the concrete to the abstract. So you can basically start off doing or using"*.

Although **existing knowledge** of programming was not necessary, in one reflection a participant noted that without this past experience they believed themselves to be at a disadvantage: *"I know that some of the class were able to transfer previous programming experience to this exercise and I badly lacked those terms of reference to transfer."* Despite this, most participants did not view a lack of programming knowledge as limiting them; instead they viewed these amongst the skills they gained during the learning experience.

Many learners described programming SLurtles and adding interactivity as *"easy"* due to S4SL. However those that added movement to objects, described the programming as *"frustrating"*, as, unlike SLurtles, the objects had no obvious direction and therefore the learners didn't know which way the object would move.

In both reflections and interviews learners described SLurtles as *"engaging"* and *"fun"* objects within *Second Life* and whilst programming them was both *"enjoyable"* and *"frustrating"*, SLurtles engaged learners in thinking about the programming concepts they were using and how to approach problem solving. As one interviewee said, *"I think it got your head around the process of programming and what programming is all about. It kind of got you into the frame of mind about the thinking that goes behind programming; that you need a lot of attention to detail and you need things exactly right otherwise they won't work."*

Barriers

The sub-category of 'Barriers' was comprised of two distinctive components: 'limitations and constraints' and 'enablers'. 'Limitations' were distinct to 'constraints', as 'limitations' were perceived as preventing the learner from achieving their goals, whereas learners described working with 'constraints' to achieve their goals. In addition, what one participant described as a limitation another might describe as a constraint and therefore were combined into one component. 'Enablers' is used to describe low barriers or those objects, tools or processes that allowed barriers to be lowered.

Constraints and limitations

Building in *Second Life* with or without SLurtles is not without its limitations and there was evidence that learners had **expectations** of what they would and would not be able to achieve at the start of the learning experience based on their **past experiences**: *“when I first came into it I was thinking, it's just like a drawing program. You're drawing for continuous lines but you're not. And then once you figure that out, you kind of go well, actually, you can use this to your advantage as in the pixel like notice board ... once you get to that point you can do, there's lots of other interesting things you can do that you wouldn't have thought if it had just been a line drawing program. So in a way, it not being as you expected to be was a good thing because it forced you to go in a completely different direction think in a completely different direction.”*

As noted earlier, during their initial explorations, learners discovered that *“the SLurtle builds from the centre of the SLurtle so it is a bit difficult when you're trying to get it to turn a certain way, but it turns and it starts building from the centre of that block rather than the very side”*. Whilst one participant described this as a limitation, some described it as a constraint to be worked with, a challenge to think about, problem solve and overcome, whilst others did not identify it as a barrier.

The number of blocks (prims) that each group could create using SLurtles was restricted due to a limitation within *Second Life* on the number of prims that can be created on an island. As shown in Figure 5.21, programming concepts such as loops could be explored in the creation of objects with multiple blocks in them, however due to the **prim limit** learners often deleted these artefacts, rethinking how to build them with less prims. As a result, *“to build a round tower, with doors and windows in it you actually need to create lots of bricks which are in a circle, which went way over the prim counter to actually do it. Yeah, there were other ways of doing it, but prim count would be the one thing that restricted you in that environment”*.

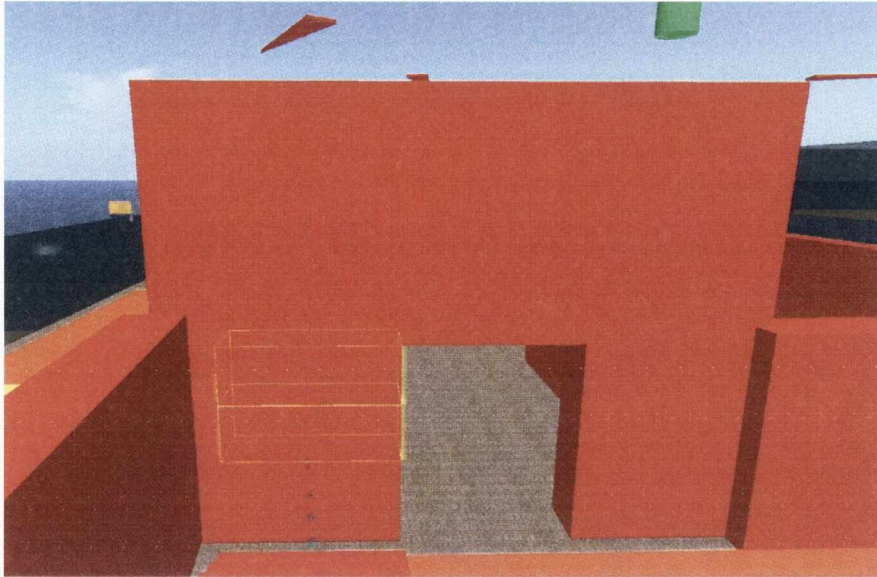


Figure 5.21 Red brick house created using loops with individual blocks highlighted in yellow.

Another barrier that several participants reported was the **permissions** system, whereby learners can share objects and the contents of scripts. This was described as particularly problematic when collaborating in the scripting of a SLurtle. Some groups were able to overcome this using the tools available to them in *Second Life* such as using “*shorthand descriptions of scripts ... typed on the chat line or a texture showing an example was pulled into Second Life and displayed*” (illustrated in Figure 5.22, taken from the same learners’ reflection). However, those that did not master the permissions system or an alternative approach found that, in the worst case, their collaboration turned into two people working independently on the same project.

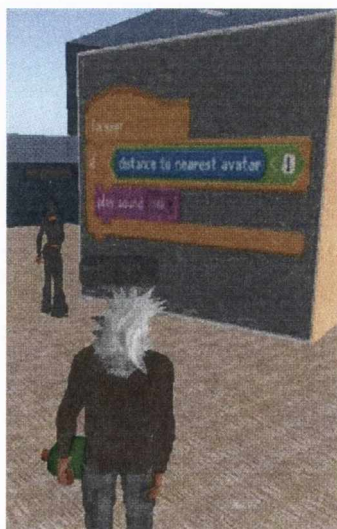


Figure 5.22 Using images to support collaboration.

While many participants described SLurtles as enabling them to easily engage with building in *Second Life* and described S4SL as an **easy to use** programming environment, *"putting the script together wasn't hard it was just knowing how to get that script and you know paste it and open it and put it into the turtle and stuff like that, just trying to remember the sequence"*. This skill-based task of transferring the script from S4SL to the SLurtle through the creation of a default *Second Life* script, as described in Chapter 3, was a barrier identified by two participants. With practice this was overcome, however it limited the ease with which they could initially engage with the SLurtles.

Other features of *Second Life* which participants described in their interviews, but most often in their reflections, as limiting or constraining the learning experience included the text-based chat tools, voice in *Second Life*, and skills such as movement of the avatar and **camera controls**. However some participants described that by engaging with the SLurtles they quickly overcame these barriers or they became irrelevant: *"And what was interesting about the SLurtles and engaging with your own scripting control of something was, you're suddenly focused on something inside the environment, where the environment now becomes, goes into your peripheral sort of consciousness."*

Enabling

It is worth noting that despite the barriers imposed by *Second Life*, learners described SLurtles as providing them with a tool without which *"we wouldn't have been able to build what we have built"*. In one reflection a learner wrote about the ease at which he was able to use the SLurtles to create objects. He described feeling like *"a child with a new toy and I wanted to play. There was no need to read the instructions."* Over time learners were able to achieve a high level of control and accuracy in what they created through S4SL and SLurtles by *"just put(ting) in exactly what you want the SLurtle to do and it did the exact angles"*. However, achieving this high level of control through their programming skills was not easy.

Learners described an initial process of exploring what they could create with SLurtles before focusing on the more difficult process of creating specific objects for their assignment: *"it was very interesting ... it was a bit of fun. ... Yes, I enjoyed them when I could do random stuff with them, and I thought oh that's good, that's cool, but then when you had to start applying specific ideas, and get it to do this and that, erm, it became a bit more difficult"*. In one reflection a learner described the lows and resulting highs *"changing one script numerous times until the SLurtle did exactly what I asked it to do. Sometimes it was frustrating but the sense of satisfaction when the SLurtle built a perfect house or a beautiful tree was worth all of the frustration"*.

5.6.1.2 Group Work

As learners were required to work in pairs on the assignment, it is perhaps unsurprising that 'Group Work' emerged as a category. However within this category there are three key sub-categories which are discussed below: 'Imbalance'; 'Communication'; and 'Collaboration' (Figure 5.23).

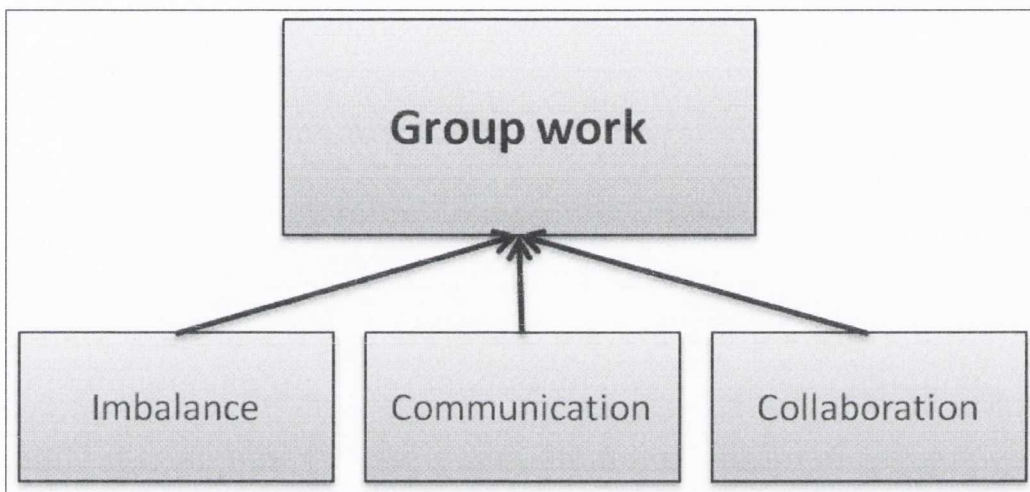


Figure 5.23 Representation of 'Group work' category.

Imbalance

In six of the first seven interviews analysed, there was mention of some form of 'imbalance' within the groups and this was explored in the relational analysis. Learners perceived an imbalance in knowledge of programming between themselves and their partner, often identified through the stronger **programmer dominating** and increasing **independent work**. For example, in an individual reflection one participant stated: *"I think 3a1 at first was a little worried about my knowledge especially as when she arrived into Second Life for our first meeting I had spent a lot of time playing."* The result of a perceived imbalance was a **lack of collaboration** and **communication** which often led to a sense of **loneliness**. Interestingly in these situations, both experienced and novice programmers described being **limited by their partner**.

Learners described recognising this imbalance and deciding to take action in a number of ways such as insisting on an increase in communication and discussion. With an increase in communication, **collaboration changed**: *"I suppose then, we kind of did everything together. There was nothing, nobody did one thing on their own then after that. And we kind of learned from each other"*. Learners described actively **learning from their partner** which helped to address the initial imbalance and their group began to *"work well"*.

It is worth noting that one participant described an **expectation** of imbalance within their group which did not materialise. Instead they collaborated and learned together through the experience.

Communication

As noted in the sub-category of 'Imbalance', communication was an important aspect of how groups worked together: *"we worked very well together. I think once initially we had the conversation around the different levels, I suppose, of competence in relation to programming, and I suppose my need for him to slow down a bit; once we had that conversation we worked very well together."*

Across reflections, interviews and chat logs there was evidence of participants using **text**-based chat, *Second Life* **voice** and **external tools** such as Skype in order to communicate within the group. While some participants described the **text**-based chat tools as sufficient for collaboration, others were frustrated by them: *"I was trying to explain to her where I thought the code was going wrong, and it was taking so long over, to get the message across. And then also, I felt that the message I was putting across might have seemed like I was telling her, or a bit, if you read the text, you could see it could be, depends on what way the person takes it."* Another participant described the **confusion** at the start of the project: *"kind of talking about one thing and then going on to the other, just kind of thinking aloud, and what was happening was there was two or three different conversations happening simultaneously, and you were answering one thing and next of all, next they were replying back to what you said two minutes ago"*.

Text-based chat was often described as "slow". Yet despite this, as discussions began to focus on specific aspects of the project, *"it just got faster"*. Whether this was due to familiarity with the technology, the mode of communication or the focus of the task is unclear.

To address the issue of speed of communication several groups used Skype whilst in *Second Life*. However it is interesting to note that in their reflections one group described how, as their understanding of programming increased, they were able to move away from their reliance on Skype when working on scripts together and began to use **text**: *"a chatting shorthand was used to describe how to put together a script"*. However this group, as with many others, continued to prefer to use Skype for **discussions**. By contrast to the use of Skype, few groups used the *Second Life* **voice** tools. Those that did noted their unease that their conversations could be heard by other groups and some encountered technical problems such as "echoes" due to open microphones.

In a reflection by one participant it was noted that although they mostly used **text**-based tools to communicate *“there are no social or body cues (non verbal information) to aid understanding. This sometimes can lead to misunderstandings.”* However several other participants described the avatars as supporting communication, in the code **avatar & communication**, by *“walking over to an area that kind of indicated what you might be talking about.”* Another participant stated that *“it helped that you were looking at somebody face to face, you kind of knew if they had scurried off to the corner that they were sick of listening to you, or you know, that they wanted to do their own thing, so, it was easier to communicate in that sense. I suppose you had a feeling that there was somebody else there”*. Others described the avatars as supporting group work by providing a focal point, removing distractions and inhibitions, allowing groups to communicate more easily.

Collaboration

As previously mentioned in the sub-category of ‘Imbalance’ many participants described a point during the learning experience at which they worked independently rather than collaboratively. However when asked about their collaborative work, learners described working with their partner in *Second Life* and on their own, depending on personal time commitments. As a result there was evidence of both **synchronous** and **asynchronous collaboration** within groups.

Learners emphasised the importance of **discussion** for the clear division of tasks and the creation of **roles**, when preparing to work in *Second Life* at different times. When working together learners would either: work on individual set tasks, asking their partner for feedback and support; or work on one task together. However in the latter situation learners described the **inability to observe what their partner was doing in S4SL** as limiting collaboration and opportunities for peer-learning. As noted in one reflection: *“SL [Second Life] has a lot of potential in terms of creating an immersive collaborative experience for learners – we have had fun engaging with SL. However in terms of working as a team to create this project SL has had its limitations – we both were unable to show the other what we were doing in terms of sharing the code/actions in real time - there is no shared access to each other’s desktops and we see this as a major limitation in terms of active participation – one at times is going to be an observer but yet not being able to observe what is going on behind the scene.”* Despite this limitation many groups described working on programmes together: *“so we figured out together the erm, the scripting for that, so it was just texting back and forth, try this, or what if that”*

Collaboration tended to focus on the unfamiliar, highlighted by the code **collaboration on unfamiliar task**, with both experienced and novice programmers supporting each other: *“there were absolute cases where I just couldn’t see why something wasn’t working, and erm, then 5b1*

would have suggested something that would never have occurred to me, and it was actually quite simple, you know that kind of a way? Where sometimes you're thinking, you're just thinking down the wrong route, and somebody else, you know, can drag you back on it."

Except for the initial workshop and preparation of their in-class presentation, many groups met exclusively online: "It was within the virtual space that we formulated the decision of what to make, something we had struggled to achieve in the offline world". For some, the need for **face-to-face collaboration** arose from difficulty with the communication tools; the permissions system; or the inability to observe their partner's desktop. In the code **avatar supports collaboration**, avatars were described by some participants as supporting collaboration at a distance, providing an opportunity to observe: "by watching each other and seeing what you were doing ... flying up together to get a perspective of the area, to say, oh here, let's put the house there, let's put the fountain there ... And it was getting the perspective together, you know, from the same angle".

5.6.1.3 Learning environment and design

'Learning environment and design' draws attention to the relationship between the virtual environment and the artefacts created. In Figure 5.24 they are represented as two categories, however they are not efficient categories as described by Merriam (1998) as they are strongly related and both have the sub-category of 'Public', as discussed in 5.5.1.6. As a result they have been combined into one category, to be discussed in combination and separately.

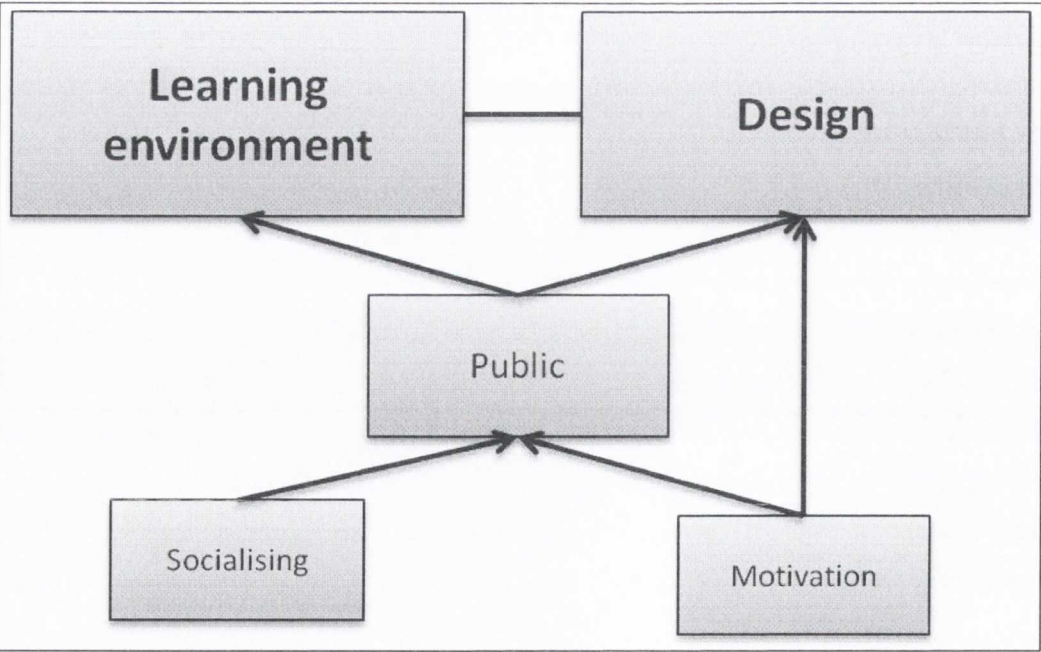


Figure 5.24 Representation of 'Learning environment and design' category.

Learning environment

The learning environment refers to the general features of the technology such as the representation of three-dimensional space and avatars, as well as the purpose built platforms on *Insula Docta TCD*.

Many participants described the **three-dimensional** environment of *Second Life* as providing them with a sense of being in a physical environment: *"because it's 3-D, it's physical, it's got surroundings to it."* Avatars were also described as mediating the sense of a physical environment, however for some participants this was not the case: *"I do prefer to directly experience the objects rather than through an avatar. The physical contact is very important for me and this is something I missed."* These participants also described feeling uncomfortable identifying themselves and others through avatars. However the majority of interviewees described the avatar as essential to the learning experience: *"If there was no avatar and the two of you logged in ... It would lessen the experience."*

Avatars supported a sense of immersion within the *Second Life* environment as well as co-presence with other learners. The sense of co-presence was also supported by the public nature of the learning environment which allowed them to enter other groups' spaces, discussed in the sub-category 'Public'. However as a result of their sense of co-presence, learners felt they needed to exhibit polite behaviour, as described in the sub-category 'Socialising' in which **etiquette** was a strong *in vivo* code: *"This was you in the same space online. And that distinction of online disappeared. There is somebody here. They are walking up, they are walking in, they are flying, you see them flying over and you know who they are because something has popped up where you just know who they are. So it did feel rude not to engage in some form of conversation."*

Although all participants had taken part in short activities in *Second Life* earlier in the course, some described their interaction with SLurtles as resulting in their first experience of **immersion** in which technology became 'invisible': *"the Second Life Saturday and the avatar and sitting on benches and the lecture and the voice that was my first immersive experience of the whole thing. And the oddness of it was very distracting. And what was interesting about the SLurtles and engaging with your own scripting control of something was, you're suddenly focused on something inside the environment, where the environment now becomes, goes into your peripheral sort of consciousness. And you're engaged with practicality of so how do I make this SLurtle turn the way I want it, go up, go left, go right. And when I stood back from that, when I sort of logged out I suddenly realised, that was the moment, where the experience of acting in an avatar's virtual presence I sort of, I got the real deal."*

The presentation platforms constructed on *Insula Docta TCD* provided each group with a blank space to create their artefacts in (Figure 5.25). Each space provided groups with a 40 metre x 40 metre flat construction space with an almost limitless height.

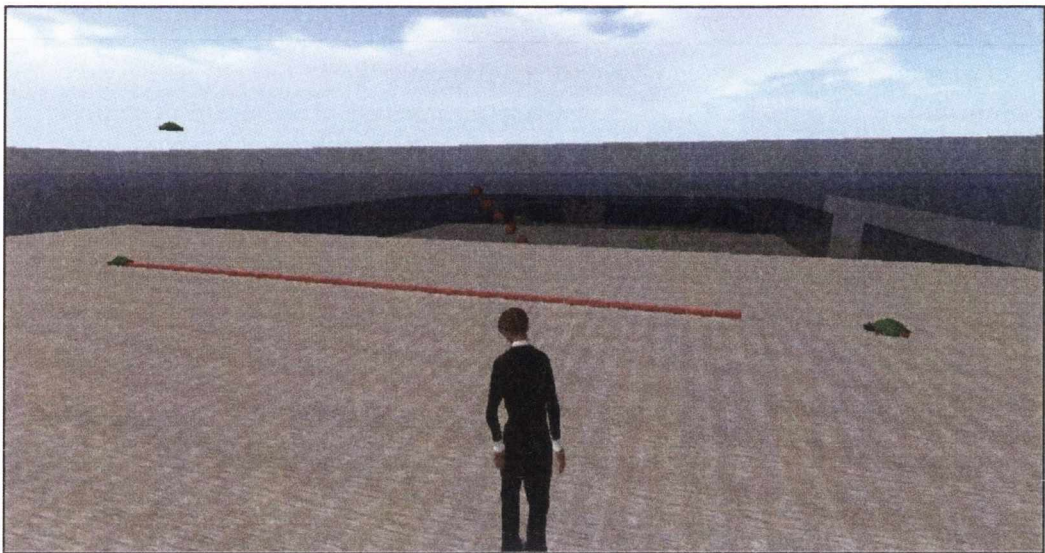


Figure 5.25 Snapshot from participant reflection: "An empty space, me and my virtual partner"

While each groups' artefacts utilised the almost infinite height of the learning spaces, few identified it as a particular advantage or disadvantage in the design process. By comparison, in the code **influence of presentation space**, the size of the construction space did influence constructions: *"the space was very very big, and we did feel like, you feel like you want to fill it, and you can see we put that wall there, erm, just to get the sense of it being filled"*.

Design

The design process for the installation began with **exploring** and generating **initial ideas**, followed by **development**, **planning** and construction. The majority of groups described returning to each of these stages in the design process several times over the four weeks.

Exploring how to use SLurtles and what could be created with them helped learners to generate ideas. This exploration was supported by the ease with which learners were able to engage in construction through the SLurtles, discussed in the following sub-section (5.6.2). To support the planning and construction process two groups described using *"paper and pen to map out"* their ideas.

The sense of inhabiting the learning space via an avatar was described by several participants as supporting the development of **initial ideas**, construction and development of the artefacts created by the groups. For example in one reflection a participant noted: *"It was within the*

virtual space that we formulated the decision of what to make, something we had struggled to achieve in the offline world. I wondered if being immersed in the virtual space, while contemplating the possibilities, had helped in arriving at this decision. We were now immersed in the space, getting a sense of its scale and depth, and watching other installations beginning to take shape. I think this helped clarify a few ideas we had brought to the space to discuss and brainstorm. In a manner of speaking, being immersed in the space helped us realise the possibilities."

As highlighted in the previous category 'Learning environment', the platforms influenced the design of the final artefacts. This was in part due to the public nature of the learning environment which is discussed in the following sub-category 'Public'. In addition the **prim count** was considered by some to be a restriction and influenced final designs. There was no evidence that the amount of space available to each group limited any of the designs, although as previously noted some groups felt a need to 'fill' the 40 x 40 metre space available to them.

Despite experiencing some frustration with coding, learners expressed an often surprising sense **of achievement** in their final artefact: *"the sense of achievement at finishing the project is something I underestimated"*. This achievement was attributed to various forms of motivating factors, discussed in the sub-category of 'Motivation' below, as well as the ease with which they could use the SLturtles: *"definitely will use it again because it was so great you could actually build stuff like that"*. Although one participant expressed **disappointment** as *"It didn't look as perfect as I wanted it to"*, she also stated: *"I think it worked out fantastically"*.

Public

'Public' is a sub-category, of importance to both the learning environment and design. As previously described, while the island used for the learning experience was a private space to address ethical concerns, each group's platform was accessible to every member of the class and this influenced both the learning experience and the final designs. For example, several participants stated that they got their ideas for certain aspects of their design from other groups. This is strongly linked to the sub-category of 'Motivation' which (as earlier shown in Figure 5.24) influenced the design of artefacts.

Within the **walls** of each platform a gap provided an entry/exit point for avatars travelling to the platform by foot. The design of several groups' artefacts incorporated this gap, placing a scripted door or 'welcome mat' (Figure 5.26). However some participants, in both chat logs and interviews, described feeling that this change to the original design of the learning space was detrimental to the otherwise public nature of the learning experience: *"we noticed some doors*

going up on the spaces, erm, and we thought that was quite, I don't know, well, a bit odd to be honest ... there almost seemed to be some sort of guardedness about individual projects, and so doors started to appear across some of the entrances to some of the spaces, and erm, I thought that was funny, I thought it sent out a message".



Figure 5.26 Welcome mat and scripted door at entry/exit points.

As described in Chapter 3, the edge of each space was marked by a semi-transparent wall. These **walls** were designed to prevent avatars falling off their platform whilst allowing learners to view other groups' spaces. One participant described wanting to be able to block their view of other groups' spaces at a distance: *"Partly, I put the poster boards up to block out, as I call it, Vegas, that's next door. It's just so busy with so much going on I felt I had to block it out"*. However most participants described being able to see into other groups' spaces an important part of the learning experience: *"made complete and absolute sense that you would have transparent walls because you were building something in a constructionist environment, where, because it's public there is more emphasis on people to actually do it and make it good"*.

Represented as an avatar within the learning environment, learners experienced a sense of presence within a public space. Several participants stated that at times they wished they could be **invisible** in the learning environment: *"at times when you're kind of under pressure it didn't, it was less convenient that you couldn't make yourself invisible, just to kind of say I'm not here."* Despite this, learners described the presence of avatars as supporting the learning experience. Seeing other avatars in the same space reduced perceptions of loneliness and supported collaboration between groups: *"it helped not knowing you were the only one, you weren't the only one in there. Do you know? And I suppose like you'd see other people there and you could ask other people for help or advice or how to do this or how do you do that? Or vice versa. So it was great, that kind of way"*. Observing and communicating with other avatars in the public learning environment also supported learners' sense of achievement: *"I came in one time*

during the assignment and there was somebody playing the piano and I thought 'now that's great'".

Motivation

The sub-category of 'Motivation' focuses on the external and internal motivations behind the design of the final artefacts. As described above, the public nature of the learning environment had a significant influence on the design of the artefact.

Knowing that other learners could see and interact with their artefacts throughout the four weeks **influenced the design** process including idea development and construction of the artefact, as noted in one reflection: *"A piano will provide an engaging and fun experience for the user through its interactivity."* In another example, although they had nearly completed before the end of the four weeks, one group wanted to be able to show the class something they wouldn't have seen prior to their class presentation: *"I don't want to have it completely done until the day before the presentation because I wouldn't want them to go through it."*

Due to the public nature of the learning environment, learners described *"looking at other people's work, and you realised, oh, you can do this as well, you know, or other people have used that so let's have a go"*. This realisation **influenced the design** of several artefacts; yet there was no evidence in the artefacts of simple copying of programmes as indicated by the variety of trees created across groups in Figure 5.27.

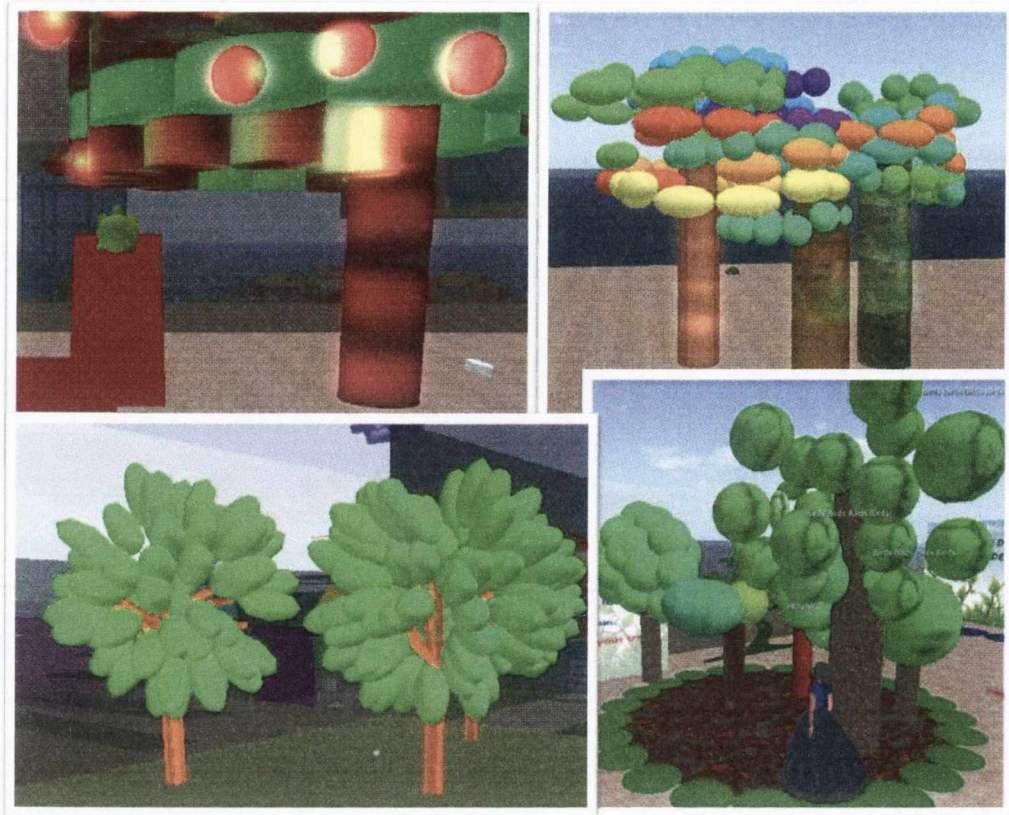


Figure 5.27 A variety of trees created by participants using SLurples

Several participants described in their reflections and interviews, feeling motivated by a sense of **fun** and excitement. As one participant noted in their reflection: *“A sense of excitement was definitely a motivating force”*, while another participant stated in their interview *“it didn’t actually feel like an assignment at times, you kind of felt guilty that you were having, doing this because it felt like fun”*.

With a sense of fun came **challenges**. While several participants described the challenges and sense of satisfaction in programming the SLurples, one participant described being challenged by their partner through the construction process: *“we enjoyed kind of pushing, you know, kind of pushing each other on every kind of step in it”*. These challenges were considered valuable and encouraged learners to further develop their existing ideas: *“so that was a good thing then, that it did feel like something that was worth doing because it was fun and it was interesting. So, erm, I think because of that our ideas did develop and we were willing to try new things, whereas if it was something that we found was a chore to do we just would have left it, and said OK, we’ve enough done to tick the boxes and that’s it.”*

Socialising

The learning environment provided opportunities for learners to socialise. This typically occurred when learners visited other groups' platforms. Whilst this was described as supporting the learning experience, it added pressure for some and others avoided it. This section focuses on the sense of co-presence and the code **etiquette** which was a particularly common code across interviews.

As previously mentioned in the sub-category of 'Communication', avatars supported work related communication within the group. Across interviews avatars were also described as supporting informal communication between participants. Only one participant described not communicating with avatars other than his partner: *"I deliberately stayed away."* For most participants the avatars supported and encouraged social communication: *"they popped up and then I'd go over to them, just quick chitchat, how you getting on, kind of. So yeah, seeing, it was seeing, where as normally, if you were in a different environment. You would know that they were there, like in Google. But you wouldn't feel the same requirement to go over to them. Right? You would know that they were there and you can chat to them. But this was, you needed to go over to them"*.

It is in this informal communication setting in which avatar presence in a space evoked a need to follow a perceived etiquette. Some participants were frustrated by the *"rudeness"* of others, whilst others did not wish to appear rude: *"Erm, I, because people type slow. And, you feel like you kind of have to sit there, and kind of pay attention"*. As shown in the following interview quote, due to the features of the technology it was not always clear if a participant was deliberately being rude or not: *"a few times I'd be talking to him, and there'd be nothing coming back and I'd be thinking. Is there something going on with his computer, or is he being kind of rude today. You know, you just kind of staring at, and then he'd get back."*

The sub-category of 'Public' describes how each avatar could freely move in and out of any groups' space and as a result some learners expressed a desire to become **invisible** in their own space. Social interaction, whilst alleviating a sense of loneliness, could add **pressure** *"see I did find it frustrating, I was saying I was lonely over here but a lot of people kept dropping in to visit, and you're kind of trying to get things done, and they would mostly just use the text tool because it was, you know, it was good and it was nice and it was fun, and I wish I had more time to chat, but sometimes you felt rude, like you couldn't ignore the text because it was there, so you had to have a chat, but you'd be awful busy and kind of feel like, go away."*

5.6.1.4 Learning

The final category is ‘Learning’ (Figure 5.28). Over the course of the four weeks there were two re-occurring learning episodes identified by the participants: learning for the learning experience; and learning through the learning experience. Within this category how learners gained their new knowledge and understanding is also explored.

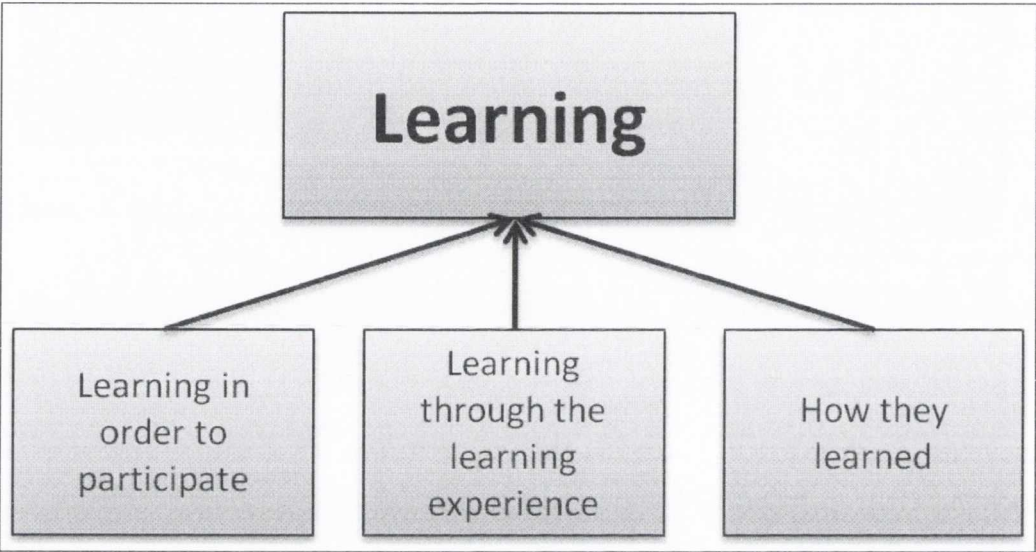


Figure 5.28 Representation of 'Learning' category

Learning in order to participate

In the first type of learning episode, learning focused on *Second Life* specific skills necessary to engage in the learning experience. These included how to control an avatar’s movement and how to use the camera controls, which were identified as barriers to engagement. However other essential skills were not identified as barriers. These included learning how to programme with S4SL, how to create a script in *Second Life* and import the S4SL script. As described by one participant these were the “mechanics” of using SLurtles.

Learning through the learning experience

Having acquired some basic skills during the workshop sessions, several participants described learning about the potential of S4SL and SLurtles by engaging in the construction of their artefact, as shown in this reflection comment: “I believe that I learned much more about the Scratch programme in the first hour of building the first section of our installation than I did during the entire in college lab / lecture sessions. This is not a criticism of the learning experience delivered during the in college sessions ... Rather, it is an observation into the level and depth of learning that seemed to occur when applying it to a vision”.

By engaging with SLurtles to create an artefact, learners identified that they had learnt about: reflection and its role in problem solving; programming concepts and processes; 3D graphics; themselves as learners, collaborators and teachers; collaborating at distance; and pedagogies introduced on the course, in particular constructionism: *"the greatest learning experience was the learning in relation to the process; by being an active participant in the process, while exploring the process, and subsequently reflecting upon the entire experience."*

How they learned

As noted in interviews, the task and having a partner were the two main aspects of the learning experience that supported learning: *"you are there to collaborate on a very challenging operation, which is outside of your comfort zone and in doing that you're going to learn extraordinary things about yourself. By working with other people that will give you a completely new perspective on the task itself. And you yourself, and perhaps learning itself."*

The task required learners to create an artefact using SLurtles. As demonstrated in the sub-category 'Thinking', by engaging with SLurtles and engaging in **reflection**, participants learned programming concepts and processes.

Those that worked with a partner who had some programming experience described their partner as supporting their learning. For example, having *"somebody there with more knowledge than myself, I suppose to kind of scaffold the learning process"* was noted by several participants as an important aspect of the learning experience.

In groups with no experienced programmer, learners described their experience as *"better because we were both on equal, equal ground, starting off"*. As a result they described **learning together**. However as noted in 'Imbalance' in 5.6.1.2, where there was a knowledge imbalance, groups needed to identify the imbalance before they were able to learn from or with each other.

Although most groups reported building knowledge together, one participant described gaining little from their partner after the initial design had been agreed. As a result she visited other groups and found support from them. **Visiting other groups'** learning spaces and interacting with avatars outside their own group was a valuable learning opportunity identified by several participants. As a result learners were able to explore alternative ideas and were motivated to develop their own artefacts. In general the learning environment was described as supporting learning, as illustrated in this reflection: *"I felt completely immersed in the virtual world and as a result I constructed knowledge based on my interactions and experiences in the virtual world (conversing with other avatars: exchanging knowledge, interacting with SLurtles and Prims)"*.

5.6.2 Phase 2: Theoretical propositions

5.6.2.1 SLurtle design

Following the identification of categories and sub-categories, the second phase of data analysis began with a focus on the constructionist principles of low-floor, high-ceiling and wide-walls which underpin the SLurtle design. There was substantial evidence to suggest that each of these was achieved from the interviews, reflections and artefacts, as well as the researcher generated codes.

SLurtles were widely described by learners as easy to use and thus providing them with a low-floor tool. However ease of use did not constrain the variety or complexity of artefacts created. For example, one group with no previous programming or virtual world experience created an eclectic set of artefacts which they described as demonstrating their developing understanding of programming over the four weeks (Figure 5.29).

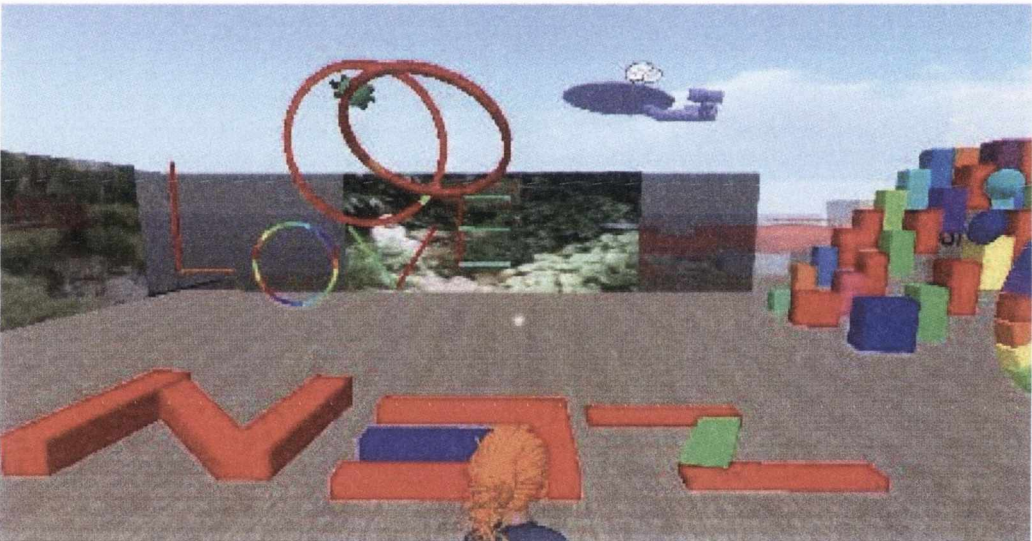


Figure 5.29 Creating a variety of objects as understanding develops

Each of the twelve groups created very different installations, illustrating the wide-walls that the tool supported. For example, other installations included a piano, assault course and enchanted forest (Figure 5.30). Importantly the variety of constructions was described by participants in interview and reflections as supporting learners in creating something that was of personal interest, a key feature of constructionism.

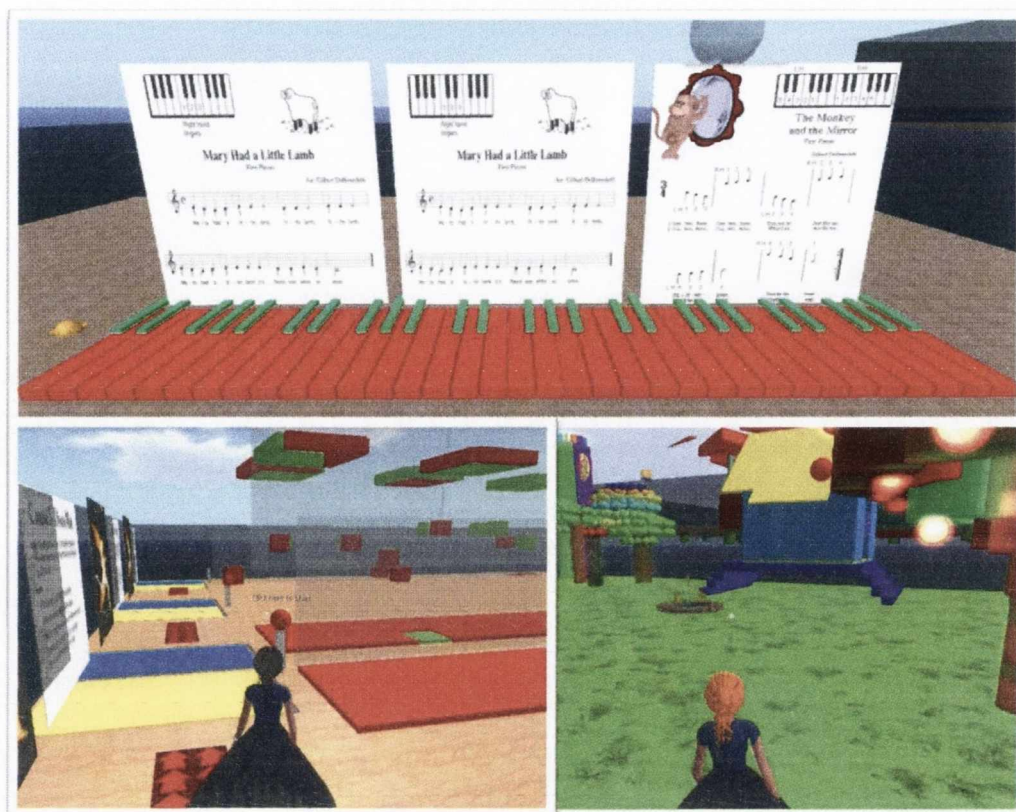


Figure 5.30 Artefacts created by learners. Top: Piano. Left: Assault course. Right: Enchanted forest.

However at the beginning of the activity it was not obvious to learners what they might create. As one participant describing his groups' installation said: *"it was so obvious how to use it (SLurtles) ... but like what we could actually build wasn't obvious ... it was a lot more intricate and complicated than that and people put a lot more effort in than just, you know, doing circles or whatever"*. This quote also highlights that while there were simple constructions that could be made; learners were able to explore the creation of increasingly complex artefacts. As the constructions became more complex so did the programmes used for construction, illustrating the high-ceiling.

While some objects created by different groups were similar there was evidence of multiple solutions to creating each object. For example, as previously highlighted, several groups created trees as part of their installations (Figure 5.27) which one participant described as requiring their most complex programme. As such the potential complexity of constructions appears to have supported the variety of constructions that were created.

There were however differences of opinion amongst participants as to whether the types of blocks that could be created by SLurtles constrained the final artefacts or not. For example one participant noted that while the simple blocks supported their first experiences of building, they

felt the aesthetic of their final design was constrained by the shapes available. While the type of blocks may have limited the appearance of the final artefact there was no evidence to suggest that they constrained the variety or complexity of constructions for this or any other participant.

It was also suggested that S4SL limited what could be created with SLurtles. One participant described the limited complexity of code that could be created in S4SL as limiting their final artefact. However in an interview, one of the experienced programmers stated that he had not been able to reach the limits of the programming environment.

5.6.2.2 Constructionism

As described in the section on data analysis (5.5), to explore constructionism in action and support the generation of research questions, *a priori* codes were used to analyse both the original data and researcher generated codes and categories. The *a priori* codes were comprised of the features of constructionism identified in Chapter 2 and used to underpin the design of the learning experience in Chapter 3. This section presents the findings of the analysis using the *a priori* codes as headings.

Construct personally meaningful artefacts

All groups created personally meaningful artefacts. This was facilitated by SLurtles and the design of the learning experience in which learners were given an open task which required them to create an interactive installation using SLurtles. This provided learners with a wide scope as to what they could create and allowed them to pursue their own interests, providing them with an opportunity to create personally meaningful artefacts. For example one group was comprised of two second level teachers one of whom taught physical education. Using this as a starting point they developed an obstacle course as their artefact, designed for new users of *Second Life* to allow them to practice and develop control of their avatar which both learners had experienced difficulty with at the start of the project. At the start of each section of the course instructions are given, in Figure 5.31 the task is to fly in and out of the 'hoops' which are green. If the avatar touches the side of the hoop the side turns red. This activity was designed to allow avatars to challenge each other, where points could be given for each remaining green obstacle.

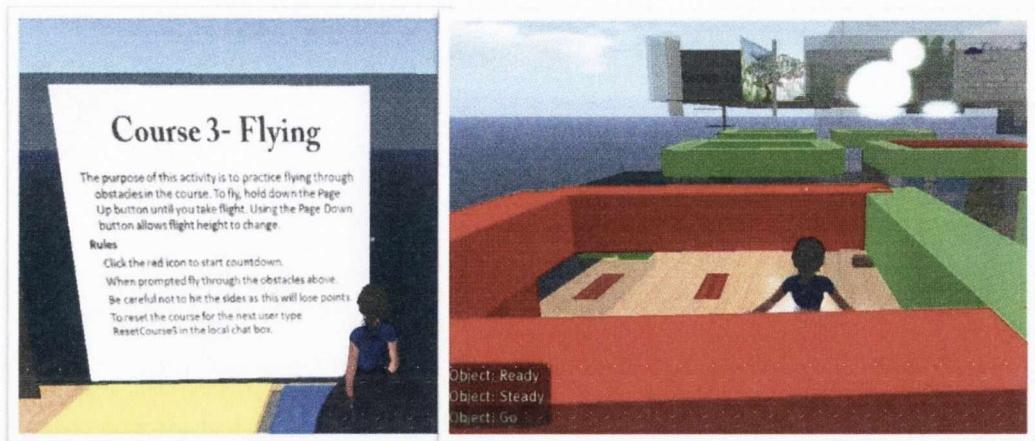


Figure 5.31 Snapshots of the obstacle course.

As noted in reflections, some groups created unfamiliar objects which they learned about through the construction process: *“Regarding the piano both of us would not have been very familiar with the piano and thus learned about the different keys and the positioning of those keys.”*

Actively explore, test and extend understanding

The construction of artefacts provided learners with many opportunities to actively explore, test and extend their understanding. Codes within the category ‘Thinking’ (5.6.1.1) provided a particularly rich source of data on this. References coded at **exploration** were often coded at **play** or **fun**, whilst **testing** was linked to **frustration** and **reflection**. It is interesting to note that exploring, testing and extending understanding were also closely linked to learners describing the movement of SLurtles, as shown in the category ‘Thinking’ and the following reflection: *“The fact that I could get immediate feedback from watching the actions of the SLurtle allowed me to evaluate what the script was doing in comparison to what I wanted to happen. I found this visual feedback allowed for an accelerated understanding of what was happening within the script than if I had to think in the abstract as to what was happening.”*

Activities which led to exploring, testing and eventual extending of understanding were often prompted by **problem solving**, a particularly strong code in ‘Thinking’. Learners described beginning the learning experience by exploring what SLurtles could do (the code **SLurtles exploring** in the category ‘design’). Others described developing their understanding of mathematics and programming by constructing complex artefacts, such as the trees shown earlier in Figure 5.27.

Opportunity to programme

A lot of the active exploring, testing and extending of understanding focused on learners' understanding of programming, as noted in the sub-category 'Programming' (5.6.1.1). There was evidence across all data sets that all learners engaged in programming with S4SL in order to create SLurtle blocks and add interactivity, with particular support from the codes within the sub-category 'Programming'.

Throughout the interviews there was evidence of learners actively engaging with SLurtles and S4SL to create their interactive installation, however this was not without difficulty as noted in the sub-category 'barriers'. While learners could observe the actions of others in *Second Life*, they were unable to observe the construction of programmes in S4SL. As a result learners spent a lot of time sending copies of the code they had written between each other whilst problem solving.

Shareable artefacts

Through the design of the learning environment, all learners could visit the artefacts of others, thus sharing in what they had created. While a few learners did not wish to visit other groups nor for others to visit them, most learners took the opportunity to explore the artefacts created by other groups at various points during the learning experience. Thus learners shared complete and incomplete artefacts.

Although the learning environment was designed to be a publicly accessible space to support the construction of public artefacts, some groups created scripted doors (Figure 5.26) which others inferred as an attempt at privacy as shown in the following quote from a chat log:

"Participant 5-2-2: i must check it out

Participant 6-2-1: they have actualt put a block at the door now!

5-2-2: wanna try the bowling lane?

5-2-2: block?

5-2-2: why?

6-2-1: not sure, so nobody can get in maybe? yes i would love to try it, then i will let you get back to your work

5-2-2: why wouldnt they want people getting in?

5-2-2: *i must check out the security measures!*

6-2-1: *don't know! it says 'welcome' over the door! bit of a contradiction :D (sic)*

Despite this perception by some, each space remained publicly accessible and most groups were keen to have other groups visit and explore their artefacts. For some this even became an important design consideration: *"trying to put notes or boards at the back for people to see to give them ideas of what to play, to help them start off, if they never played the piano before"*. In addition, by sharing their constructions groups gained feedback on their artefacts from others, while some groups were influenced to further develop their artefacts after they had explored other groups' artefacts.

It is interesting to note that while learners generally welcomed visitors to their spaces, some stated that they would have liked to have a private area to test S4SL scripts. However this was most often attributed to the previously mentioned issue around deleting objects *"...kind of like a practice run to see if it would work out instead of letting him do it and then it was all a load of delete and if it doesn't work out."*

While the SLurtle constructions were easily shared between groups, the programmes implemented by SLurtles to create the artefacts were inaccessible to those who had not created them. In addition, the programmes which made the artefacts interactive were inaccessible due to the permissions system. Finally, as highlighted above, learners were unable to share in the development of programmes in S4SL. Thus the SLurtle constructed artefacts were easily shared but not the programmes.

Bricolage

Bricolage refers to the development of an artefact over time (Papert, 1991) and was evident across data sets. Figure 5.32 shows two constructions described as *"early versions"* in one of the group reflections. The final artefact, shown earlier in Figure 5.21, reused the red building. This is one example of the incremental construction process described by many participants.

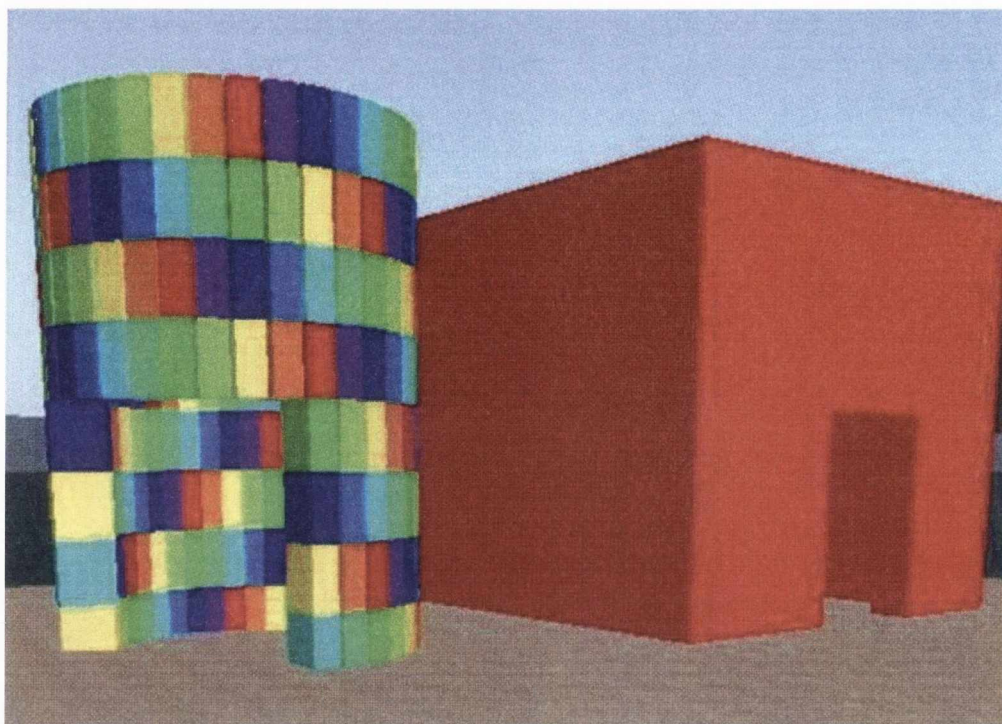


Figure 5.32 Early constructions

As previously described, groups developed their installations throughout the four weeks as their knowledge and understanding of programming developed. Some initially focused on a “centrepiece” and then decided they needed to fill their remaining space, as described in the ‘Learning environment and design’ category, while others were influenced by the artefacts created around them.

Although most groups described their artefacts as developing and changing over the four weeks, a few stated that their original ideas did not change throughout the process. However one such group stated in their reflection that the colour of the SLurtle blocks available to them influenced the final appearance of the artefact: *“Unfortunately black or white do not seem to be colours supported by Scratch for SL. Therefore our piano will be unique and will consist of a set of red and green keys.”* In addition, on seeing other groups’ installation spaces they decided to add objects to fill their installation space. Thus, while the overall idea or theme for their space may not have changed, components of the design did, suggesting that the design developed over time.

In-situ

In situ refers to the location that learning takes place. Most learners described in their interviews or reflections undertaking problem solving and developing their understanding

within the virtual rather than physical world. However some described 'ending up' using pen and paper to solve some programming problems. The virtual world was also the place where ideas emerged and were developed. Learners were also aware that their virtual learning space was a shared space, as noted in one reflection: *"We were immersed in our own learning and construction, while surrounded by the progress of the learning and construction of others."*

Although operating in a virtual space, learners identified SLurtles and the objects they created as objects they were able to interact with, although still recognised as intangible: *"In the literature, there are many references to the making of tangible objects in the real world and the social nature of the process. It was interesting that our experience, a constructionist experience, involved the production of what many people would consider an intangible object, created in a world that many people would consider an anti-social space, not of the real world."*

For some, although they were aware that the objects were intangible they viewed the learning environment and objects as **physical**: *"it's not like a website, because it's 3-D, it's physical, it's got surroundings to it"*. However others described this experience as mediated through their avatar and as a result they were not as close to the objects as they would be in the physical world: *"I also recognise that my learning is stronger when I get to experiment with building objects in the real world and the SL has provided me (to some extent) with this opportunity. I do prefer to directly experience the objects rather than through an avatar."*

'Invisible' technology

Papert (1980s) describes wishing the computer to be 'invisible' during learning experiences, much like a pencil is invisible when writing, *"The computer becomes just an instrument"*. Thus the computer becomes 'invisible' when the learner does not need to focus on how to use the software or input devices and instead focuses on the learning content. Although the researcher generated codes demonstrate that learners began by learning the skills required to use S4SL and *Second Life*, as they engaged in the learning activity these skills became more familiar as did the virtual environment: *"I actually found it quite easy to forget that you were actually, you know, in the zone of a virtual world"*. It is interesting to note that while many skills became familiar some learners expressed ongoing frustration with transferring scripts from S4SL to *Second Life* and back again. This resulted in S4SL being reinstalled as a temporary fix. As a result it may be suggested that for these learners the software did not become invisible.

Collaborating on constructions

Collaboration was self-reported by the learners and developed into the *in vivo* code **collaboration**. In their reflections each group reported collaborating on the construction of

their artefact and as shown in the sub-category 'collaboration' there is evidence of collaboration taking place during the learning experience both within and between groups. However the sub-category 'imbalance' provides evidence that such collaboration may not have occurred throughout the learning experience, yet once an imbalance was addressed by a group they were able to collaborate on constructions.

As artefacts were constructed in a publicly accessible space there was an opportunity to discuss constructions and to share code, as noted in the *a priori* codes **opportunity to programme** and **shareable artefact**. This occurred both within and between groups, as noted in one interview: "*I'd normally wander over, see how they were getting on, see what was what, was there anything I could help with*". While learners shared and discussed programmes, there was no evidence of learners simply copying the code created by others, as highlighted in the sub-category 'motivation'.

Although learners recognised that artefacts were shareable with others in their class they were also aware of the barriers to sharing scripts and SLurtle blocks within their group. The **Second Life permission** system was identified as a barrier to the learning experience, limiting the sharing of and collaboration on scripts. Despite this barrier learners described collaboratively constructing their artefacts and found alternative approaches to **sharing scripts**.

5.6.2.3 Perceived educational affordances

The previous sub-section presented the findings of the analysis of constructionist features during the learning experience. This section presents the findings of the key perceived educational affordances of *Second Life* identified in Chapter 2, which were used as *a priori* codes to analyse the data.

Creation of persistent objects: Construction, programming and persistence

The perceived educational affordance of the 'creation of persistent objects' was leveraged throughout the learning experience. To aid analysis, this perceived educational affordance was broken down into its three constituent parts: construction, programming and persistence.

There were many examples across the data sets of learners being "*able to create, build and delete work*" throughout the learning experience. Learners used SLurtles to build and rebuild artefacts as they explored and tested their understanding, picked out by several participants as an important feature: "*being able to erase and start all over again is great*." Participants used SLurtles to construct objects, however to remove them they used the *Second Life* tools, as illustrated in this excerpt from a chat log: "*now to delete my mess... i presume i can select all the blocks using the build button? (sic)*". As objects were 'non-physical' they could be created

at any height and would stay in that position: *“at one stage it became easier to put the SLurtle up a height and then execute the commands and look at them from there.”*

As described in the sub-category ‘Programming’ and the *a priori* code **opportunity to programme** there were many examples of learners using S4SL to programme SLurtles and the installations. Although the task required learners to use S4SL, It is interesting to note that there was no evidence of any participant using *Second Life*’s programming environment, whether experienced programmer or not.

Persistence was an important perceived educational affordance as, together with the public nature of the learning environment, it allowed learners to watch *“other installations beginning to take shape”* over time and without the person constructing the artefact being online. It also provided an opportunity for learners to gain feedback from others and allowed learners to contribute to the construction of their artefact when their partner was offline.

Flexibility

Second Life afforded flexibility in terms of both time and location of learners’ engagement. Chat logs demonstrate the variety of times of day that learners logged into *Second Life*. Interviews show that learners were able to collaborate at distance from their homes or in a face-to-face setting depending on their requirements, synchronously or asynchronously.

Embodied social presence

Learners identified a sense of presence in the learning environment and co-presence with other learners through embodiment in their avatars, as discussed in the category ‘learning environment and design’. The sub-category of ‘socialising’ also highlights that the three-dimensional environment, avatars and communication tools also supported socialising between groups within a public environment.

Immersion

Five participants explicitly stated in reflections or interviews that they felt *“immersed”* in both *Second Life* and the learning experience. There was no evidence to suggest that any of the other participants did not feel a sense of immersion. Learners who identified being immersed in the *Second Life* environment identified the three-dimensional landscape, avatars and communication tools as supporting the sense of immersion: *“the avatar’s presence and the avatars capability of being able to talk is a further immersive element”*.

Participants identified several features of immersion such as not noticing the passage of time as they engaged in programming the SLurtles. As noted in one reflection: *"time doesn't seem to exist there and one can get so immersed in the experience that one loses track of time"*.

Another feature of immersion identified in one reflection was the learner losing awareness of the computer interface: *"Looking back, its quiet incredible to think that the vista for all this activity was a very narrow laptop screen ... For the large part it was very easy to be fully immersed in the experience. It was easy to forget just how narrow this vista was, and even easier to feel absorbed by its seemingly eternal depth."*

Collaborative learning

As shown in the earlier findings, there was evidence of both collaboration and learning taking place during the learning experience. However there was much less evidence of collaborative learning. Where a programmer and non-programmer were paired together, learning tended to be one-way and this could be constrained by the communication tools available in *Second Life*: *"I found it very difficult to convey my knowledge across the medium of chat"*. Those that described learning together often described the inability to observe the other person's screen as limiting collaborative learning.

5.7 Discussion

The implementation of a SLurtle based learning experience described in this chapter provided an opportunity to undertake an exploratory case study with the following research aims:

- Explore SLurtles in action with learners
- Explore the learning experience in action with learners
- Refine in-world data collection
- Generate research questions for future research

This section addresses each of these aims in turn. Beginning with SLurtles, each of the following sub-sections critically examines the findings in order to answer the guiding research question posed at the beginning of the chapter. Several lessons were learned about conducting research in NGO-VWs through the implementation of this case study and these are discussed and implications for the second case study are drawn in the sub-section on in-world data collection (5.7.3). This section concludes by discussing several areas for future research (5.7.4) in order to generate and refine questions for the second case study.

5.7.1 SLurtles in action

Underpinning the design of SLurtles are the concepts of a low-floor (easy to use), high-ceiling (powerfully expressive) and wide-walls (support the creation of a variety of artefacts), concepts

central in the design of constructionist tools for learning. While design features such as persistence can be programmed into objects in-world, there was no way to be sure that SLurtles would provide learners with a low-floor, high ceiling and wide wall tool until used by learners. Therefore, while maintaining the broad exploratory aim of this case study, the following research question was posed to focus discussion of the findings:

- Do SLurtles provide learners with a pedagogical tool with which to engage in constructionist learning in virtual worlds?

In order to answer this question, four sub-questions were posed:

The first sub-question focuses on whether or not SLurtles provided the learners with a low-floor construction tool, which was the initial motivation behind the construction of SLurtles. The findings demonstrate that, yes, SLurtles are easy to use construction tools without which learners stated they would not have been able to achieve such complex artefacts. There was, however, an initial skill barrier described by some participants when transferring a script from S4SL to SLurtle and this limited their initial engagement with SLurtles. Although there was only evidence of this from two interviews, it is unclear how many other participants may also have experienced this barrier but not reported it. While this may raise the floor for initial engagement with SLurtles, the creation of objects using the 3D object modelling tools in *Second Life* would, for novices, be a much higher barrier to entry.

Generic *Second Life* skills and tools were also identified as barriers, in particular avatar movement, camera controls, permissions and communication tools. It is unclear from the findings as to what extent these limited engagement with SLurtles, however once learners engaged in the use of SLurtles these barriers were quickly overcome or became irrelevant. These barriers suggest that there may be some in-world skills that learners need to successfully master in order to initially or fully engage with SLurtles, however there is insufficient data to draw any firm conclusions on this.

The second and third sub-questions consider the high-ceiling and wide-wall concepts of constructionist tools in relation to SLurtles. Again the findings show that SLurtles do provide learners with a high-ceiling and wide-wall tool. Each of the groups created very different installations, suggesting that SLurtles do support the wide-wall concept. There were mixed views on the complexity of the artefacts that could be created using SLurtles. While some considered S4SL or the type of SLurtle blocks limited what could be created, others viewed these aspects of SLurtles as enabling them to create complex artefacts.

The fourth sub-question explores how learners' used SLurtles as part of a constructionist learning experience. The SLurtle character, its clear position and heading together with the blocks it created, provided learners with a focal point through which they were able to gain feedback and reflect on their programmes. Learners were able to quickly engage in using the SLurtles to create objects and explore and test their understanding through concrete constructions.

The limited variety of simple blocks was used to create a wide variety of artefacts of varying complexity, identified as personally meaningful constructions. There was evidence that as constructions became more complex so did the programmes used for the constructions. It is also interesting to note that there was no evidence of the experienced programmers using the in-world programming tool, suggesting that S4SL provided a suitably high-ceiling programming environment with which to programme SLurtles. Due to the persistent nature of the blocks, learners were able to share their artefacts during and after construction. This supported collaboration with their partner and the wider class group.

Within the category 'Thinking' there is evidence of learners engaging in an experiential learning cycle (Kolb, 1984). Although Kolb's model is often critiqued, it provides a useful frame of reference to which the findings in the category of 'thinking' can be discussed. The SLurtle's movement, indicated by its clear position and heading, as well as the SLurtle blocks created, provided the learners with a concrete experience which they could observe and reflect upon. This provided learners with an opportunity to reassess their code asking questions of themselves and their partner including "why didn't it work, or why did it work?" and comparing the outcome to the original plan. This was followed by the redesign of the programme which was exported from S4SL into *Second Life* and implemented by the SLurtle to provide the learner with a concrete experience. The full stages of this process, mapped onto Kolb's model, are illustrated in Figure 5.33.

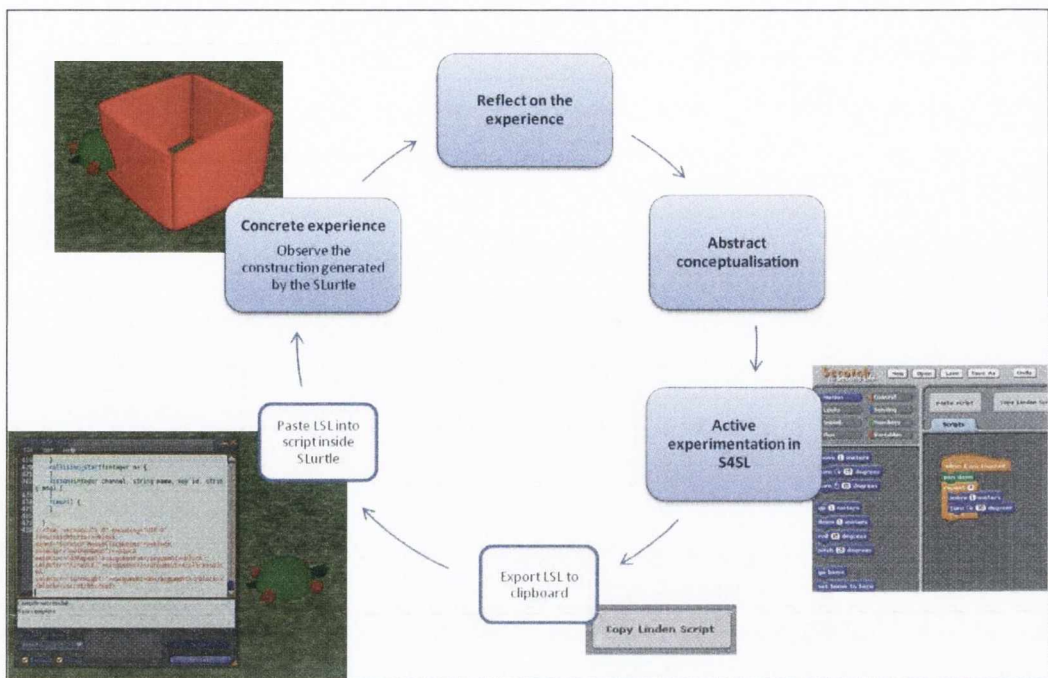


Figure 5.33 The use of SLurtles mapped onto Kolb's experiential learning model

While Hoyles and Noss (2003) may argue that as the learners in this context are not engaged in a microworld they will lose the psychological connection between the abstract code and the concrete output, the findings show that the learners described using SLurtles as supporting the exploration and testing of their abstract understanding of programming through concrete constructions. However as S4SL is currently unavailable within *Second Life*, the disconnect that may result from moving between two programmes could reduce the effectiveness of SLurtles in supporting learners' concrete experience. In addition it has the potential to diminish the sense of immersion experienced by learners and thus the tools learners engage with may not be 'invisible', an important feature of constructionist learning experiences (Papert, 1980s; 1991).

The process of exporting the code from S4SL into the SLurtle was also identified as an initial skill barrier and demonstrates the lack of 'bidirectionality' (Hoyles, Noss & Adamson, 2002) between code and SLurtle. While this lack of bidirectionality also supports the notion that this learning context does not provide a microworld for learners, it is important to note that this was not the aim when developing SLurtles, but rather to create a low-floor construction tool. To address these issues, further development of S4SL to provide a representation of the S4SL environment in *Second Life* may be necessary.

Despite some limitations, SLurtles clearly supported learners' creation of artefacts as they engaged in the constructionist learning experience. While not easily achieved, learners began to explore more complex constructions over time. Exploring, testing and extending their

understanding they gained a high sense of satisfaction when they were able to programme the SLurtles accurately. SLurtles engaged learners in thinking about programming by providing them with a programmable low-floor tool for the construction of a wide variety of personally meaningful and shareable artefacts within the NGO-VW *Second Life*. Therefore the answer to the main research question is yes, SLurtles provide learners with a pedagogical tool with which to engage in constructionist learning in NGO-VWs.

5.7.2 Learning experience in action

Overall participants enjoyed and engaged in the learning experience. The task was both challenging and fun and as a result was considered by the learners to be worthwhile. Learners expressed a sense of achievement in the artefacts they created. The module aimed to provide learners with experience of programming and constructionist learning and participants identified both these and other learning outcomes.

To explore the learning experience in action the findings of the constant comparative analysis and analyses based on the *a priori* codes for constructionism and perceived educational affordances are discussed. The findings of the constant comparative analysis provide a rich description of the learning experience based on the subjective experience of the learners as interpreted by the researcher, while the use of *a priori* codes provide a focused analysis with which to answer the research questions:

- Are learners able to engage in constructionist learning?
- Are the perceived educational affordances utilised by learners to support their engagement?

The findings of the second phase of the data analysis demonstrate that learners engaged in each of the features of constructionist learning over the course of the learning experience. Similarly the perceived educational affordances were found to support learners' engagement. However the findings do not identify any causal relationships between the perceived educational affordances of the technology and the features of the pedagogy.

Drawing together the findings from all three sets of data analysis and the answers to the research questions, this section considers the proposed alignment of the features of constructionism and the perceived educational affordances of NGO-VWs as shown in Table 5.7. These are discussed under the headings of the features of constructionism. Avatars were found to be a cross-category theme appearing to influence several aspects of the constructionist learning experience and so are discussed separately at the end of this sub-section

Table 5.7 Alignment of perceived educational affordances of non-goal orientated virtual worlds and the features of constructionism (Table 2.5)

Constructionism	Perceived educational affordances	
Construct personally meaningful artefacts	Creation of persistent objects	Construction
Actively explore, test and extend understanding		
Opportunity to programme		Programming
Shareable artefact		Persistence
<i>Bricolage</i>	Flexibility	
<i>In-situ</i>	Embodied social presence	
'Invisible' technology	Immersion	
Collaborating on constructions	Collaborative learning	

Construct personally meaningful artefacts to actively explore, test and extend understanding

The findings show that the learning experience provided all learners with an opportunity to construct personally meaningful artefacts and through their construction learners were able to actively explore, test and extend their understanding of programming and mathematics. While SLurtles were shown to enable learners in the construction of their artefacts as well as the development of their understanding of programming and mathematics, there were other barriers to the construction process that emerged.

As discussed in the previous section, some generic *Second Life* skills and tools were identified as limiting learners’ initial engagement with SLurtles. While avatar movement was an initial barrier to engagement identified by some, avatars were found to support communication in both group and social settings. Camera controls were also found by some to be a barrier to the construction process. However those comfortable with their avatar, described their avatar as an essential element of the learning experience, particularly in providing them with an opportunity to observe their partner and construct personally meaningful artefacts.

Opportunity to programme

One of the aims of the learning experience was for learners to gain an experience of programming. Although learners were not taught any specific programming concepts there was evidence from artefacts and interviews of learners using and, in their own words, “learning” several programming concepts. Through engaging in the construction of their artefacts via SLurtles, learners were provided with not only an opportunity to programme but also an intrinsic need to engage in programming.

S4SL provided learners with a low-floor tool for programming and while it does not provide every function of the LSL language, those learners with experience of programming were able to create complex programmes through the use of variables. Although learners described S4SL as easy to use, several found the transfer of scripts from S4SL to SLurtles to be an initial barrier. Over time this barrier was overcome by all learners through their continued engagement in the construction of their artefacts with SLurtles. While this barrier may have the potential to prevent learners from engaging in programming and the construction of personally meaningful artefacts, this case study suggests that this barrier is temporary.

As noted in Chapter 2, constructionist learning environments are designed to enhance the most important features whilst removing those that might distract the learner by “muddying” the outcome (Edwards, 1998). While there was no evidence to suggest that the transfer of scripts from S4SL to SLurtles “muddied” the outcomes, this does not mean that it did not happen. By comparison there was evidence that this barrier initially distracted learners, requiring them to focus and learn the process of transferring the scripts, suggesting that the technology was not ‘invisible’ from the start of the experience. As such this barrier may require further research on its impact on learners’ engagement as well as future technical development.

‘Invisible’ technology

Of the three levels of immersion identified by Brown and Cairns (2004), there was evidence of some learners experiencing the third level, total immersion, characterised by the learner being no longer aware of the computer interface. As such the technology became ‘invisible’.

Most learners experienced the second level of immersion, engrossment, in which the controls become ‘invisible’, in other words the learner does not need to think about how to use them in order to use them. However as noted above the transfer of scripts and general NGO-VW skills such as walking, were an initial barrier for some learners which limited their initial engagement in the learning experience. Engagement is the first level of immersion identified by Brown and Cairns (2004) in which participants have overcome these initial barriers and are able to engage in the game or, in the case of this study, the learning experience. Thus, not all learners experienced immersion throughout the learning experience and many experienced different levels of immersion.

It is also possible that by moving between S4SL and *Second Life* the sense of immersion may have been reduced. Faiola and Smyslova (2009) note that a sense of presence within NGO-VWs supports immersion. Removing the learner from the virtual world in which they are embodied as an avatar to the stand-alone application S4SL in which there is no embodiment or sense of

co-presence, may have limited the level and length of immersion learners experienced and reduced the sense of learning *in-situ*. Thus, while learners experienced immersion whilst in-world, supporting the constructionist notion of 'invisible' technology, by leaving *Second Life* in order to programme the SLurtles, the sense of immersion and an 'invisible' technology may be lost.

Shareable artefact

Within the category 'learning environment and design' there was evidence to show that learners were aware that the artefacts they created were shareable both during and following their construction. As anticipated this was supported by the persistent nature of the environment, allowing others to visit artefacts when those that had constructed them were offline, however the public nature of the learning environment was also important. When online, the public nature of the learning environment enabled learners to visit each others' learning spaces to observe and discuss the artefacts, especially their development. The public nature of the environment also supported learners' social interactions within the wider group.

All constructions could easily be shared at all stages of the learning experience as each groups' space had a combination of semi-transparent low walls and the access system was used to provide all members of the class access to each learning space. The access system was also used to prevent non-members from accessing the island for ethical reasons described in Chapter 4. However in a different learning context it may be suitable to provide open access to non-members. Alternatively the access system could be used to prevent member avatars from visiting the constructions of others.

As noted in the findings on the features of constructionism, some participants expressed a desire to have a private area where they could test their programmes. While private learning spaces, in combination with opaque high walls and roofs, would allow learners to share only their completed artefacts, this would prevent them and others from engaging in dialogue about the constructions during the construction process. Thus, opportunities for groups to learn from one another during the learning experience would be greatly limited.

While persistence is necessary for artefacts to be shared when their creators are not online, it appears that the access controls, which afford learners either public or private learning spaces, are also important. While Dickey (2011) identifies security as a perceived educational affordance, related to access controls, the findings of this study suggest that it is the public or private nature of the environment rather than security which was important to learners. As such, 'public or private learning environments' is also considered to be a perceived educational

affordance of this feature of the technology. Therefore, this perceived educational affordance needs to be leveraged to provide public learning environments to support the sharing of artefacts during constructionist learning experiences in NGO-VWs.

Bricolage

Papert (1991) uses the term *bricolage* to refer to the development of an artefact over time. Rather than following a pre-determined design, the design of the artefact develops during the construction process. Both construction tools and flexibility afforded by NGO-VWs supported *bricolage*, allowing learners to build and rebuild their artefacts. Thus, learners were able to develop their artefacts from their initial ideas as they gained a greater understanding of programming, the potential of construction with SLurtles and their own ability.

In order to engage in *bricolage*, learners need to engage over a period of time. The NGO-VW allowed learners not only to engage over a period of time but at a time and from a location that suited them.

In-situ

The majority of learners described participating in the learning experience and engaging with other learners 'in-world'. This was clearly supported by the embodied social presence afforded by the learners' avatars. As previously discussed, 'avatar' was a cross-category theme, particularly strong in 'group work', 'learning environment and design'. Together with avatars, the 3D environment and communication tools provided learners with a sense of presence in the environment and co-presence with others. They supported the construction and sharing of artefacts, enabled socialising and supported peer-learning.

Embodied social presence supported learners in participating in the learning experience within the virtual world. Thus, their learning could be defined within a certain context, described by Ackerman (2004) as *in-situ*. Additionally, learners expressed gaining knowledge which could be transferred to other learning contexts.

While many learners engaged in the learning experience within the virtual world, others felt the need to meet face-to-face or to problem solve using pen and paper. Thus they engaged in aspects of the learning experience outside of the virtual world. Therefore the learning context is extended outside of the virtual world and in these contexts is not supported by the perceived educational affordance of embodied social presence.

As highlighted in the previous sections, the use of an avatar appears to have influenced many aspects of the learners' experience of constructionist learning in the NGO-VW. The avatar

supported learners' sense of embodied social presence and immersion within the learning environment, allowing them to visit, share and discuss constructions *in-situ*. They supported a limited observation of partners and enhanced the sense of being in a public space. Although a few participants described identifying themselves through an avatar as uncomfortable, others found it liberating, which resonates with the literature (Chapter 2). Those comfortable with their avatar, described their avatar as an essential element of the learning experience, particularly in providing them with an opportunity to observe their partners and construct personally meaningful artefacts. While the embodied social presence and engagement in the learning experience was found to support collaboration, it did not necessarily support collaborative learning which was also limited by other factors.

As Taylor (2002) notes, it is impossible to forget that others are present in a virtual world and similarly it is impossible to become invisible in *Second Life*. Thus the avatar provides an outward signal of being present in the virtual world. Many learners described this as an advantage over typical assignments on the course, providing opportunities to learn with and from their peers. Yet others found that the appearance of an avatar could be distracting, invoking social norms that they felt obliged to follow, and at the extreme it had the potential to limit learning.

Collaborating on constructions

As previously discussed; avatars, communication tools and the 3D environment were found to afford learners an embodied social presence within the virtual world. This embodied social presence and engagement in the learning experience supported collaboration on constructions. However there was limited evidence of collaborative learning which was theoretically aligned to collaborating on constructions and anticipated to support this feature of the pedagogy.

Gamage et al. (2011) link the perceived educational affordance of co-presence to Dalgarno and Lee's (2010) collaborative learning in NGO-VWs. However it was also noted that collaborative learning is a form of activity, in which features such as communication tools and avatars, in combination with an activity, afford collaborative learning.

There was substantial evidence of learners engaging in the learning activity, using communication tools and avatars. This would suggest that while learners both engaged in the learning activity and experienced an embodied social presence within the virtual world through the use of avatars and communication tools in the 3D environment, these did not lead to collaborative learning. Yet they did support the collaborative construction, discussion and sharing of artefacts. Thus while embodied social presence and engagement in the learning

experience support collaboration they do not necessarily support collaborative learning. This may be due to the barriers identified by the learners or the design of the learning experience.

Collaborative learning was limited by imbalances within groups. *Second Life's* communication tools were identified as a barrier by learners, however an increase in communication and discussion was needed to address group imbalances. These imbalances and barriers may have been the reason why some groups reported a need to meet face-to-face or used *Skype* as the preferred medium for communication. Although avatars supported learners in the observation of their partners, they were unable to observe their actions in S4SL and this was also found to limit collaborative learning. This was further hindered by the permission system which was a barrier to learners sharing their programmes within *Second Life*. It is likely that skill-based barriers to collaborative learning may also have been barriers to immersion, limiting engagement in the learning experience.

Although the findings suggest that collaborative learning was limited there was evidence of all three forms of Resnick's (1996) distributed constructionism: discussing constructions; sharing constructions; and collaborating on constructions. Chapter 2 proposed an alignment between the perceived educational affordance of collaborative learning and collaborating on constructions. While the embodied social presence, persistence and public nature of the learning environment were found to support the discussion and sharing of constructions, there is little evidence in the findings to support the alignment of collaborative learning and collaboration on constructions. Thus this aspect of the alignment between pedagogy and technology requires further development.

5.7.3 In-world data collection

One of the aims of exploratory case studies is to pilot the study's research procedures (Yin, 2003). In this study the non-traditional in-world data collection techniques were examined, including in-world interviews and recording in-world artefacts but in particular, the use of chat logs as a substitute to observation. As direct observation of participants was not feasible and the technical overhead and time required made it impossible to record participants' avatars in-world, chat logs were proposed as a substitute. However there is no evidence of this data collection technique being used by other researchers. Therefore it was necessary to pilot the approach and the following research question was posed:

- Do chat logs provide an adequate means of data collection?

While chat logs were identified as providing an opportunity to record the conversational interactions of participants during the learning experience without the presence of the

researcher, there were several unanticipated difficulties in the collection of the chat logs. In total only five participants out of 24 provided their chat logs to the researcher. One reason for this may be the use of Skype as the primary medium for communication whilst using *Second Life*, as reported in the findings. Three of the five participants that provided their chat logs reported that they had used Skype, suggesting that the chat logs do not provide a full account of their communication whilst participating in the learning experience in *Second Life*. In response to the request for chat logs, some participants reported that during the learning experience they had changed the computer they were working on and forgotten to record the chat logs on their new computer.

In addition to the data collection issues, as participants control the data set until it is sent to the researcher they are able to edit the data, thus reducing the reliability of it. It was presumed that the chat log of each participant's partner would provide an opportunity to identify omitted, edited or added sections of the chat log, however with only five chat logs available this was not possible. Thus this data set was considered incomplete and potentially unreliable. Although data was collected, it was limited and thus in this study chat logs did not provide an adequate means of data collection.

Interviews, by comparison were found to be a rich source of data whether conducted in-world or face-to-face. While face-to-face interviews provided an opportunity for the researcher to use non-verbal cues, interviewing in-world provided an opportunity for the participants to demonstrate their artefacts and take the researcher to illustrative examples of what they were talking about. While the visual nature of this interaction potentially provided an additional rich source of data, the researcher was only able to record the audio due to constraints imposed by the researcher's ethics committee.

While conducting interviews in-world appear to provide the researcher with a number of opportunities such as interviewing in context and note-taking during the interview, there are important implications and potential problems that need to be considered prior to their use. Guidelines for traditional interviewing state that opportunities for interruptions to occur must be minimised, however there was evidence that these distractions were not always avoidable in-world and tended to come from the participant's location outside the virtual world. For example during one interview the recording was paused for the interviewee to take a phone call. Low quality audio also greatly affected one interview to the extent that it was extremely difficult to transcribe the interview and thus the interview was removed from the data set. However conducting interviews in-world provided access to participants otherwise unavailable.

Recording artefacts using screen capture software provided an opportunity to capture and store images of the artefacts created by learners in the NGO-VW. Although the artefacts are persistent until deleted, there was no access to the asset registry and therefore no back-ups could be created. This is similar to the problem reported by Alison et al. (2010) regarding learner assessment in-world. In addition the artefacts had to be removed from the island shortly after they were created, yet for research purposes artefacts may need to be stored for extended periods of time.

Screen capture provided an opportunity to record images of completed artefacts as well as those under construction. Without these recordings there would be no evidence that these artefacts existed. They also provide an opportunity to record the data within the context it was created and to later review the data without accessing the NGO-VW.

However, as highlighted in Chapter 4, recordings are limited and generate a form of artefact themselves. For example when recording an artefact created in the virtual world, data is limited by camera position and how the user interacts with the artefact. The recording is also limited by the researcher's understanding of the artefact they are recording. Thus, the data collected may be biased by the act of recording.

5.7.4 Future research

At the commencement of this research those studies that underpinned learning experiences in NGO-VWs took broadly constructivist approaches with only limited consideration of the features or perceived educational affordances of the technology in relation to the specific features of the chosen pedagogies. Through the proposed alignment of pedagogical features and the perceived educational affordances of the technology, this thesis identified constructionism as a potentially appropriate pedagogy for use in NGO-VWs. Through the exploratory case study reported in this chapter, an initial understanding of constructionism in NGO-VWs has been developed.

The final aim of this study was to generate research questions for future research. This section presents six areas for future research that emerged from the findings. Of these two were followed up in the second case study presented in Chapter 6: barriers to learners' engagement and avatars. These are presented first, followed by the other areas considered but which were beyond the scope of this research. The research questions which are answered in the second case study are presented in the following conclusion (5.8).

- Barriers to learners' engagement

The findings highlighted a number of *Second Life* interface skills that were potential barriers to learners' engagement in the learning experience. Future research could identify which skills create barriers that limit engagement in constructionist learning experiences in NGO-VWs. This could then be extended to identify how these barriers impact the perceived educational affordances. For example, examining whether camera and avatar movement controls reduce learners' sense of embodied social presence or immersion within NGO-VWs.

- Avatars

Avatars were highlighted in the data analysis process as a cross-category theme, with a role in each of the five categories identified. This would suggest that the avatar is a key feature of the learning experience for learners, thus future research into the role of avatars within each of the identified categories as well as the perceived educational affordances and features of constructionism are possible areas for future research. For example, examining how the avatar supports the learners sense of *in-situ* active engagement with the learning experience, how the learner engages with objects and other learners in the virtual world through the avatar. Avatars are often referred to in the educational use of NGO-VWs and as such are not specific to constructionist learning experiences. However there is no research to date in the educational literature on either NGO-VWs or constructionism exploring the role of avatars in constructionist learning experiences. Based on the findings of this case study, the avatar supports the perceived educational affordance of embodied social presence. However, there are barriers to the use of avatars. Therefore, the role of the avatar; barriers to their use; and engagement with SLTurtle as mediated through avatars, are of interest.

- Sharing artefacts throughout the construction process

The public learning environment was of particular importance to the collaboration on constructions, as well as the discussion and sharing of artefacts. While the original proposed alignment of persistence with the construction of a shareable artefact is supported by the findings of this study, the emerging perceived educational affordance of public or private learning environments is also significant in supporting the construction of shareable artefacts. This perceived educational affordance also appears to support distributed constructionism: discussing, sharing and collaborating on constructions. However, unlike sharing a completed artefact as per the *Scratch* website where learners can upload, discuss and share

constructions, NGO-VWs provide an opportunity to engage in the process of construction in a public environment. Thus learners can discuss, share and collaborate on constructions throughout the *bricolage* construction process and this may enhance opportunities for learning. Currently there is limited understanding in the literature on constructionism of the impact of sharing early constructions with others during the *bricolage* construction process online. Research in NGO-VWs may provide a particularly advantageous opportunity to study this issue due to each participant's embodied social presence.

- Alignment of collaborating on constructions and the perceived educational affordances of NGO-VWs

As discussed in the previous section, it was proposed in Chapter 2 that the perceived educational affordance of collaborative learning could be leveraged to support the third form of distributed constructionism, collaborating on constructions. While there was evidence of collaboration in the findings there was limited evidence of collaborative learning. Learners tended to work together, support each other in problem solving but they did not report learning together. This outcome may be due to the specifics of the bounded case under study, or it may not. As such this aspect of the alignment of pedagogy and technology should be further examined in a similar bounded case study. This would provide an opportunity to study both the original proposed alignment and the potential alternative alignment suggested above, between embodied social presence and collaborating on constructions.

- Development of S4SL

The existing implementation of S4SL as a stand-alone programme separate to the virtual world appears to be associated with barriers to engagement with SLurtles. These barriers may also be associated with reducing the sense of immersion experienced by learners and awareness of the technology. Learners who are focused on the technical skills required to use an application cannot become immersed in the NGO-VW nor can they fully engage in the constructionist learning experience. Development of a programming environment similar to S4SL within *Second Life* which automatically communicates the programme to the SLurtle, while providing an equally low-floor programming tool for learners, could remove this barrier. By removing the manual process of placing the programme in the SLurtle the barrier would be removed, thus allowing learners to more quickly engage with

SLurtles. This would also allow learners to participate in the entire learning experience *in-situ*, increasing immersion and the sense of an ‘invisible’ technology. An implementation of S4SL within the virtual world could also be developed to support the collaborative construction, sharing and discussion of programmes, providing multiple avatars with a shared interface. Another area for development of the application could be the introduction of ‘bidirectionality’ (Hoyles et al., 2002) between S4SL and SLurtles.

- Low-floors, high-ceilings and wide-walls

While SLurtles have been shown to provide a low-floor, high-ceiling and wide-wall construction tool, much of the data is drawn from learners’ perceptions. Further research is needed to understand the points at which the floor, ceiling and walls stop and begin to limit what learners may achieve. This may be undertaken in comparison to other in-world tools or other constructionist environments such as *Scratch*. However the need for such research also highlights a potential limitation in the discourse surrounding constructionist tools; how to measure floors, ceiling and walls and whether these are comparable between tools.

5.8 Conclusion

The exploratory case study presented in this chapter has provided an opportunity to implement and explore SLurtles and a constructionist learning experience in action with a group of 24 post-graduate learners. Additionally data collection techniques have been trialled. However the main aim of exploratory case studies is to generate and refine research questions when there is a dearth of existing literature and theory in the area (Yin, 2009). Thus this case study has had four research aims:

- Explore SLurtles in action with learners
- Explore the learning experience in action with learners
- Refine in-world data collection
- Generate research questions for future research

The initial motivation for creating SLurtles was due to the high-floor object construction tools currently available in NGO-VWs (Dickey, 2005; Sanchez, 2009) which may limit learners’ engagement with constructionist learning experiences in-world. The findings demonstrate that SLurtles provided learners with a low-floor programmable construction tool with which they were able to create a variety of complex artefacts. While initial constructions were easy, more complex constructions required more complex programmes and with this came a sense of

challenge, hard fun and achievement. Although most learners had little or no previous programming or virtual world experience, they were able to collaborate at distance to create complex artefacts through the use of SLurtles.

Although beyond the scope of this research, there may need to be future development of SLurtles and S4SL to address the barriers highlighted in the findings. Barriers to learners' engagement with SLurtles highlight the need to consider the redesign of S4SL as an application accessible from within the virtual world. Automatic rather than manual transfer of scripts and bi-directionality may also enhance learners' experience of using SLurtles to support their learning. However the limitations of this research restrict any redevelopment of the application.

Overall, this case study has demonstrated that SLurtles provide learners with an empowering low-floor, high-ceiling and wide-wall construction tool with which learners were able to engage in the construction of personally meaningful and shareable 3D artefacts as part of a constructionist learning experience in the NGO-VW. Although designed for *Second Life*, SLurtles have the potential to be used in a number of other NGO-VWs developed through the *OpenSim* project. Despite being presented in terms of *Second Life*, the design concepts behind SLurtles could also be implemented in the development of similar tools in other NGO-VWs such as *Active Worlds*.

Discussion of the learning experience focused on the proposed alignment between the perceived educational affordances of NGO-VWs and the features of constructionism. While the findings broadly support the proposed alignment of pedagogy and technology; embodied social presence, immersion, collaborative learning and public/private learning environments are four perceived educational affordances which require further study in the context of a constructionist learning experience. In addition their alignment to the features of constructionism also requires in-depth examination.

This study has identified an additional perceived educational affordance: 'public/private learning environments' which can support or limit the sharing of artefacts throughout the construction process. The findings suggest that with persistence, public/private learning environments can be leveraged to support the construction of shareable artefacts. This perceived educational affordance, along with embodied social presence and immersion may also support distributed constructionism, particularly collaboration on constructions. It is unclear whether the design of the learning experience, the bounded system of the case under study or other factors influenced the lack of collaborative learning. It may also be possible that

collaboration on constructions does not require collaborative learning. These aspects of the alignment between pedagogy and technology present several areas for further study.

It is important to note that this learning experience was designed for a specific purpose. As such the findings cannot be readily generalised to other learning contexts. Chapter 3 identifies that a SLurtle learning experience may take a variety of forms depending on the context. For example there may be multiple learners using one computer. In such a context the role of the avatar may be reduced to that of a navigation tool or all members of the group may feel embodied by the avatar. However in this study avatars were highlighted as an important aspect of the learning experience, a common theme across all categories presented in the findings. Avatars are also an important feature of the technology, contributing to the perceived educational affordance of embodied social presence. As such it would appear to be an important element within the learning experience.

This study also provided an opportunity to refine the in-world data collection approaches used prior to the second case study. Chapter 4 highlighted the possible use of chat logs to support observations and this was examined through the question:

- Do chat logs provide an adequate means of data collection?

In this case study they provided insufficient quantities of data for primary analysis and provided limited support for validation. While their effectiveness may have been limited by the duration of the learning experience, no assumption can be made. However as a result of this, participant chat logs are not used for data collection in the second case study.

By comparison to participant chat logs, conducting interviews in-world through the medium of voice provided substantial data for analysis. Although this data collection method was not without limitations, it provided an opportunity to access participants otherwise unavailable and was a valuable data collection tool.

In-world artefacts were recorded using screen capture tools. These recordings were dependent on the movement of the researcher's avatar and camera, as well as the researcher's understanding of the possible ways to interact with the artefacts. However they provided a reliable source of data on the artefacts created by learners without relying on third party storage of assets.

The final aim of this case study was to generate research questions for the second case study. While there are several areas of research that could be undertaken it is clear that a greater understanding of some of the key findings is necessary. Of these, barriers and avatars have

been selected for further research. While a range of barriers were identified and possible areas for future research have been discussed to reduce these barriers, it is unknown whether these barriers were specific to this case or what the outcomes of these barriers were. By further developing an understanding of the barriers and their outcomes, strategies can be developed to reduce their impact on learners through development of both tools and teaching strategies. These strategies may also be relevant to non-constructionist learning experiences in NGO-VWs. As such the following research question is posed:

- How do barriers affect constructionist learning experiences in non-goal orientated virtual worlds?

As avatars are an important feature of the technology and of particular relevance to distributed constructionism, a further understanding of the role of the avatar in constructionist learning experiences in NGO-VWs is necessary. By understanding how avatars support and limit learners, learning experiences can be designed to leverage the opportunities and reduce the limitations. While there is literature on the role of avatars in general, there is a need to examine their impact on the learner during constructionist learning experiences, thus the following research is examined in the second case study:

- What role does the learner's avatar play during a distributed constructionist learning experience in non-goal orientated virtual worlds?

These questions are examined in the following instrumental case study, reported in Chapter 6.

6 Case 2: Instrumental Case study

6.1 Introduction

As highlighted in Chapter 2, prior to the research undertaken in this thesis few reported learning experiences in NGO-VWs were underpinned by constructionist pedagogy. Those that did, did not provide a detailed justification for the choice of pedagogy with consideration of the perceived educational affordances of the technology, nor did they report outcomes about the use of the pedagogy. As such, the primary aim of this thesis is:

To explore constructionism in action in non-goal orientated virtual worlds

In the previous chapter (Chapter 5) an exploratory case study is described through which an initial broad examination of constructionism in action was facilitated. From this study several areas for future research emerged: the use of shared versus private spaces for construction; the development of S4SL as an in-world tool; a comparison of SLurtle and *Second Life* building tools; the barriers of NGO-VWs for learners; and the role of the avatar in constructionist learning experiences.

While the impact of private versus public construction of artefacts is of interest and would support the primary research aim of this thesis, this is a phenomenon which also exists in physical learning environments such as the use of shared spaces for art and design students. S4SL and SLurtles are central to the learning experiences implemented in this thesis and are also of interest. They have been shown to support the novice learners' engagement in a constructionist learning experience; however, they may not be required by learners who have existing programming and 3D modelling skills.

By comparison, barriers to engagement and the role of the avatar are specific to NGO-VWs and may have the greatest impact on a constructionist learning experience in NGO-VWs. As constructionism aims to provide learners with low-floor tools, any barrier, particularly those specific to the technology, may raise the floor to engagement. Avatars are unique to virtual worlds and as such provide learners with an additional tool both to master and to support sharing, discussing and creating artefacts in distributed constructionist learning experiences. As such further research into barriers and avatars would deepen the emergent understanding of constructionism in action in NGO-VWs.

In this chapter an instrumental case study approach is used to develop an understanding of these general areas through researching a specific case. Following a description of the research

questions, context, learning experience and data collection, this chapter presents a detailed account of the data analysis process which follows an adapted form of Krippendorff's (2004) approach to content analysis. The findings develop the emerging understanding of barriers to constructionist learning experiences in NGO-VWs and the role of avatars. While all learners may experience personal barriers, those learners that experience technical barriers may be restricted in their engagement with the learning experience and have a limited connection to their avatar. Those that had a negative association to their avatar did not experience embodied social presence, a key feature in the design of the learning experience. However when interacting with other learners in-world they identified a sense of co-presence. These findings are important in developing an understanding of constructionism in action in NGO-VWs, particularly the role of the avatar and distributed constructionist learning experiences.

6.2 Research questions

The research questions were developed from the findings of the first case study, through which barriers and avatars were identified as two areas of particular importance to distributed constructionist learning experiences. As previously described, constructionism aims to provide learners with low-floor tools with which they can quickly engage; however barriers may raise the floor to engagement. Thus the first research question focuses on barriers and is answered by addressing three sub-questions:

- How do barriers affect constructionist learning experiences in non-goal orientated virtual worlds?
 - What barriers do learners experience?
 - Can the barriers identified in the first case study be generalised to other cases?
 - What are the outcomes of the barriers identified?

Avatars are unique to virtual worlds and as such provide learners with an additional tool both to master and to support sharing, discussing and creating artefacts in distributed constructionist learning experiences. Thus, the second research question focuses on the role of the avatar and is answered through three sub-questions:

- What role does the learner's avatar play during a distributed constructionist learning experience in non-goal orientated virtual worlds?
 - What are the factors that influence the use of the avatar?
 - How does the avatar influence interactions between learners?
 - What are the outcomes of using an avatar?

To answer these questions a constructionist learning experience similar to that of the first case study was implemented with a similar group of learners. This provided an opportunity to draw comparisons between the two studies. The bounds of the second case study are presented through the description of the context (6.3) and learning experience (6.4) which follow.

6.3 Context

The context of the instrumental case study is similar to that of the exploratory case study reported in Chapter 5. In this study, a group of 28 learners participated in the learning experience over six weeks as part of a post-graduate course. The intended outcomes were the same as the previous case study; that learners should experience a constructionist learning activity and gain an understanding of programming. 25 of the learners who agreed to participate in the research study were included in data collection, as described in 6.5, of which two had experience of *Second Life* and two were experienced programmers. An overview of the participants is provided in Appendix G.

14 pairs were formed, however by the end of the first week one of these pairs was split with one learner completing an individual project and the other joining another group. Another pair only engaged in the learning experience after the other groups had completed, thus changing the context of their engagement with the learning experience and so were excluded from data collection. Each group participated in the learning experience on the same *Second Life* island, *Insula Docta TCD*, in an access controlled space which only provided access to participants, as described in Chapter 4. The learning task required each group to create an interactive installation. By the end of the learning experience the group of three, the individual and 11 of the 12 pairs, submitted the artefacts they had created, together with individual and group reflections on the process, for assessment as part of the module requirement.

6.4 Learning experience design

Following a request by the module co-ordinator, the design of the learning experience remained broadly in line with that of the first case study. As such, learners were given an open task to create an interactive installation using SLurtles and S4SL and were provided with a wide variety of SLurtles. As the learning experience was part an accredited course, each group was provided with a discrete learning space on an access controlled island. As per the first case study, each learning space was a discrete 40 x 40 metre platform. By leveraging the perceived educational affordance of public or private learning spaces, which emerged in the previous case study, each learning space was public, providing all learners with access to each other's spaces to support collaboration and socialising.

Learners were provided with a five hour in-world introduction to *Second Life* as part of their course, similar to that experienced by the participants in the first case study. This provided learners with a similar opportunity to familiarise themselves with many of the application controls prior to the commencement of the learning experience. However there were no pre-designed activities for learners to practice their camera controls in the original implementation and camera controls were identified as a barrier in the previous case study. To address this, a location with short activities and instructions on posters was designed for learners to practice their camera skills (Figure 6.1).



Figure 6.1Camera skill activity station

The first case study demonstrated the efficacy of SLurtles and as such learners were introduced to SLurtles as low-floor construction tools during an initial face-to-face lecture and workshop. In addition, to address the barrier of the *Second Life* permission system identified in Chapter 5, this initial session included an introduction to the sharing of scripts and SLurtles between avatars. Following this, learners were given six weeks to create an interactive installation on their platform before presenting their installation and reflections on the experience to the class.

6.5 Data collection

Data collection involved participant-observation over six weeks during the learning experience and interviews and reflections were collected in the four weeks following (Figure 6.2).

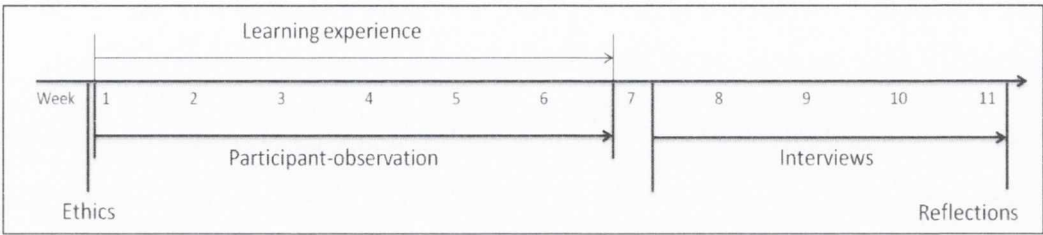


Figure 6.2 Data collection over time

Observational data was recorded by the researcher as participant chat logs had been an unreliable source of data in the first case study. Although there were limited opportunities for data collection in the second case study over the duration of the learning experience, participant-observation provided a more reliable data collection approach. To allow the researcher to actively participate whilst recording data, the researcher’s own chat logger was the primary data collection instrument with still images taken from the researcher’s screen.

Interviews provided the primary source of data for analysis. Following an open invitation to participants, an opportunistic sample of nine participants took part in individual, focused, open interviews conducted face-to-face. Each interview lasted between 30 and 70 minutes. Each interview opened with the researcher asking the participant to “tell me what you did for the assignment”. The interview, while open, was focused by the research questions through which the researcher prompted the participant to discuss both barriers encountered during the learning experience and the role of the avatar. Audio recordings of the interviews were transcribed, assigned a coded number with which to identify the participant and imported into NVivo8 in preparation for data analysis.

Following the interviews, learner’s reflections were collected. As highlighted in Chapter 4, these documents were created for a specific purpose and with a particular audience in mind. Therefore they are treated as corroboratory evidence.

Following a request for participants, 26 of the 28 learners gave permission for data to be recorded. The two learners that did not provide consent were members of two different groups. The ethical implication of this is that no data could be recorded from these individuals, which was a particular concern during participant-observation. In addition, even though the other member of the group had provided informed consent, no data from the artefact or joint reflections of these groups could be recorded. One of these groups was the twelfth pair,

described earlier in the context (6.3) as engaging in much of the learning experience following the submission of artefacts and reflections by the other groups. Thus, all data regarding this group was excluded from data analysis and the participant who gave consent was not invited for interview.

As a result of the pair which split early in the learning experience, a group of three and an individual were created. Considering the aims of the study (focusing on barriers and the avatar) as well as the design of the learning experience (which supports socialising between groups) the decision was made to include these participants in the data collection process and to keep this in consideration during data analysis.

26 participants originally gave their informed consent to participate in the research, however, following the decision to exclude one group this was reduced to 25. The final amount of data available was further reduced due to incomplete submissions of reflections by twelve participants within four weeks of the end of the learning experience. Only four groups provided individual reflections from all members of the group. Of these only three provided group reflections and of this sub-set all members of only one group participated in interviews. As such the group reflections were discounted as a data set.

As shown in Table 6.1, both interviews and reflections were collected from seven participants. A further two participants took part in interviews but did not provide their reflections. Six participants provided reflections but were unavailable for interview. This resulted in nine individual interviews and 13 individual reflections available for analysis, in addition to the participant-observations. The implications of having such a small data set for content analysis are discussed in the Conclusion at the end of this chapter (6.9), however Krippendorff (2004) notes that this analytical approach is often used with small data sets in academic research.

Table 6.1 Data collection by participant

Group number	Participant number	Interview	Reflection
1	1-1	Y	Y
	1-2	-	-
	1-3	-	-
2	2-1	Y	-
3	3-1	-	-
	3-2	-	-
4	4-1	Y	Y
	4-2	-	-
5	5-1	-	-
	5-2	-	Y

6	6-1	-	Y
	6-2	-	Y
7	7-1	Y	Y
	7-2	-	-
8	8-1	Y	Y
9	9-2	Y	Y
	9-1	Y	Y
10	10-2	Y	Y
	10-1	Y	-
11	11-2	-	-
	11-1	-	Y
12	12-1	-	Y
	12-2	-	-
13	13-1	-	Y
	13-2	-	Y

6.6 Data analysis

As stated in Chapter 4, content analysis provides a framework with which to scaffold the data analysis in this case study. Content analysis provides the researcher with a relatively clear process to follow, however in practice, as a qualitative technique it retains some of the ‘messiness’ inherent in qualitative data analysis (Hatch, 2002). Unlike open coding, used in the coding comparison in the first case study, content analysis provides the researcher with an opportunity to focus on a particular area of interest whilst remaining open to emergent codes (Krippendorff, 2004). Based on the researcher’s interpretation of textual data and the inferences drawn from the quantitative analysis of these interpretations, the researcher may find themselves moving between steps as they seek to further develop their understanding of the data.

Data analysis focused on the interviews as the primary source of data. The analysis process used in this case study follows Krippendorff’s (2004) approach to content analysis: unitising, sampling, coding, reducing, inferring and narrating. As illustrated in Figure 6.3, this process begins with the rich textual data and over the course of the analysis is represented in a form increasingly abstract from the original. The data is unitised and sampled, qualitatively coded and finally reduced to its smallest level of representation for the purpose of quantitative analysis. The results of the quantitative analysis then need to be interpreted and used to infer answers to the research questions through the use of analytical constructs. This process further increases the level of abstraction away from the data, as the language of the researcher and research context are increasingly used. Finally a narrative is presented with which to answer the research questions.

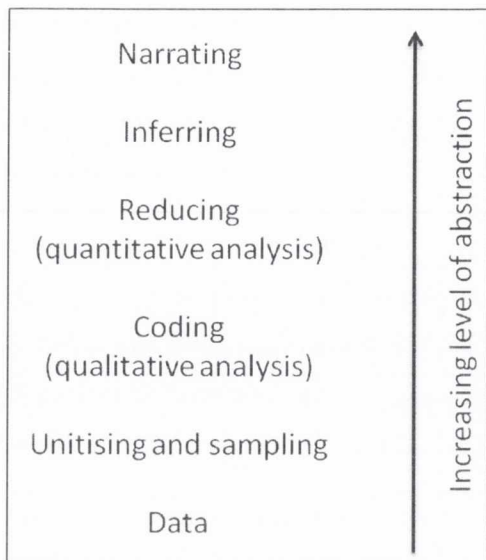


Figure 6.3 Overview of data analysis process

While validation is not always possible in content analysis, this study provides two additional sources of data which are used for this purpose: reflections and participant-observations. This process is undertaken after drawing abductive inferences to find evidence to strengthen or refute the inferences made. Therefore the steps followed in this analysis are:

1. Unitising and sampling
2. Coding
3. Reducing
4. Inferring
5. Validating
6. Narrating

The following sub-sections describe, with illustrative examples, each of the steps followed in the content analysis process, with narration presented in the Findings (6.7).

6.6.1 Unitising and sampling

The first step in the process of data analysis was the unitising and sampling of data. As described by Krippendorff (2004), the approach to unitising text may take many forms depending on the context and may emerge during the process of reading through the data. Therefore prior to unitising, the data was read and re-read in a process of sensitising the researcher.

Krippendorff (2004) identifies three types of units: sampling units; recording units; and context units. Sampling units are used for the purpose of sampling the data and aim to be both

mutually exclusive and naturally occurring. In this study the sampling units are defined as individual participants. As the participants have connections with each other, these are recognised in the analysis and all relevant information is contained in individual sampling units. Due to the quantity of data available in this study, every participant who provided data was included in the sample.

Recording units are smaller than and contained within sampling units. In their smallest form they may be single words. The size of the unit is not restricted by the sampling unit, for example in an interview a participant may mention a barrier at which point the researcher asks for clarification and the participant continues speaking. In such a case this would be recorded as one unit for analysis. In another example (Figure 6.4) the unit may be part of a conversation recorded during participant-observation.

[2011/03/15 12:32] P71: Hi Sorry my internet very slow this eve...
[2011/03/15 12:33] Researcher: np :)
[2011/03/15 12:33] P71: Hard to move around

Figure 6.4 Example of a recording unit

Finally, context units limit the data considered in recording units. In this study the context is defined by the research questions which focus on the barriers and role of the avatar during a SLurtle-based constructionist learning experience. Thus the context units ‘barriers’ and ‘avatars’ are used. While there may be data regarding avatars and barriers throughout the sampled text, only those referring to the SLurtle-based learning experience are included. For example, in one interview a participant described barriers encountered whilst engaged in *Second Life*. During this, they made comparisons to an earlier constructionist learning experience on their course, in which they used *Lego Mindstorms*. Although an aspect of the participant’s past experiences which may have influenced their perceptions of barriers in *Second Life*, data referring to the barriers encountered by the participant whilst engaging with *Lego Mindstorms* are not relevant to this study and are therefore outside the scope of the context unit.

While the use of NVivo8 provided an opportunity to search for keywords and mark the surrounding text as a unit for analysis, text was primarily sampled based on the researcher’s interpretation of the data. Following the initial reading of the data to sensitise the researcher, it was re-read to identify units referring to ‘barriers’. This was then repeated for ‘avatars’. A keyword search was then used to ensure that all references to ‘avatars’ and ‘barriers’ had been

considered. While additional references were identified during this process they were determined by the researcher to be outside the context of the study.

Across data sets and samples, a total of 95 units of data were recorded for analysis within the context of ‘barriers’ and 97 units under ‘avatars’. Table 6.2 illustrates the distribution of these units for analysis by sampling unit (participant).

Table 6.2 Units of data recorded by sampling unit and data collection source

Sampling unit (participant identifier)	Source						Total	
	Interview		Reflection		Participant- observation			
	Barriers	Avatars	Barriers	Avatars	Barriers	Avatars	Barriers	Avatars
1-1	10	12	1	0	0	0	11	12
2-1	7	7	n/a		0	0	7	7
4-1	13	11	7	1	1	0	21	12
5-1	n/a		0	0	0	0	0	0
6-1	n/a		2	0	1	0	3	0
6-2	n/a		3	0	0	0	3	0
7-1	7	15	4	0	1	0	12	15
7-2	n/a		n/a		1	0	1	0
8-1	1	6	1	0	0	0	2	6
9-2	7	5	1	0	0	1	8	6
10-1	1	10	1	0	0	0	2	10
10-2	8	6	2	0	0	0	10	6
11-1	7	21	n/a		0	0	7	21
12-1	n/a		2	0	0	0	2	0
13-1	n/a		2	0	1	0	3	0
13-2	n/a		2	1	1	1	3	2
Total	61	93	28	2	6	2	95	97

Generally, between nine and ten percent of each interview was coded at ‘barriers’, while for ‘avatars’ the units ranged from four to fourteen percent of the original data. By comparison 81% of the raw participant-observation data was assigned to ‘barriers’. However this is likely to be a function of the presence of the researcher in the learning environment as learners would often seek out the researcher to ask technical questions.

6.6.2 Coding

The second step in the data analysis process is coding. As previously highlighted, qualitative data analysis is a messy process (Hatch, 2002). This was particularly true in the coding stage of the content analysis. This section describes the coding process which began with an *a priori* set of codes which were later developed into a coding template. This coding template was then used in the analysis of the full data set.

Following the unitising of the data, units recorded at 'barriers' or 'avatars' were coded as such using *NVivo8*. This allowed the researcher to analyse all units coded at barrier separately from those coded at avatar. As interviews provided the primary data source, initial coding of the data focused on units identified in interviews only. Codes are highlighted in **bold** throughout the rest of this chapter.

6.6.2.1 Barriers

Within the context of barriers, initial coding of the first two interviews was conducted with a set of *a priori* codes. These codes were the emergent codes under the sub-category 'barriers' from the first case study. While the contexts of the two case studies are similar, they are separate bounded cases and as such learners may encounter barriers that did not emerge in the previous case study. Thus, during analysis of the first two interviews the researcher remained open to codes emerging from the data.

With several new codes emerging it became clear that this initial set of codes was insufficient. For example initial codes such as **SL skills** encompassed several potential barriers. As such this code appeared to be redundant and the new codes **SL chat** and **SL objects – no heading**, were added. This prompted a process of remodelling the initial codes and the emergence of categories to be used in the content analysis. Figure 6.5 shows a model created in *NVivo8* at an early stage of this process.

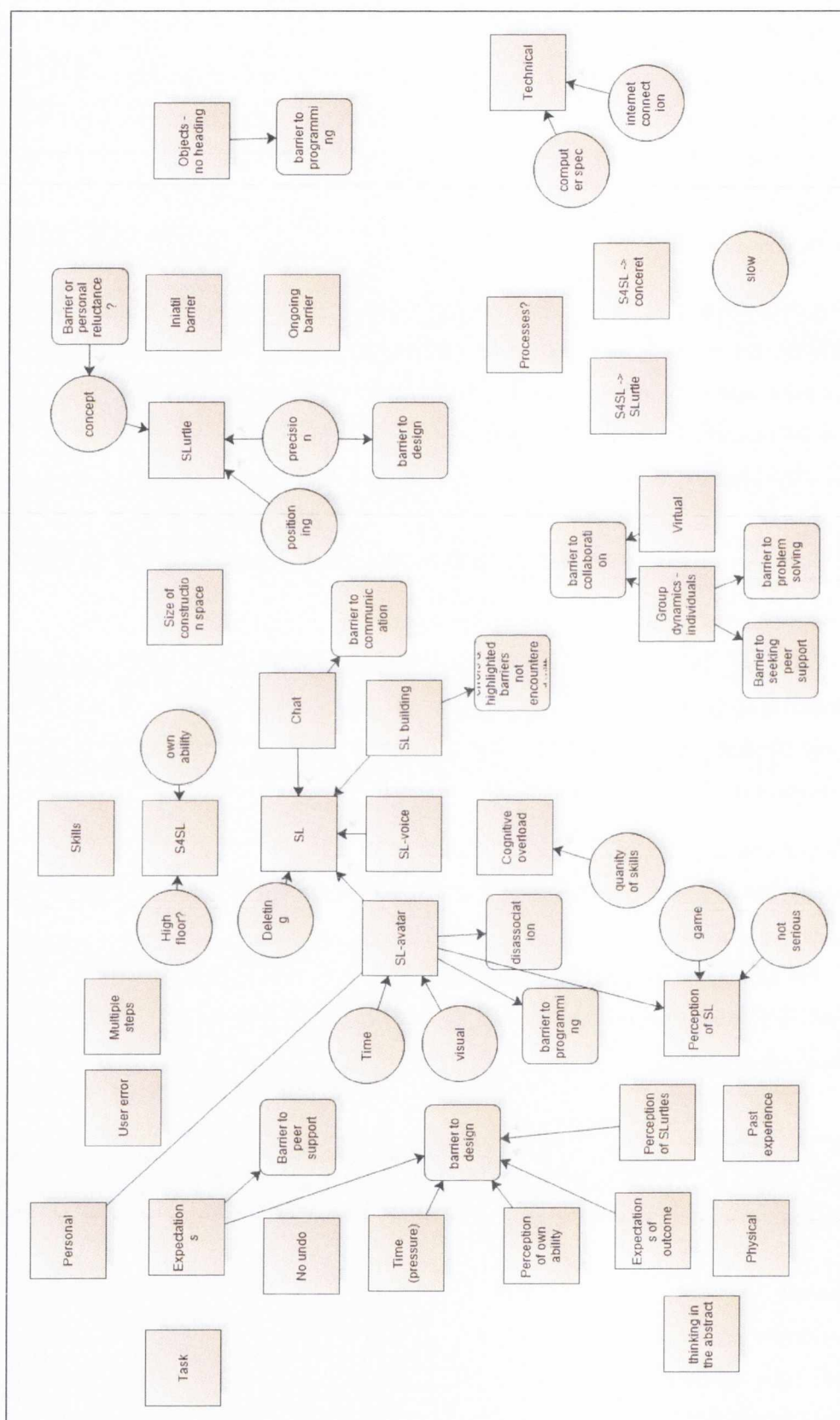


Figure 6.5 Early model of ‘barriers’ codes in NVivo8

Through review and modelling of codes to see how they naturally clustered, categories were developed. The final categories used in this study identify the **duration** of the barrier; the **outcome** of the barrier; and the **type** of barrier. It should be noted that value neutral codes were used within the category of **outcomes** and each should be prefixed with 'barrier to...', for example 'barrier to **collaboration**'. To further classify the **type** of barriers encountered by participants three sub-categories were developed: **learning experience**, **personal** and **technical**. Within these categories and sub-categories, 35 codes were used in the final coding template which was used to analyse all interview data:

- Duration
 - Initial
 - Ongoing
- Outcome
 - Association with own avatar
 - Collaboration
 - Communication
 - Design
 - Engagement in the learning experience
 - Highlight barriers not encountered with SLurtles
 - Peer support
 - Problem solving
 - Programming
- Type
 - Learning experience
 - Size of the construction space
 - SLurtles
 - Task
 - Personal
 - Expectations
 - Group dynamics – individuals
 - Past experience
 - Perception of own ability
 - Perception of SL
 - Perception of SLurtles
 - Physical
 - Thinking in the abstract

- Time
- Technical
 - Cognitive overload
 - Computer
 - Multiple steps
 - S4SL
 - S4SL to SLurtle
 - SL avatar
 - SL building
 - SL chat
 - SL objects – no heading
 - SL voice
 - User error
 - Virtual

6.6.2.2 Avatars

The analysis of data unitised under ‘avatars’ followed a similar approach to that of ‘barriers’. In the exploratory case study, ‘avatars’ was a common theme across all categories and several sub-categories. As such the initial *a priori* code set was identified by examining all of the final emergent codes from the first case study related to avatars. However following the remodelling of codes for the analysis of ‘barriers’, the researcher anticipated that emergent codes may lead to the necessary remodelling of codes under ‘avatars’.

During the initial data analysis using the *a priori* codes, further codes were derived responsively from the data. Through consideration of the research question, removal of redundant codes and modelling (e.g. Figure 6.6), **tool**, **social interaction** and **behaviour** initially emerged as high level categories, with **control**, **identity** and **visual representation** sub-categories of **social interaction**.

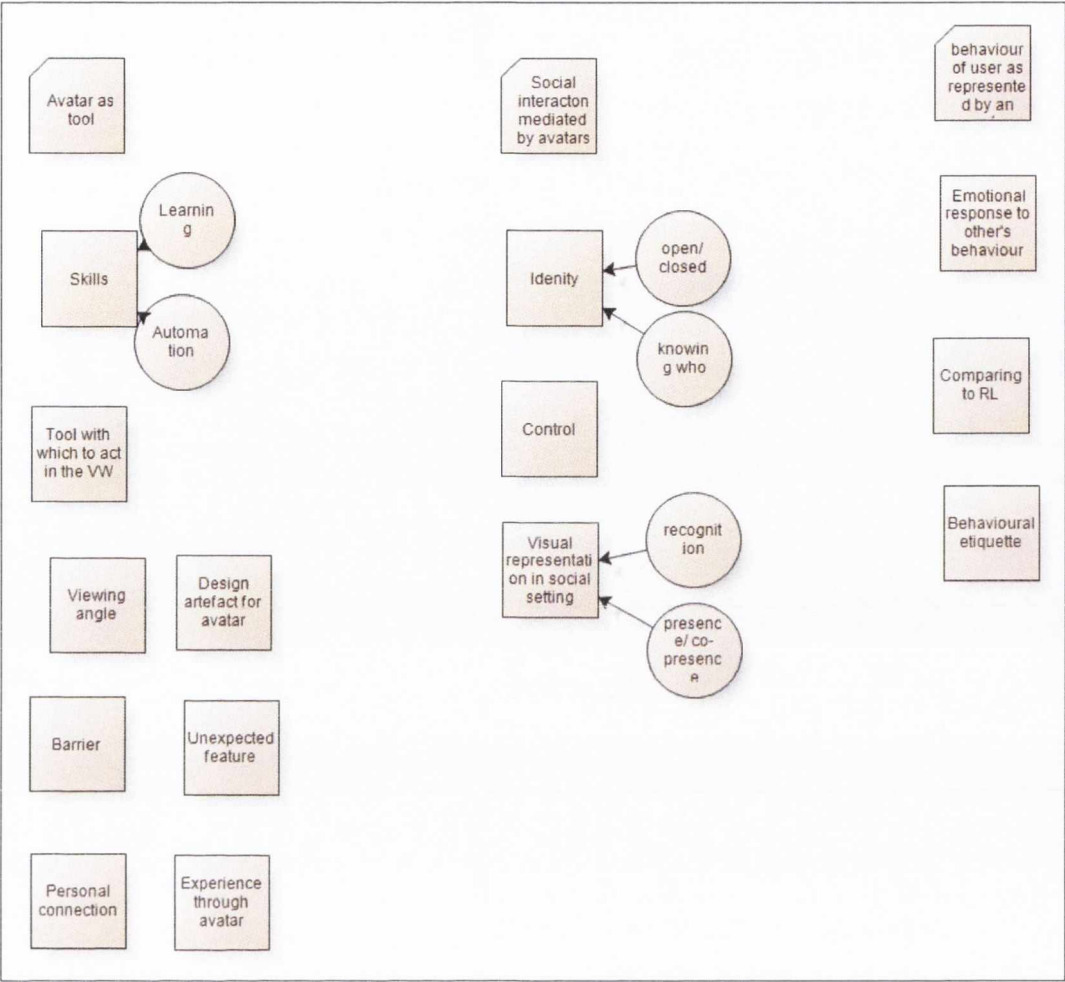


Figure 6.6 Developed model 'avatars' codes

However in drawing up the final coding template there was uncertainty as to whether **behaviour** was the same level or a sub-category of **social interaction**. Through peer validation and reconsideration of both coding and interpretation of data, **behaviour** remained as a category as it included both behaviour observed at a distance and behaviour during social interactions. An alternative interpretation that social interactions were a form of behaviour was also considered, however keeping these as separate categories provided greater opportunity for cross-tabulation during reduction of the data (6.6.3). Finally, units coded at **personal connection** occurred at either end of a dimension from positive to negative and were coded as such.

Following the remodelling of codes, 18 codes and one dimension were used in the final coding template which was applied to the interview data:

- Behaviour
 - Compared to 'real life' behaviour
 - Emotional response to observed behaviour
 - Etiquette
- Social interaction
 - Control
 - Identity
 - Closed
 - Knowing who
 - Open
 - Visual representation
 - Co-presence
 - Presence
 - Recognition of other avatars
- Tool
 - Barrier
 - Design artefact for avatar
 - Personal connection
 - *Negative*
 - *Positive*
 - Skills automated
 - Skills learnt
 - Viewing angle
 - With which to act in VW
 - Unexpected feature

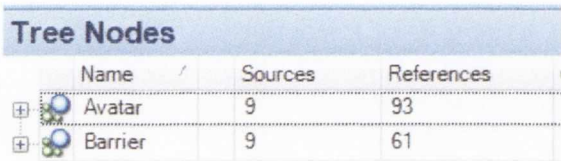
6.6.3 Reducing

The third step in the process was reducing the data, moving from qualitative analysis to quantitative results with the aim of reducing and simplifying the previous qualitative coding of units. The first stage in this process is to create frequencies of each code. While this may traditionally be followed by a range of statistical tests, with a sample size of nine, only cross-tabulation of co-occurring codes was appropriate. Cross-tabulation generates a frequency table of codes assigned to the same unit, through which co-occurring codes can be identified. Co-

occurring codes are two codes applied to the same unit, highlighting a potential association between these codes.

NVivo8 was a particularly valuable tool in this process. For example, following the final coding of data, the frequency of participant interviews (labelled ‘sources’ in NVivo8) and units (‘references’) coded at each context, category, code and dimension, were available. In addition, the use of matrix coding queries supported the creation of cross-tabulation tables. The cross-tabulation process created cross-tabulation of codes by participant and codes by codes, within each context.

Figure 6.7 provides the frequency results of the sources (participant interviews) and references (units) coded at ‘avatars’ and ‘barriers’ as illustrated by NVivo8. However once expanded, the display is difficult to read and therefore Table 6.4 presents the frequency of ‘barriers’ codes assigned to each interview and the number of units within those interviews.



Tree Nodes			
	Name	Sources	References
+	Avatar	9	93
+	Barrier	9	61

Figure 6.7 Screen shot of the frequency of recording units coded to each context unit.

It should be noted that as one unit of data may be assigned more than one code, the number of sources and units coded to a category may equal the sum of the units assigned to each code within that category. For example, in Table 6.3 27 units are coded at the category **outcome**, however the sum of the units assigned to each code shown in Table 6.4 is 32. This result was not unexpected. Appendix D presents the results of the cross-tabulation of codes by interview participant and the symmetric cross-tabulation of codes by codes within the context of ‘barriers’.

Table 6.3 Frequency of interviews and recording units at categories within 'barriers'.

Category	Interviews	Units
Duration	7	11
Outcome	6	27
Type	9	30

Table 6.4 Frequency of interviews and units at codes within the context 'barriers'.

Category	Sub-category	Code	Interviews	Units
Duration				
		Initial	7	9
		Ongoing	2	2
Outcome				
		Association with own avatar	2	4
		Collaboration	2	2
		Communication	1	1
		Design	4	10
		Engagement in the learning experience	5	6
		Highlight barriers not encountered with SLurtles	1	1
		Peer support	1	1
		Problem solving	2	2
		Programming	3	5
Type				
	Learning experience			
		Size of construction space	1	1
		SLurtle	1	1
		Task	1	2
	Personal			
		Expectations	4	5
		Group dynamics – individual	2	2
		Past experience	3	4
		Perception of own ability	3	6
		Perception of SL	3	3
		Perception of SLurtles	4	4
		Physical	1	2
		Thinking in the abstract	2	6
		Time	2	3
	Technical			
		Cognitive overload	3	4
		Computer	2	3
		Multiple steps	2	2
		S4SL	3	3
		S4SL to SLurtle	2	2
		SL avatar	4	8
		SL building	1	1
		SL chat	1	2
		SL objects – no heading	1	1
		SL voice	1	1
		User error	2	9
		Visual	2	3

Across the nine interviews, 93 units were assigned to the context ‘avatars’. To provide a feel for the data, Table 6.5 presents the frequency that codes were assigned to participant interviews and units within those interviews. The results of the cross-tabulation of ‘avatars’ codes by interview participant and cross-tabulation for all ‘avatars’ codes in a symmetric matrix, are presented in Appendix E.

Table 6.5 Frequency of interviews and units at categories and codes within the context avatars.

Category	Sub-category	Code	Interviews	Units
Behaviour			6	10
		Compared to ‘real life’ behaviour	2	2
		Emotional response to observed behaviour	2	3
		Etiquette	6	7
Social interaction			8	39
		Control	1	3
	Identity		5	11
		Closed	2	2
		Knowing who	4	8
		Open	1	1
	Visual representation		8	29
		Co-presence	8	21
		Presence	2	6
		Recognition of other avatars	3	4
Tool			9	64
		Barrier	3	11
		Design artefact for avatar	1	3
		Personal connection: +ve	5	22
		Personal connection: -ve	4	20
		Skills automated	4	4
		Skills learnt	3	3
		Unexpected feature	1	1
		Viewing angle	1	5
		With which to act in VW	4	9

6.6.4 Inferring

The fourth step in the content analysis process is the drawing of abductive inferences. To answer the research questions, content analysis requires the researcher to consider the quantitative results of the sampled text and abductively infer answers to the research questions. In order to abductively infer answers to the research questions, Krippendorff (2004) describes the use of analytical constructs. Analytical constructs represent everything the

researcher knows about the context of the data and are used to guide the analysis as a form of testable hypothesis. In this study, the analytical constructs rely on both the existing results of the first case study which provide existing generalisations from related research and the researcher's experience of the context. The context refers to the bounds of the case which includes the programming and *Second Life* experience of participants, as well as the learning experience designed and implemented by the researcher, described in this chapter within the sections on context (6.3) and learning experience design (6.4).

Inferences are drawn from the quantitative data generated which provides an account of the learners' experiences as recalled during the open interviews. The process of developing inferences began by examining the frequency of codes assigned to individual interviews and noting those of interest. For example, within the context 'barriers' it was noted that all participant interviews provided evidence of **personal barriers**. Interestingly participant 9-2 only experienced **personal barriers** and no codes were assigned to this interview under other categories or sub-categories within the context 'barriers'. This provided an initial source of interest to be further developed; considering why personal barriers, which also had a higher frequency to other forms of barriers, might be more prominent in the minds of the participants than technical barriers.

Krippendorff (2004) highlights the importance of modifiers in inference statements. As statistical tests were not possible due to the sample size, it is possible that the results of the cross-tabulations may be due to chance co-occurrence of codes. For example, through the cross-tabulation of codes to interviews within the context 'avatars', it was noted that **barriers** and **personal connection negative** were the most commonly co-occurring codes with a frequency of seven. Examining the cross-tabulation of codes by participant interview, three of the four sources coded at **personal connection negative** were also coded at **barriers** within 'avatars'. By comparison, of the five sources coded at **personal connection positive**, none of these sources were coded at **barriers**. From this the following inference was made:

- If participants experience barriers to the use of their avatar then they are *likely* to experience a negative connection to their avatar.

Finally, while the cross-tabulation of codes often provided the starting point for drawing abductive inferences, visual models of the data were also created to support the clarification of potential links between codes. These models often required several iterations and were developed using the quantitative data generated. For example, the cross-tabulation of barrier codes under the categories of **type** and **outcome** contained a substantial amount of data, presented in Appendix D and discussed in the findings section (6.7). While many inferences

may be drawn from this data, by representing the data in a different way it was possible to identify associations between barriers and outcomes which may be of particular interest. Using the cross-tabulation data, Figure 6.8 maps barriers to outcomes, excluding the codes **communication** and **highlight barriers not encountered with SLurtles** as these were each associated with only one barrier. Lines in red highlight barriers which had multiple outcomes.

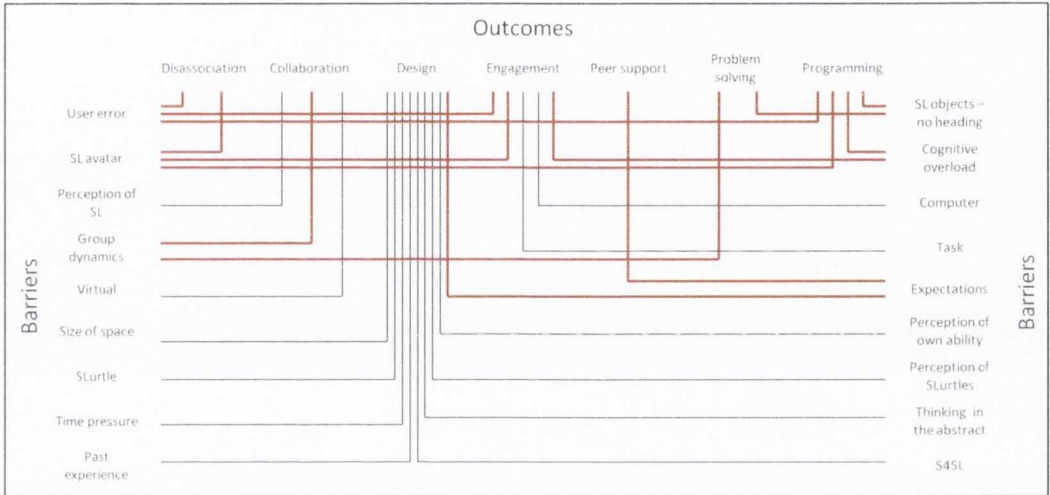


Figure 6.8 Model of type by outcome codes highlighting barriers with multiple outcomes

In order to focus on the complex relationships between barrier codes assigned to more than one outcome, those codes linked by cross-coding to only one outcome were removed from the model to produce Figure 6.9.

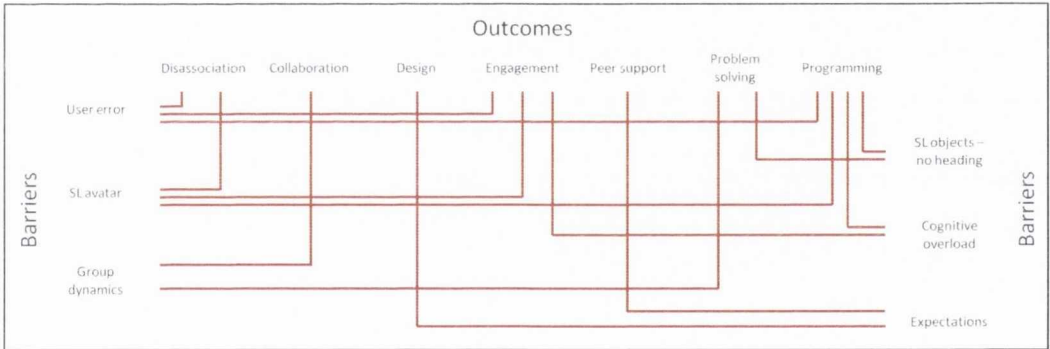


Figure 6.9 Model of barriers with multiple outcomes

Figure 6.9 highlights six barriers, three personal and three technical, each with two or three associated outcomes. These highlighted potential areas of interest which were compared to the results of the cross-tabulation of personal barriers by technical barriers and outcomes by outcomes. These connections are illustrated in blue in Figure 6.10.

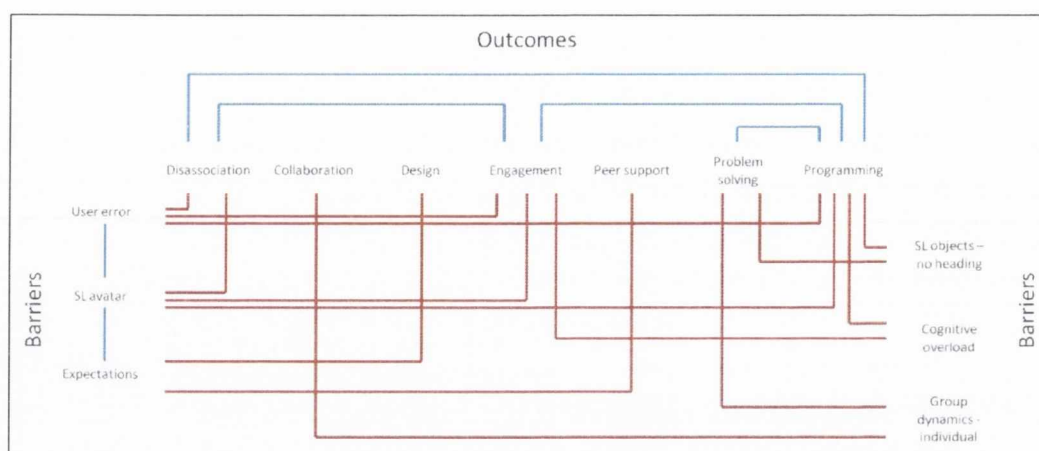


Figure 6.10 Model of barriers with multiple outcomes, cross-tabulation between categories overlaid

Through this process, the codes **user error** and **Second Life avatar** stood out as notable barriers, with **disassociation**, **engagement in the learning experience** and **programming** highlighted as notable outcomes. Although **expectations** and **problem solving** were highlighted by the additional cross-tabulation data overlaid on the model, the code **expectations** was not connected with a notable outcome and **problem solving** was not connected to a notable barrier. By comparison both **user error** and **Second Life avatar** were associated with the three outcomes of note and these outcomes co-occurred with each other. This led to the examination of the occurrence of these codes in the interviews of each participant. The final inferences drawn are presented in the findings section (6.7).

6.6.5 Validation

The fifth stage of the data analysis process was one that would not typically occur in content analysis, that of validation. Content analysis provides an opportunity to infer the unobserved through analysis of textual data, however it should be possible to validate inferences through observation, in principle at least (Krippendorff, 2004).

Unlike traditional content analyses which focus on newspaper articles or political speeches, in which often only one form of data is available, this case study provided an opportunity to collect participant-observations in-world as well as participant's reflections. As the reflections were created for assessment purposes they were treated as a secondary data source and therefore suitable for triangulation along with participant-observations which were time limited and relied on recorded text-based communication with and between participants.

All participant-observations and reflections were analysed using the same unitising procedure and the final coding templates developed through analysis of the interviews. Following qualitative analysis, frequencies and cross-tabulation were used to reduce the data. This

included cross-tabulation of codes by participant number for comparison between data sets for an individual participant. This was made possible by creating a participant code which was applied to the data, rather than making the data anonymous. This data was then used to validate inferences drawn from the interview data.

In total 34 units of data were coded under the context 'barriers'. Of these, six units came from participant-observations, all of which were coded at **computer** as the barrier type. These units came from the observation data of five participants, four of whom provided reflection data. The fifth did not provide reflection data or participate in interviews. The remaining 28 units came from 13 reflections. These were cross-tabulated and the results are presented in Appendix F.

There were only two units identified within the reflections under 'avatars'. These were coded at **barrier** and **personal connection positive**. There were also two units identified from the participant-observations, coded at **co-presence** and **personal connection positive**. An overview of these results is presented at the end of Appendix F.

6.7 Findings

The final step in the content analysis process is the narration of findings. This section uses the language of the context and the researcher to present the findings and abductive inferences, beginning with 'barriers' and followed by 'avatars'. As per the first case study (Chapter 5), codes are formatted bold. The abductive inferences are presented as 'if-then' statements in bullet points. It should be noted that as these inferences are drawn from limited data through a single case study and therefore it may not be appropriate to generalise them out to other contexts.

6.7.1 Barriers

As shown in Figure 6.11, within 'barriers' three categories were developed: 'type', 'outcome' and 'duration'. All participants interviewed encountered at least one type of barrier, whether related to the design of the **learning experience**, **personal** or **technical** barriers. However only two participants identified barriers related to the design of the learning experience, five identified technical barriers, while all nine participants described personal barriers. Outcome refers to the effect of the barrier on the learner's experience. Finally, duration refers to the length of time a barrier limited a learner's engagement. Barriers were either experienced at the beginning of the learning experience and then overcome (**initial**) or continued to limit the learner throughout the learning experience (**ongoing**). The following sub-sections describe the key finding, drawing inferences presented as 'if-then' statements in bullet points.

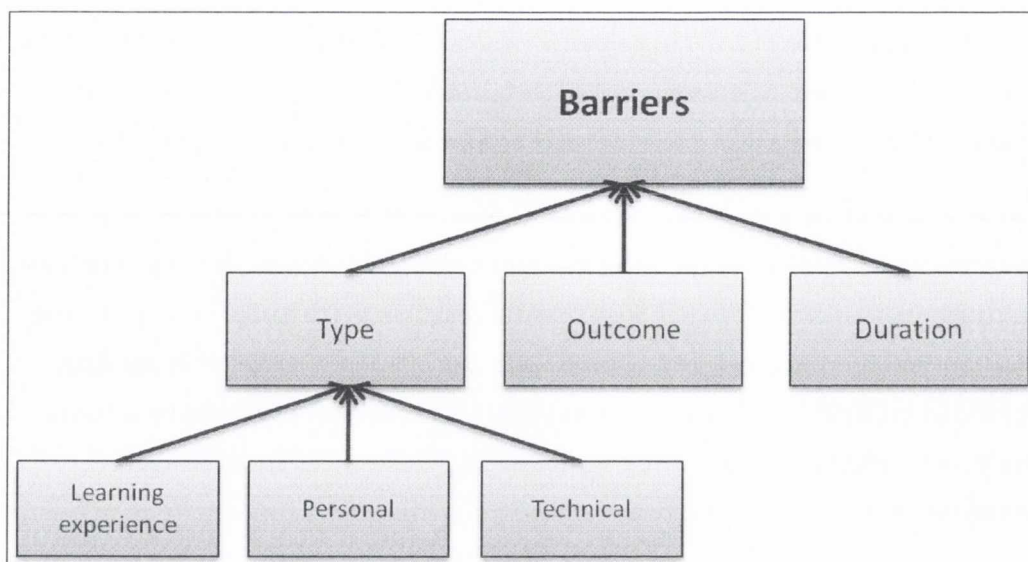


Figure 6.11 Representation of categories and sub-categories within 'barriers'

6.7.1.1 Learning experience barriers

Only three barriers were identified within the sub-category 'learning experience' and these came from just two participant interviews (1-1 and 2-1). Of the barriers identified, it should be noted that only participant 2-1 identified the **size of the construction space** and the assigned **task** as barriers. This participant was the only one to undertake the learning experience without a partner, as previously described. As the learning experience was designed for learners working in groups, this discrepancy may explain why no other participant identified these barriers and highlights the importance of designing the learning experience to meet the needs of a specific learning context (as highlighted in Chapter 3).

The **SLurtle** was the only other feature of the learning experience identified as a barrier and again this was only by one person. There was no evidence from reflections or observations to suggest that other learners experienced these or any other barriers related to the general design of the learning experience. Therefore the following inference is drawn:

- If small groups of learners participate in a SLurtle-based learning experience, then they are unlikely to experience barriers related to the design of the learning experience.

6.7.1.2 Personal barriers

'Personal barriers' are the personal and interpersonal barriers identified by learners, ranging from external time pressures to personal expectations and perceptions. All interviewed participants described barriers that were classified as personal. Of these, personal **expectations** which learners brought to the learning experience and their **perception of SLurtles** were the most common barriers. These are further discussed with reference to the

outcomes of these barriers in the later sub-section on barrier types and their outcomes (6.7.1.6).

60 of the 61 units for analysis were coded at barrier 'type'. Of these, 29 were coded at 'personal' barriers and 34 were coded at 'technical' barriers. This was explored in the cross-tabulation of barrier type codes (Appendix D) however there were no noteworthy results to report.

6.7.1.3 Technical barriers

Six of the nine participants interviewed identified 'technical' barriers to the learning experience. Of these, the *Second Life* avatar (**SL avatar**) was the most frequently identified barrier across interviews. The cross-tabulation of codes (Appendix D) shows that this may only be a temporary (**initial**) barrier for some learners, while for others it may be **ongoing**.

Other *Second Life* tools, although identified as barriers, were only coded in one participant interview each. This leads to the conclusion that while the learning experience of individual learners may be limited by *Second Life* skill acquisition, these skills did not limit the engagement for the majority of learners in this case study.

It is interesting to note that of the *Second Life* tools that were identified as barriers, three (**SL building**, **SL objects – no heading** and **SL voice**) were identified by the same participant (1-1). The same participant identified two other 'technical' barriers. Additionally they associated some of their technical difficulties with **user error**. While this participant had no previous experience using *Second Life*, none of those interviewed had any previous experience either.

User error was also identified in other units coded at 'technical' barriers (**multiple steps**, **S4SL to SLurtle** and **SL avatar**). One interpretation of this information is that user error was a factor in the manifestation of these technical errors. Another may be that with so many technical skills to master, user error became more likely. The **multiple steps** which were required to transfer codes from S4SL to the SLurtles (**S4SL to SLurtle**) appeared to be a temporary barrier. However there were no reports of the transfer of code from S4SL to other objects in *Second Life* limiting learners. As such, during learners' initial engagement in the learning experience they may have focused on the transfer of code to SLurtles to create objects and when they came to programme objects they had mastered the necessary skills.

- If learners do not have pre-existing experience of *Second Life*, then while they may be limited by the use of an avatar, other technical skills are unlikely to negatively affect their learning experience.

- If there are too many technical skills to learn, then these skills as well as user error may become barriers.
- If learners perceive the multiple steps to transfer code from S4SL to SLurples as a barrier, then this is typically only a temporary barrier.

6.7.1.4 Outcomes

Six participants identified outcomes to the barriers they encountered during the learning experience. These outcomes were mostly described in terms of the learners’ disengagement with the learning experience. Limitations to the **design** of the artefact and difficulties with **programming** were also likely outcomes. It should be noted that while value neutral terms are used for coding and they should be prefixed by ‘barriers to’.

While some outcomes were associated with others there was no directional relationship between them (Figure 6.12). Through the cross-tabulation of codes, three other outcomes were found to co-occur with barriers to **programming**: limited association of the learner to their avatar, reduced **engagement in the learning experience** and barriers to **problem solving**. The disassociation of the learner from their avatar also co-occurred when learners reported limited engagement. As there was no directional relationship between codes, these associations were further explored on an individual participant basis. This indicated that all three participants who identified barriers to **programming** also identified barriers to **engagement in the learning experience**. Two of these also identified barriers to **problem solving**.

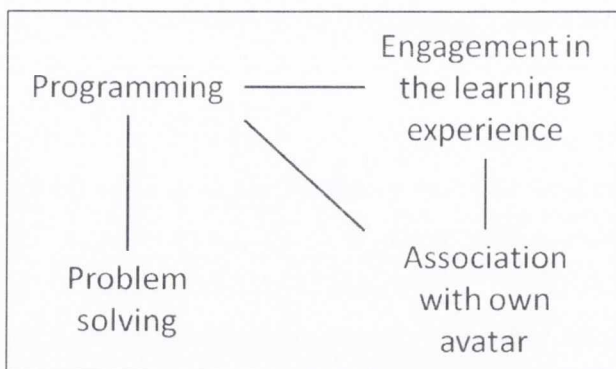


Figure 6.12 Representation of associated outcomes of barriers

Associations between the limited **engagement in the learning experience** and other outcomes could be anticipated as the avatar, programming and problem solving could all be considered to be part of the wider learning experience. Similarly **problem solving** is an important aspect of **programming**. Based on these results there are some tentative inferences that may be drawn:

- If learners identify the outcome of a barrier, then it may be a barrier to engagement in the learning experience.
- If learners do not associate themselves with their avatar, then their learning experience may be limited.
- If learners experience barriers to programming, then they may also be limited in their engagement with the learning experience.
- If learners experience barriers to problem solving, then they may also have difficulties with programming.

6.7.1.5 Interviews not coded at outcomes

Three interviews did not identify outcomes of the barriers. These were however all coded at 'personal' barriers and two had identified temporary barriers at the beginning of the learning experience, coded **initial**. The latter interviews were with the only participants with any previous knowledge of programming within the sample. Of these, one self-reported experience of both reading and writing code, while the other self-reported limited experience of reading code.

The experienced programmer identified in both interview and reflections that the only barrier they encountered was their initial perception of *Second Life* but there were no outcomes. The participant with limited experience of programming only identified their **perception of SLurples** as a barrier in the interview however in their reflection document the **computer** was also reported to be a barrier for this participant. The code **computer** was a broad code which encapsulated computer related barriers such as problems with graphics cards and hard disk failure. These findings suggest that:

- If learners are experienced programmers, then they may only be limited by temporary personal perceptions of the technology.
- If learners have some experience of programming, then technical skills related to the *Second Life* and S4SL might be learned quickly and therefore not identified as barriers.
- By comparison: If learners have no experience of programming, then they might identify technical skills as barriers.

6.7.1.6 Barrier type and outcomes

In total 36 units identified both barriers and their outcomes. Technical barriers were associated with all outcomes except for limited **peer support** which was associated with personal **expectations** of the learning experience. Personal barriers were associated with five of the nine outcomes. However not all barriers had a clear effect on the learners' experience.

The cross-tabulation of barrier type and outcome (Appendix D), suggests that some barriers had multiple outcomes. For example, learners’ personal **expectations** of the learning experience appeared to be a barrier to **design** and limited learners’ perceptions of support within their group. Both **user error** and the technical use of the avatar were identified as barriers to learners’ association with their own avatar, **engagement in the learning experience** and **programming**. Finally, the lack of any clear heading on objects created in *Second Life* was associated with difficulties in **problem solving** and **programming**. The links between these barriers and outcomes are illustrated in Figure 6.13 in which arrows indicate potential directional relationships between barrier codes and their outcome codes.

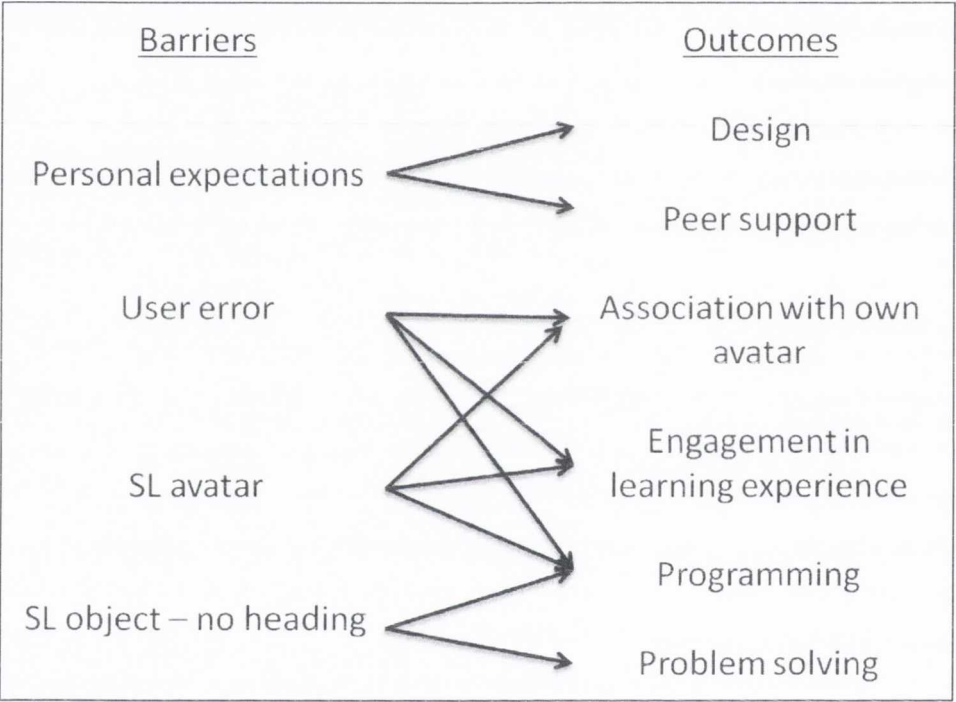


Figure 6.13 Illustration of barrier codes and associated outcome codes.

Some outcomes were also associated with multiple barriers as illustrated in Figure 6.14. **User error**, control of the **avatar** and learners’ perceptions of *Second Life*, were all linked to the sense of disassociation from the learners’ own avatar. Barriers to collaboration included the **virtual** nature of the learning experience and when the group dynamic was perceived to be that of two individuals working on the same project.

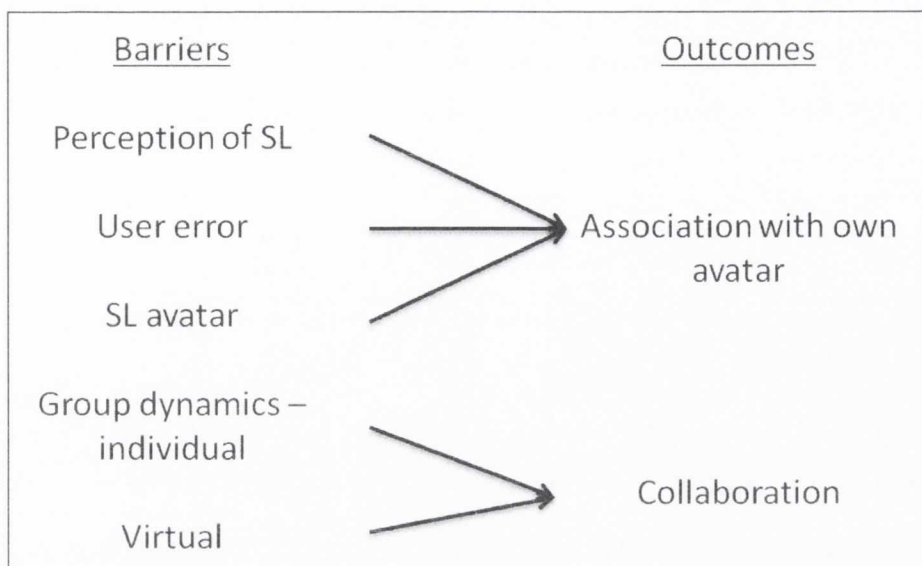


Figure 6.14 Illustration of the multiple barrier codes linked to the codes ‘association with own avatar’ and ‘collaboration’.

In total there were nine barriers to **design** identified across the three categories: learning experience (**size of construction space** and **SLurtle**); personal (**expectations**, **past experience**, **perception of own ability**, **perception of SLurtles**, **thinking in the abstract** and **time pressure**); and technical (**S4SL**), suggesting that all three forms of barrier could impact the design of the learners’ artefacts. While a wide range of barriers appear to limit the **design** of the artefact, the majority of codes co-occurring with **design** were personal barriers. From this it may be inferred that in a similar case, the **design** of the artefact is most likely to be affected by **personal** barriers.

The cross-tabulation of so many codes with **design** may be due to of the focus of the task, which was to create an interactive installation. As such, learners may have been particularly aware of barriers which limited their achievement of this tangible outcome of the learning experience. Although **design** was identified as an outcome in only four of the nine interviews, it should be noted that no outcomes or technical barriers were identified in three of the remaining five interviews.

Disengagement in the learning experience was most commonly associated with technical barriers (**user error**, **cognitive overload**, **computer** and **SL avatar**), an important consideration in constructionist learning experiences which aim to lower the barriers to learners’ engagement through ‘invisible’ tools. Another important aspect of constructionist learning experiences is **programming**. There were multiple technical barriers to **programming**: **user error**, **cognitive overload**, the avatar and objects which lacked a clear heading. However **programming** was not

associated with these barriers in the validation process, which instead identified the following personal barriers: **past experience**, **perception of SLurtles** and **thinking in the abstract**. There were also multiple barriers to **problem solving**, such as learners working individually rather than together (**group dynamics – individual**) and objects’ lack of a clear heading. Figure 6.15 illustrates the technical barriers to engagement in the learning experience, programming and problem solving.

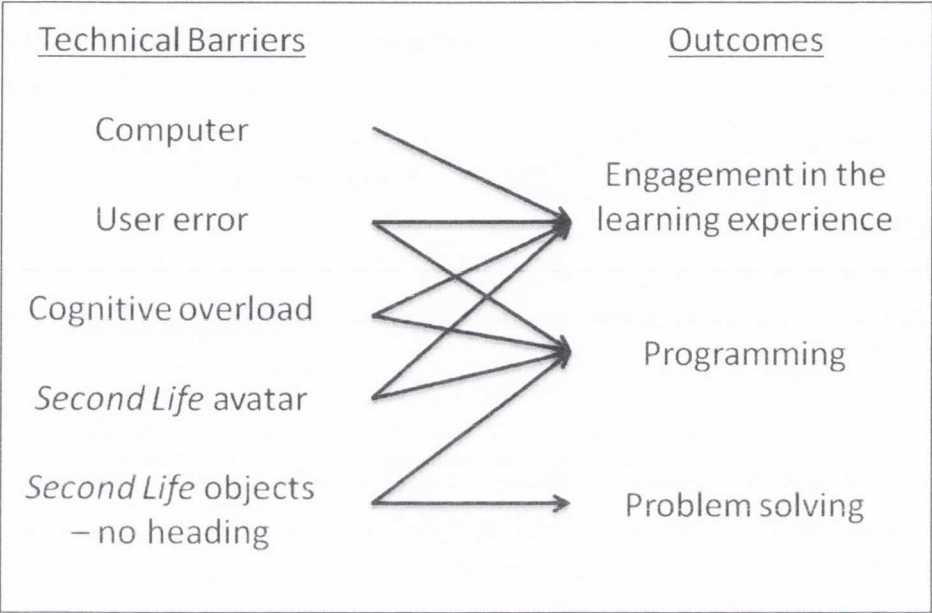


Figure 6.15 Illustration of technical barriers to engagement in the learning experience, programming and problem solving.

Considering the strongest associations between barriers and their outcomes, the following set of inferences is drawn from this analysis:

- If learners identify their avatar as a barrier, then they may experience disassociation from their avatar.
- If learners experience user error and technical skill barriers to using their avatar, then they might experience disassociation from their avatar, problems with programming and engagement in the learning experience.
- If a pair becomes two individuals working separately, then this may limit collaboration and problem solving.
- If *Second Life* objects are programmed by a learner, then the lack of heading of the object may hamper problem solving and programming.
- If learners’ personal expectations are not met, then they may feel that peer support did not occur.

- If learners identify barriers to the design process, then these barriers may be personal barriers such as perceptions and expectations.

6.7.1.7 *Duration*

Barriers and their outcomes could be either coded as **initial**, and therefore temporary at the start of the learning experience, or **ongoing**. In total, seven of the nine interviews were coded at **duration** and all of these were coded at **initial** although a few participants also identified ongoing barriers and outcomes. Both personal and technical barriers were predominantly **initial**, with only the avatar identified as both a temporary and **ongoing** barrier across the interviews. From these findings the following inference is drawn:

- If learners experience technical barriers, then they may only be temporary.

The only other barrier to be ongoing throughout the learning experience was when learners worked as individuals rather than together. Although this only occurred in one unit, this unit was also coded at **collaboration** as an outcome. This suggests that the outcome of the ongoing group dynamic was that collaboration was negatively affected. The only other outcome of a barrier that was given a duration was limited **engagement in the learning experience** which was only temporary, however there is no clearly associated barrier and as the previous subsection demonstrated, **engagement in the learning experience** may be associated with multiple technical barriers. Thus only one broad inference is drawn:

- If the group tends towards learners working individually, then this may be an ongoing barrier to collaboration.

While there were several types of barriers identified as temporary, there was additional evidence to support the association of learners' perceptions of *Second Life* and thinking in the abstract as initial barriers from learners' reflections. This suggests that:

- If learners' perceive *Second Life* to be a barrier, then this may be temporary.
- If thinking in the abstract is a barrier, then this may be an initial barrier, overcome during the learning experience.

6.7.1.8 *Overview of inferences on barriers*

The inferences drawn from the results of the analysis, supported by the analytical constructs and validation process, highlight some potential associations between barriers and their outcomes. Although none of the participants from whom data was collected had any previous experience of *Second Life*, there was no single technical barrier identified by all participants. This suggests that previous experience of *Second Life* was not a factor.

All learners experienced personal barriers but not technical barriers. While both personal and technical barriers negatively affected learners’ experiences, it is beyond the scope of this research to suggest which was the most influential. As such future research involving a large sample may examine the personal factors, such as past experience. This is further explored in the discussion section (6.8) which follows.

Figure 6.16 provides an overview of the inferences drawn in the above findings, highlighting the three most commonly occurring barrier codes (**expectations, perception of SLurtles and SL avatar**) and the three most commonly occurring outcome codes (**design, programming and engagement in the learning experience**). The most common barriers and outcomes are marked by a *. Arrows illustrate potential directional associations between individual barriers and outcomes, while lines between codes highlight possible associations without any suggested directional influence.

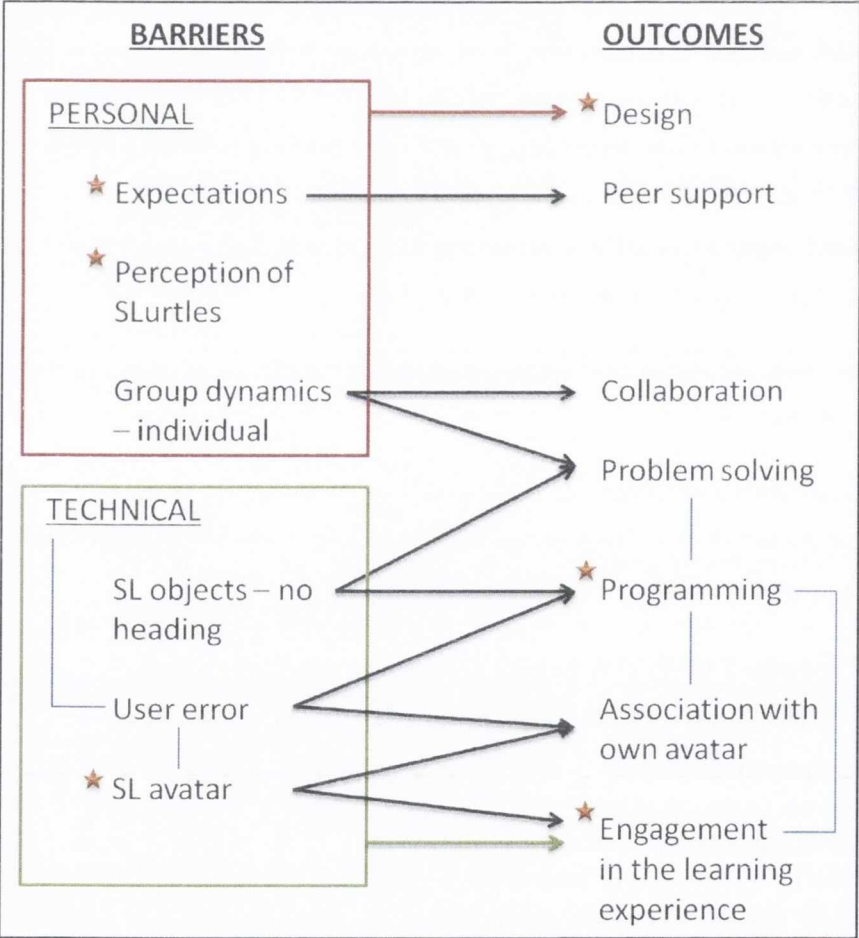


Figure 6.16 Illustration of ‘barriers’ inferences

The inferences illustrated in Figure 6.16 highlight links between several barriers and their outcomes. In the discussion section (6.8) these inferences are used to answer the research question:

- How do barriers affect constructionist learning experiences in non-goal orientated virtual worlds?

6.7.2 Avatars

As illustrated in Figure 6.17, within the context of ‘avatars’ three categories were identified: ‘behaviour’, ‘social interaction’ and ‘tool’. ‘Social interaction’ is sub-categorised into ‘identity’ and ‘visual representation’.

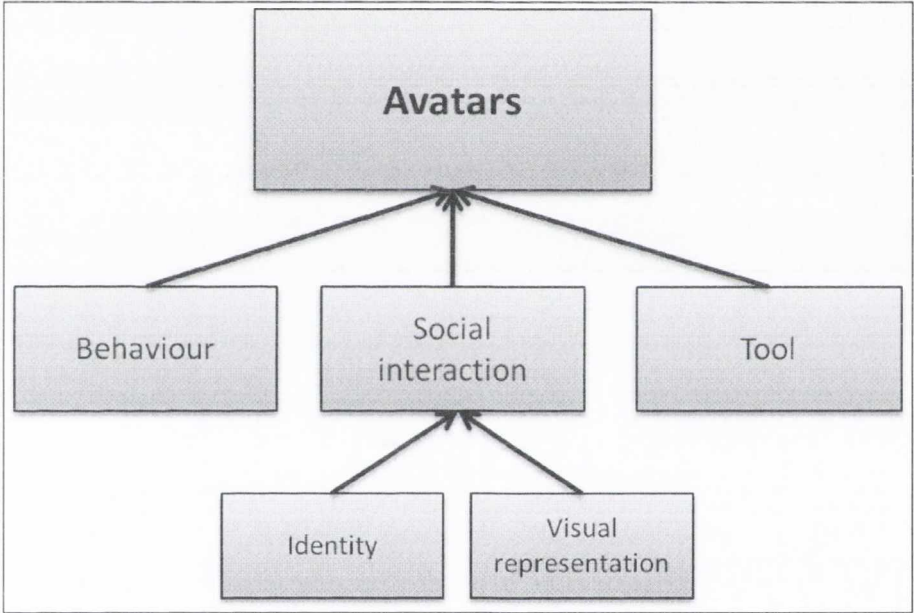


Figure 6.17 Representation of categories and sub-categories in 'avatars'

Behaviour was referred to by six of the nine interviewees, while all but one participant brought up social interactions whilst discussing the role of avatars in the learning experience. Finally, all interview participants referred to their avatar as a tool, whether to be learnt or to do things with. The following sub-sections describe the findings, presenting inferences about the case as ‘if-then’ statements.

6.7.2.1 Behaviour

While comparisons were made between avatar behaviour and the behaviour of people in the physical world, **etiquette** was the most frequent behaviour code. Six of the nine interviews were coded at **etiquette**. Through cross-tabulation (Appendix E) with ‘social interaction’ and ‘tool’ codes, **etiquette** was found to co-occur with **co-presence** and the sense of a positive

personal connection to the avatar (**personal connection positive**), suggesting a possible link. By examining the cross-tabulation of codes by interview, **etiquette** was found to be coded at four interviews that identified a positive connection with their avatar, one negative connection and the only interview not coded at either positive or negative personal connection. In addition to this, the code **emotional response to other avatars behaviour** was only coded in those interviews also coded at **personal connection positive**. Therefore the following inference was drawn:

- If learners experience a positive connection with their avatar, then they might have a sense of or need for in-world etiquette between avatars and may have an emotional response to others' behaviour.

6.7.2.2 Social interaction

Co-presence was coded in eight of the nine participant interviews and coded at 21 units in total. As such it was one of the most commonly assigned codes within the context of 'avatars'. It was also coded in participant 2-1's interview, who did not have a partner during the learning experience. This suggests that participants did not limit their interactions to only their partner, which is supported by evidence from the participant-observations.

Within the category of 'social interaction', **co-presence** co-occurred with **control**, **knowing who** and **recognition of other avatars**. While there may be some expectation that these codes would be linked, there was no evidence to support any connection. Thus the only inference made is:

- If learners engage in social interaction via their avatars, then they may experience a sense of co-presence.

6.7.2.3 Avatar as a tool

All participants described using the avatar as a tool and all but one identified either a positive or negative connection to their avatar during the learning experience. As shown earlier in Table 6.5, the most frequently assigned codes were **personal connection positive** (with a frequency of 5 interviews and 22 units), **personal connection negative** (4 interviews and 20 units), although no specific question about this was asked during the interview.

Barriers to using the avatar, such as needing to spend time thinking how to move the avatar, were often identified by participants who described a negative connection with their avatar. Through cross-tabulation of codes (Appendix E), it was noted that the codes **barrier** and **personal connection negative** were the most commonly co-occurring codes with a frequency of seven. As **barrier** was only coded at 11 units, this suggested a potentially strong association

between these codes. Examining the cross-tabulation of codes by interview, three of the four interviews coded at **personal connection negative** were also coded at **barriers**. As **personal connection negative** was identified in the coding template at one end of a dimension, the opposite code, **personal connection positive** was also examined. Of the five interviews coded at **personal connection positive**, none were coded at **barriers**. While this suggests a particularly strong link between perceived barriers to the use of the avatar and the learners' sense of personal connection to their avatar, there was one participant that did not fit this pattern. This participant (10-1) was the only one coded at **personal connection negative** that was not coded at **barrier**.

While barriers to the use of avatars were associated with a negative connection to the avatar, those learners who had gained mastery over the use of the avatar described a positive connection to their avatar. The only other code within the category 'tool' which co-occurred with either positive or negative personal connection codes was **skill automation**. This referred to skills required to use the avatar, such as avatar movement, which the learner was able to use without consciously thinking about it. Interestingly this code co-occurred with **personal connection positive**. While these codes only co-occurred twice, they were only assigned four times in total. The cross-tabulation of codes to interviews (Appendix F) shows that where the codes did not co-occur at the same unit, **skill automation** was only assigned to interviews which were also coded at **personal connection positive**, providing more evidence of an association between these codes.

From these results the following inferences are derived:

- If learners experience a negative connection with their avatar, then they may experience barriers to using the avatar as a tool.
- If learners experience a positive connection with their avatar, then they are unlikely to experience barriers to using the avatar.
- If learners experience a positive connection with their avatar, then they may have automated associated skills.
- If learners experience a negative connection with their avatar, then they may not have automated associated skills.

6.7.2.4 Avatar as a tool for social interaction

The above inferences draw attention to the potential importance of the personal connection that participants had with their avatar. As such both positive and negative personal connection codes were the initial focus of the cross-tabulation of **tool** and **social interaction** codes (Appendix E).

Personal connection positive co-occurred with four **social interaction** codes. Of these, **co-presence** and **presence** co-occurred with the highest frequency. **Presence** describes a sense of being in the virtual world, while **co-presence** describes a sense of being with other people in the same space. The co-occurrence of codes suggests a possible association and this lead to further examination of these codes through cross-tabulation of codes with interviews (Appendix E). This showed that while **co-presence** was coded in eight of the nine interviews, **presence** was only coded at interviews coded at **personal connection positive**, strengthening the association.

By comparison, **personal connection negative** did not co-occur in units with social interaction codes. However participants who described in their interviews a negative personal connection to their avatar highlighted the importance of **knowing who** the person was behind other avatars that they met. Interestingly they also described a sense of **co-presence**. Although they were not coded at the same unit, being coded in the same interview suggests that while these participants had a negative connection to their avatar this did not prevent a sense of co-presence with others. However none of these interviews were coded at **presence** suggesting that there is an association between the learners' personal connection with their avatar and their own sense of presence within the environment. While the results of the cross-tabulation may lead to the assumption that those who had a negative connection to their avatar had a greater need to know who the people behind other avatars were, there is insufficient data to draw any inferences.

It is interesting to note that when referring to the coding by interview (Appendix E) two of the four interviews in which the avatar was described as a tool **with which to act in the virtual world** were also coded at **presence** and **co-presence**. The other two were coded at **personal connection negative** and **co-presence** but not **presence**.

From this analysis of 'social interaction' codes co-occurring with the codes **personal connection negative** and **personal connection positive** the following inferences are drawn:

- If learners have a positive connection to their avatar, then they may experience both a sense of presence in the environment and co-presence with other learners.
- If learners have a negative connection to their avatar, then they may not experience a sense of presence in the environment.
- If learners have a negative connection to their avatar, then they may experience a sense of co-presence with other learners.

The only participant (4-1) not to be assigned any codes under the categories of 'social interaction' or 'behaviour' was the only participant that provided units for analysis under the

context of ‘avatars’ in their reflection. This suggests that the avatar was particularly important for the learner as reflections tend to focus on what is personally meaningful to the learner. Although only one unit was coded, it was coded at **barrier**. Their interview was also coded at **barrier** as well as **personal connection negative** and was not assigned any other code. While insufficient to draw any strong inferences, this suggests that:

- If barriers to the use of the avatar are particularly strong, then learners may be unable to engage in social interactions through their avatar.

This may explain why this was the only participant with no data coded at **co-presence**, however this is an assumption with insufficient data to draw any firm inferences.

6.7.2.5 Overview of inferences on avatars

The inferences drawn from the data analysis highlight some potential associations between the learner’s personal connection to their avatar and the role of the avatar in the learning experience. Table 6.6 presents an overview of the connections between codes and personal connection, whether positive or negative. Those coded green may occur and those in red are less likely to occur.

Table 6.6 Tendency of codes occurring in relation to the learner's personal connection with their avatar

	Positive Personal connection	Negative Personal connection
Sense of presence	Green	Red
Sense of co-presence	Green	Green
Sense of/need for etiquette	Green	Red
Emotional response to behaviour	Green	Red
Automated skills	Green	Red
Barrier to use of avatar	Red	Green

This highlights that learners with a positive personal connection to their avatar are more likely to experience a sense of presence in the NGO-VW; a need for etiquette; an emotional response to other avatars; and have automated skills in the use of their avatar. They are unlikely to experience barriers to the use of the avatar. By comparison those with a negative connection to their avatar are more likely experience barriers to the use of their avatar. Finally, learners are as likely to experience a sense of co-presence with other learners in the virtual world

whether they have a positive or negative connection to their avatar. It should be noted however that these inferences are not directional.

In the following discussion, these inferences are used to answer the research question:

- What role does the learner's avatar play during a distributed constructionist learning experience in non-goal orientated virtual worlds?

6.8 Discussion

Focusing on barriers to the learning experience and the role of the avatar, the two research questions guiding this case study are:

- How do barriers affect constructionist learning experiences in non-goal orientated virtual worlds?
- What role does the learner's avatar play during a distributed constructionist learning experience in non-goal orientated virtual worlds?

The answers to these questions are presented in the conclusion of this chapter (6.9). In order to answer these questions, subsidiary questions were developed for each. These sub-questions are answered in the following sub-sections through discussion of the findings and current literature.

6.8.1 Barriers

In order to gain a greater understanding of the barriers which limit learners' engagement in SLurtle-based constructionist learning experiences the following research question was posed:

- How do barriers affect constructionist learning experiences in non-goal orientated virtual worlds?

To answer this question, three subsidiary questions are posed:

- What barriers do learners experience?
- Can the barriers identified in the first case study be generalised to other cases?
- What are the outcomes of the barriers identified?

6.8.1.1 *What barriers do learners experience?*

In total 24 barriers were identified by learners, sub-divided into three categories: learning experience, personal and technical. Barriers under the heading of the learning experience focused on the design of the SLurtle-based activity and not aspects of the wider context such as the introduction of NGO-VWs for teaching and learning.

The design of the learning experience created barriers for only two participants. Importantly one of these did not have a partner to work with although the learning experience was designed for learners working in pairs. As such it would appear that if small groups of learners were to participate in a similar learning experience they would be unlikely to experience barriers related to the design of the learning experience. However if learners work independently then the learning experience would need to be redesigned, as previously suggested in Chapter 3.

All learners experienced personal barriers, while only some experienced technical barriers. In total nine barriers were identified as personal barriers. These describe the personal and interpersonal barriers identified by learners, ranging from external time pressures to personal expectations and perceptions.

The remaining 12 barriers were identified as technical barriers. Those categorised as technical barriers focused on the technical skills required in order to participate in the learning experience. These barriers tended to focus on *Second Life* skills and in particular the use of the avatar. Inferences drawn from the data suggest that these technical skill barriers were also associated with user error. It is unclear from the data whether this is due to cognitive overload, multiple steps to complete tasks or other factors. However technical barriers were also found to be temporary barriers, therefore learners may simply require additional time to learn the skills, allowing them to overcome these barriers prior to engaging in a SLurtle-based constructionist learning experience.

Having identified the barriers which learners encountered during the learning experience, to further develop the answer to this sub-question, this discussion examines the relevant literature. Although broadly based on the reflections of participant-researchers, rather than data collected from learners, the literature identifies technical barriers as one of eight broad areas under which most barriers to the educational use of NGO-VWs can be classified (Warburton, 2009). In-world skills such as avatar movement and communication (Sanchez, 2007; Cheal, 2009; and Jarmon et al, 2009) formed a common sub-set of the technical barriers identified, which is comparable with the findings of this study.

Unlike Sanchez (2009b) and Allison et al. (2010) there was no evidence in this study to suggest that programming or construction were barriers to the learning experience. As found in the first case study, SLurtles provide learners with a low-floor, high-ceiling and wide-wall construction tool. This was used by learners in conjunction with S4SL which is designed to provide a low-floor visual programming environment. However it is interesting to note that when programming objects other than SLurtles, learners experienced barriers to programming

which were associated with the lack of heading of the non-SLurtle object. User error was also a barrier to engaging in programming and this is discussed further in the following sub-section (6.8.1.3) answering the sub-question: What are the outcomes of the barriers identified?

Warburton (2009) also identifies time as a potential barrier. Savin-Baden et al. (2011) note that in order to acquire the in-world skills necessary to fully engage in learning experiences in NGO-VWs, those without previous experience of the technology may require more time than anticipated by the educator to become familiar with the technology. While none of the participants interviewed had any previous experience of using *Second Life* and all had been provided with the same introduction to the technology, some learners may have spent additional time practicing skills than others. This could explain why some learners experienced technical skill barriers that others did not. However there is no data available to support this hypothesis and there may be other factors to consider.

As previously noted in the literature review (Chapter 2), Savin-Baden et al. (2011) found that avatars distracted some learners, however the quotes presented suggest that this was a skill barrier, rather than due to embodiment as an avatar. The findings of this study support the hypothesis that it is the technical skills required to use the avatar which can be a barrier. Warburton (2009) describes virtual and physical identities as a key area which may be a barrier to engagement in learning experiences. Although the skills required to use the avatar were identified as a potential barrier to engagement in the learning experience, there was no evidence to suggest that identity was a barrier to learning. The role of the avatar is further discussed in 6.8.2 which follows.

Warburton (2009) identifies a further five key areas under which most barriers can be classified: Culture, collaboration, economic, standards and scaffolding persistence and social discovery. There was no evidence to suggest that these areas limited the learning experience at all.

6.8.1.2 *Can the barriers identified in the first case study be generalised to other cases?*

The barriers identified in the first case study can be generalised to other cases in which similar groups of learners engage in similar learning experiences. Although codes were re-categorised or re-named, most of the barriers identified in the first case study were also identified in the second case study. The barriers identified in the first case study formed an *a priori* set of 27 codes with which to begin analysis of the data. The final coding template included 24 types of barrier codes, sub-categorised into learning experience, personal and technical.

Two barriers identified in the first case study were not identified in the second case study:

- Permission system
- Camera controls

The permission system was identified in the first case study as a particular barrier to the collaborative construction of artefacts, particularly scripting. As scripting both SLurtles and the objects they created were of particular importance to the learning outcomes, the learning experience (6.4) was redesigned to include a particular focus on the mechanisms within *Second Life* to share both objects and scripts. The results of this case study suggest that this intervention was successful as the permission system was not identified as a barrier by learners.

Similarly a short activity was designed for learners to practice their camera skills. Camera controls were also not referred to in the interviews suggesting that the addition of this activity may have reduced this barrier. Therefore, while many of the barriers identified in the first case study were identified in the second, which suggests that they could be generalised to other similar cases, changes in the design of the learning experience and context of the learners may reduce or potentially increase the technical barriers encountered by learners.

6.8.1.3 What are the outcomes of the barriers identified?

There were a number of outcomes to the barriers which learners encountered during the learning experience. The most prominent of these were reduced engagement in the learning experience, difficulties with programming and limitations to the design of the learners' artefact.

The inferences drawn from the data suggest that of the 24 barriers only five had clearly associated outcomes. For example, personal expectations could result in peer support difficulties. The remaining four barriers were associated with two or more outcomes. Groups in which learners felt like they were working on their own rather than with another person could result in a group dynamic barrier. This could be an ongoing barrier to collaboration and was also associated with difficulties in problem solving.

Another barrier to problem solving was the lack of heading of *Second Life* objects. Unlike the SLurtle, objects may not indicate their heading and as such became a barrier to both problem solving and programming. It is perhaps unsurprising to note that learners who experienced barriers to problem solving were also likely to experience barriers to programming. However there were other factors which were identified as barriers to programming, in particular user error.

As previously mentioned, user error was associated with general technical skill barriers and there may be a causal link, however there is insufficient data to draw such a conclusion. Whether these barriers are associated with tasks that require multiple steps or cognitive

overload due to the number of new skills to be learnt and used is unclear. It is also possible that other factors are influential. However as user error is identified as a potential barrier to both general engagement in the learning experience and programming, which is a key aspect of the learning experience, it is a particularly important barrier to be addressed in the design of the learning experience.

The technical skills required to use an avatar could also be a barrier to engagement in the learning experience. However it is interesting to note that these technical skills also became a barrier which limited some learners' sense of association with their avatar. This point is further explored in the following sub-section discussing the role of the avatar in the learning experience.

The general literature lacks an understanding of the influence of barriers experienced by learners on learning experiences. Although small scale, this study suggests potential links between barriers and outcomes from the perspective of the learners in this case. As previously described in the review of the literature, most authors that address this issue speculate on the effect of barriers on learners. For example, staff involved in the *PREVIEW* project (Savin-Baden et al., 2011) stated that the user interface required significant effort to learn and that this could be a barrier to learners' engagement in learning. However there was no evidence to suggest that learners' engagement in the learning experience was diminished by learning these skills.

In the case study presented in this chapter, beyond the initial introduction to *Second Life* prior to the learning experience, there is no data available to indicate the amount of time or effort spent by participants in order to learn how to use *Second Life*. Similarly there is no evidence to suggest whether other factors may be involved. However those learners who had not overcome the technical skill barriers required to use *Second Life* during the learning experience, were more likely to be limited in their engagement in the learning experience, which is an important consideration for educators.

6.8.2 Avatars

The second research question focuses on the role of the avatar and is answered through three sub-questions:

- What role does the learner's avatar play during a distributed constructionist learning experience in non-goal orientated virtual worlds?
 - What are the factors that influence the use of the avatar?
 - How does the avatar influence interactions between learners?
 - What are the outcomes of using an avatar?

6.8.2.1 *What are the factors that influence the use of the avatar?*

There are two key factors that influence the use of the avatar: the learners' level of technical skills in using the avatar; and a learners' sense of personal connection to their avatar both influence how the avatar is used. The findings of this research suggest that these factors are interconnected.

Those learners that described gaining automaticity of controls for using the avatar had much stronger personal connections to their avatars than those who focused on the difficulties they had in using the avatar. Automation of controls is associated with the second level of immersion, in which the user has overcome initial barriers such as learning controls and these controls have become 'invisible' (Brown and Cairns, 2004). This suggests that it may only be after the avatar controls have become 'invisible' that learners are able to experience a personal connection to their avatar.

The findings show that learners who experienced barriers to the use of their avatar typically disassociated themselves from their avatar. As such, learners described their avatar as an independent character over which they had little control. There was no evidence to suggest that this was associated with using the avatar to experiment with a different identity, as suggested by Taylor (2002), however there was reference to the avatar in the 3rd person. This highlights an area requiring particular attention from designers of constructionist learning experiences in NGO-VWs. Whether this should be through providing additional activities focusing on skills such as walking and flying or customising the appearance of avatars may depend on the learning context.

It is also unclear as to the directionality of the association between these two factors, which would affect whether avatar controls need to become invisible or whether learners' preconceptions need to be addressed first. Thus future research may be necessary to examine learners' preconceptions and whether these influence how learners feel about their avatar and in turn influence their acquisition of technical skills.

The connection between avatar and user may be influenced by similar factors to those which influence notions of identity. While there were references to identity in this study, there was insufficient data to draw inferences between identity and personal connection. However Adams et al. (2011) found that learners' identities in the NGO-VW were constrained by existing notions of what it is to be a student and how to learn. Learners may have similar preconceptions or beliefs about people who use virtual worlds and have a connection with their avatars, which could influence their own personal connection to their avatar.

6.8.2.2 *How does the avatar influence interactions between learners?*

Avatars provide learners with a tool or representation of themselves within the learning environment with which to interact with others and act upon the world. Represented by avatars, learners experience a sense of co-presence when interacting with others regardless of their emotional connection to the avatar. It is this co-presence that supports communication between learners.

A learner's personal connection to their avatar appears to be related to the learners' experience of presence in the NGO-VW, emotional response to others' behaviour and expectations of etiquette. Notably learners with a positive connection to their avatar were more likely to experience these interactions between learners, than those with a negative connection to their avatar.

6.8.2.3 *What are the outcomes of using an avatar?*

Those learners that expressed a positive connection to their avatar experienced a sense of presence within the environment, had emotional reactions to the behaviour of other avatars and were aware of in-world etiquette. By comparison those learners that did not form a positive connection with their avatar did not have these experiences and instead were aware of the barriers surrounding the use of the avatar.

6.9 Conclusion

This case study focused on answering two research questions:

- How do barriers affect constructionist learning experiences in non-goal orientated virtual worlds?
- What role does the learner's avatar play during a distributed constructionist learning experience in non-goal orientated virtual worlds?

In order to answer these questions the previous discussion focused on answering the sub-questions for each question. This section draws together the answers to these sub-questions to answer the main research questions. Following this the limitations of the study and areas for future research are discussed.

6.9.1 Barriers

While barriers to the educational use of NGO-VWs have been reported in the literature, they tend to focus on educator perspectives and assume barriers for learners. Additionally they have not identified the outcomes of such barriers. This study has identified that technical barriers may have a wide range of outcomes, from limiting engagement in the learning experience to programming and the disassociation of learners from their avatars. As key

features of constructionist learning experiences, approaches to limit the associated technical barriers need to be explored by the designers of constructionist learning experiences in NGO-VWs.

Learners who experience barriers to using their avatar may disassociate themselves from their avatar. User error may also be a factor. However the findings suggest that user error may be more likely when learners have difficulty with the use of NGO-VW tools such as the avatar. This may be as a result of cognitive overload due to engaging in a learning experience using unfamiliar tools. Those who experienced user error also encountered barriers to engaging in programming in S4SL and general engagement in the learning experience. Again the user's avatar may also be a factor.

As programming is central to the design of the learning experience, barriers to programming require careful consideration during the design of constructionist learning experiences in NGO-VWs. This study found evidence to suggest that barriers to problem solving could affect programming as well as user error and the avatar. If the barriers which are specific to NGO-VWs cannot be overcome, the use of NGO-VWs for constructionist learning requires careful reconsideration. However if they are anticipated, approaches can be developed to reduce these barriers. As such, further research is necessary to carefully examine the barriers to programming learners encounter in-world.

Barriers to problem solving included personal barriers. However, while a range of personal barriers were identified, few were clearly associated with outcomes. As such it is difficult to draw any firm conclusions as to how these barriers affected the learning experience. However collaboration and problem solving did appear to be limited when learners perceived the group dynamic to be that of two individuals working separately in the same space. Considering the findings of the first case study, this dynamic was not unexpected. The first case study identified that individuals within groups might work independently rather than collaboratively if they perceived an imbalance within the group. This was also associated with a lack of communication and loneliness. It may be that by not addressing the imbalance, which leads to the individual group dynamic, those participants in the second case study did not engage in communication about problem solving.

The results of this study provide an insight into the barriers that may be experienced by learners engaging in learning experiences in NGO-VWs. However the nature of the research limits the richness of understanding of the case and the extent to which generalisations could possibly be made to a similar group of learners in a similar context and the same learning experience. The findings do not indicate which factors relating to the participants, context or

design of the learning experience may influence the barriers and associated outcomes that learners identify.

6.9.2 Avatars

Unlike traditional constructionist environments, such as *Scratch*, NGO-VWs provide users with avatars with which to interact with other people and objects. The first case study concluded that avatars were an important feature for distributed constructionism in NGO-VWs, enhancing the sense of constructing and sharing artefacts with others. As such it is important to develop our understanding of the role of the avatar in distributed constructionist learning activities.

This study has found that while engaging in distributed constructionism in NGO-VWs, avatars provide learners with a sense of co-presence with others whether or not learners experience a sense of presence or personal connection to their avatar. This suggests that regardless of learners' personal feelings about being represented as an avatar, they have a sense of being co-present with others; sharing, discussing and constructing artefacts together. This resonates with Taylor's (2002) suggestion that it is only through social interaction that users feel present in the virtual world, however in this study the participants indicated a distinction between presence and co-presence. As Schroeder (2011) notes, at this time we do not know enough about presence and co-presence and thus no firm conclusions can be drawn.

While the perceived educational affordance, embodied social presence, was identified from the literature and used in the alignment of pedagogy and technology, there is no suggestion in the literature that social presence requires synchronous communication with avatars in the same location. However this study suggests that learners may not experience a sense of presence in the virtual world via their avatar when alone. Instead they experience co-presence when they engage in social interactions with other avatars that are present in the same location at the same time.

Although distinctions between embodied social presence and co-presence may appear to be slight, this study suggests that this may be an important distinction as not all learners experienced a sense of presence. Those learners that did not experience a sense of presence had a negative association with their avatar and described barriers in the use of the avatar as a tool; however, they were able to engage in social interactions and through these interactions experienced a sense of co-presence.

Therefore embodied social co-presence, rather than embodied presence, is important in distributed constructionist learning experiences in NGO-VWs. This is made possible through the use of avatars, a feature unavailable in traditional constructionist environments.

6.9.3 Limitations

Data analysis

In Chapter 4 the limitations of using content analysis in the context of this case study are discussed. However it provided a framework to scaffold the analysis of data and as such the limitations of this approach should be considered alongside the conclusions drawn from the analysis.

While Krippendorff (2004) states that content analysis is often used in small studies with few data sets, there are limitations to this approach. The primary limitation encountered by this study was due to the sampling of data, which was opportunistic. Those participants available and willing to participate in interviews within the first four weeks following the end of the learning experience provided the primary data sources. However with only nine interviews statistical tests could not be applied to the frequency data produced through the reduction of qualitative data to a quantifiable form. Although frequencies of chance could be calculated, due to the low sample size and few co-occurring codes, the likelihood of obtaining a type-I error was high. Therefore it is unknown as to whether the associations between codes are the result of chance co-occurrence or not.

The use of content analysis together with the small sample size limits the richness of the description of the case which is one of the aims of any case study. Additionally, individual interpretation can introduce researcher bias despite rigour in the analysis process. Thus while a number of inferences are drawn no firm conclusions can be drawn. The directional arrows in Figure 6.16 suggest potential relationships in this case, however the relationships between barriers and their outcomes are likely to be much more complex than presented in this chapter. Those codes assigned to data and not discussed in the findings due to low frequencies; lack of co-occurrence; no validating data; and/or no analytical constructs, may be important factors in understanding both barriers and the role of avatars. Importantly the sample size is insufficient to accept that they may be irrelevant.

Due to these limitations, at most this study indicates potential associations and highlights the most common barriers in this case, as well as factors associated with the use of an avatar in a constructionist learning experience in a NGO-VW. At the very least they describe the interpreted experience of some learners which indicate areas for future research.

Data collection

Of the 13 individual reflections collected, 12 identified barriers but only 2 included references to avatars. This may be due to the original purpose and intended audience of these documents.

Written for assessment by the learner and to be read by the module co-ordinator, these factors would affect what the learners chose to include and exclude. As such they were treated as secondary sources and only used for validation. This meant that they did not necessarily address the issues focused upon in this study.

Participant-observation was also only used for validation as there were limited opportunities for data collection. As it was not possible to directly observe participants, the direct interaction of participants at the computer with the various in-world tools could not be recorded. However it was possible, through chat logs, to collect their conversations with the researcher and each other, when the researcher was present. As a result only one unit was identified under the context of barriers for each of six participants and none for avatar. However it is interesting to note that all units identified computer related barriers and occurred during conversations with the researcher. As such the presence of the researcher may have significantly influenced the data recorded.

Context

As a bounded case it is important to acknowledge the limitations of this research with regard to the context of the study. It should be noted that this case involved mature students enrolled in a 3rd level course, who had previously met face to face for a semester and continued to meet face to face. Although the learning experience was designed to be completed at distance, it is unknown the extent to which learners meet with their partner or others face-to-face or in-world as this was outside of the scope of this study. However as the avatar is considered to be an important feature of distributed constructionism, if learners met face-to-face to share, discuss and co-construct their artefacts, they may not have engaged in distributed constructionism but rather traditional constructionism. In addition, the barriers encountered may also be influenced. Similarly in a different context the design of the SLurtle-based constructionist learning experience may be quite different, as indicated in Chapter 3. It is unknown how context and design factors have influenced the results of this study.

This highlights the messy nature of case study research, in which a range of unidentified and uncontrollable factors may or may not influence the outcomes of the study. While outside the scope of this study, this may be considered in future research. However as described by Hargreaves (1997), educators may identify similar features between a case study and their own context, take the most relevant findings from the research and apply them to support their own educational setting.

6.9.4 Future research

This case study has identified a set of barriers that may be experienced by learners engaged in a specific form of a SLurgle-based constructionist learning experiences in NGO-VWs and these barriers are similar to those identified in the first case study. While potential outcomes of some of these barriers have been identified, there is insufficient data to draw any firm conclusions.

Constructionist learning experiences aim to provide low-floors for learners creating 'invisible' technology tools. However learning experiences need not be without barriers; although these barriers should be low-floor and therefore easily overcome. If these barriers present a high-floor barrier and limit engagement in learning, they need to be addressed in either the design of the learning experience or the choice of technology. In this case study some technical skills presented learners with a high-barrier which limited their engagement with the learning experience. However it should be noted that not all participants experienced technical barriers and thus future research involving a large sample may examine the individual factors, such as past experience, which may influence this outcome.

This study suggests an association between technical skill barriers and difficulties encountered by learners in engaging with programming, associating with their avatar as well as general engagement in the learning experience. However there is insufficient data to suggest that these outcomes are due to anything more than chance. Therefore further research is required, extending this study to multiple cases in which learners participate in constructionist learning experiences in-world. The coding template and approach to unitising data sources developed as part of this study could be applied across cases, creating a rich data set to which tests of statistical significance between associations could be applied. This research could provide evidence of those barriers which need to be clearly addressed in the design of constructionist learning experiences in NGO-VWs.

How these barriers are designed out will also require research. Due to limited contact time it may not be possible to address all barriers by adding activities or instruction. Some learners may find downloadable manuals useful, while others may prefer to access similar information in-world together with short activities allowing learners to practice these skills *in-situ*.

Focusing on the avatar, learners may experience a sense of embodied social co-presence through the use of an avatar. A sense of presence, awareness of the behaviour of avatars and automated skills may not be necessary to fully engage in and develop understanding during a constructionist learning experience. However the current study suggests that use of the avatar may be a barrier to engaging in constructionist learning experiences. Consequently, further research is necessary to understand whether these factors influence the perception of the

avatar as a barrier and with what outcomes. Other research questions to be addressed include: Is a positive connection associated with learners' perception of identity, whether augmentationist or immersionist? Do learners' pre-conceptions influence their self-reported association with their avatar? Can these factors be used to predict whether learners will identify the avatar as a barrier during the learning experience? Are skill barriers the only reason for learners experiencing a negative connection to their avatar? Semantic analysis may provide a particularly interesting approach for in-depth analysis of learners' descriptions of their avatar in use.

In distributed constructionist learning experiences the avatar may play a particularly important role, supporting social interaction through embodied social co-presence which can support the discussion, sharing and construction of artefacts. The only participant that did not identify co-presence was not coded under social interaction or any behaviour code. Whether each group interacted online was outside of the scope of this study. However future research could examine whether a negative personal connection or skill barriers prevent or limit social interaction in-world and whether this is associated with group-dynamics, peer support or collaboration.

Finally, as highlighted in the limitations, the nature of case study research results in a range of uncontrollable and potentially unidentifiable factors. However researchers need to remain open to emergent factors whilst educators need to consider individual differences in the design of any learning experience. Consequently, future case study research into these areas needs to remain open to emergent results and maintain careful consideration of the bounds of the case.

7 Discussion & Conclusion

7.1 Introduction

Non-goal orientated virtual worlds have the potential to provide an exciting new environment to engage in constructionist learning. With inbuilt construction and programming tools and without the boundaries of goal-orientated virtual worlds, learners can engage in a process of *bricolage* to construct personally meaningful 3D artefacts in order to explore, test and extend their understanding.

There is a paucity of literature on constructionism in action in NGO-VWs. While Chapter 2 demonstrates the theoretical alignment of technology and pedagogy, there are no results or findings reported in the literature that enhance our understanding beyond the theoretical propositions. There are also aspects of NGO-VWs unavailable in traditional constructionist environments. These lead to the question of whether constructionism is actually an appropriate pedagogy for use in NGO-VWs in practice.

To begin to shed light on the complexity of this issue, the dearth of literature in the area has necessitated a broad exploration into the pedagogy in action. Thus, the primary aim of the research presented in this thesis has been:

To explore constructionism in action in non-goal orientated virtual worlds.

To address this aim the following section presents the understanding of constructionism in action in NGO-VWs, developed through the research presented in this thesis. Aspects of this are then discussed in more detail; beginning with the theoretical alignment of pedagogy and technology, followed by barriers to engagement and finally opportunities for enhanced distributed constructionism. Beyond the primary aim, two further areas of interest emerged due to the requirements of the research: data collection and ethical approaches in NGO-VWs. These are considered under the sub-heading of 'further outcomes', prior to a discussion on future research.

7.2 Constructionism in non-goal orientated virtual worlds

The paucity of literature and the non-traditional features of the technology, led to the question of whether constructionism is actually an appropriate pedagogy for use in NGO-VWs and the need for an exploratory study. The research in this thesis has demonstrated that constructionism is indeed an appropriate pedagogy for use in NGO-VWs and highly successful when learners are provided with SLurtles to lower the barriers to engagement.

Constructionist theory posits that learning is most effective when learners engage in the construction of personally meaningful and shareable artefacts as they actively explore, test and extend their understanding (Papert, 1991). Artefacts develop *in-situ* over time through a process of *bricolage* and the construction process is facilitated through the use of 'invisible' technology (Papert, 1980s). Programming is also a central aspect of most constructionist learning experiences (Hoyles et al., 2002). As well as sharing artefacts, learners may also discuss and co-construct artefacts in distributed constructionism (Resnick, 1996).

Through alignment of pedagogy and technology, educators can design learning experiences underpinned by constructionist theory by leveraging a wide range of the perceived educational affordances of the technology. However NGO-VWs are not designed to support constructionist learning. The tools commonly available which support construction and programming, present the learner with a high-floor barrier which they must first overcome before they are able to engage in the construction of personally meaningful artefacts. Therefore low-floor, easy to use tools are required to support learners' engagement. This thesis has demonstrated that SLurtles provide learners with a powerful low-floor, programmable construction tool with which learners can engage in the construction of a wide variety of complex artefacts.

Although SLurtles lower the barrier to construction, this thesis has demonstrated that learners may encounter other barriers to engagement. While many of these barriers are personal, such as a learner's preconceptions of NGO-VWs, some relate to technical skills required to engage in the learning experience. Additional time to practice skills and providing in-world resources were approaches successfully implemented to reduce barriers in the second case study. However some learners still encountered skill-based barriers to the use of their avatars.

Unlike traditional constructionist learning environments, learners in NGO-VWs are represented as an avatar. Avatars have agency (Bell, 2008) and through the avatar a user can interact with their environment, including other people. As such the avatar becomes a key aspect of any learning experience in a NGO-VW. Avatars have two key implications for constructionist learning experiences in NGO-VWs. The first is that the acquisition of skills necessary to use the avatar may be a high-barrier for learners to master before they are able to engage in the learning experience. However the findings of the second case study demonstrate that avatar skill acquisition is a temporary barrier and may therefore be considered to be a low-floor barrier. The second implication is that the avatar provides the learner with a sense of co-presence with other users and therefore provides a unique opportunity to engage in distributed constructionism.

In the following sub-sections, the alignment of pedagogy and technology, barriers to engagement and opportunities for distributed constructionism are discussed in more detail.

7.2.1 Alignment of pedagogy and technology

Constructionism was identified as a potentially appropriate pedagogy for use in NGO-VWs, following the four stage process presented in Chapter 2. The theoretical alignment of pedagogy and technology suggested that all features of constructionism could be supported by the perceived educational affordances of NGO-VWs, as outlined in Table 7.1.

Table 7.1 Alignment of constructionism and the perceived educational affordances of non-goal orientated virtual worlds (Table 2.5)

Constructionism	Perceived educational affordances	
Construct personally meaningful artefacts	Creation of persistent objects	Construction
Actively explore, test and extend understanding		
Opportunity to programme		Programming
Shareable artefact		Persistence
<i>Bricolage</i>	Flexibility	
<i>In-situ</i>	Embodied social presence	
'Invisible' technology	Immersion	
Collaborating on constructions	Collaborative learning	

In Chapter 3 the proposed alignment was used to inform the design of a learning experience for a specific context. To design a constructionist learning experience, the perceived educational affordances were leveraged to provide opportunity for the features of the pedagogy to emerge. The learning experience was then implemented across two case studies reported in Chapters 5 and 6.

The first implementation provided an opportunity to broadly examine the proposed alignment between pedagogy and technology (Chapter 5). The findings generally support the proposed alignment of pedagogy and technology; however collaborative learning, embodied social presence and public/private learning environments are three perceived educational affordances which require further study in the context of a constructionist learning experience.

In the first case study there was evidence of collaboration and learning, however there was limited evidence of collaborative learning. Some groups that experienced an imbalance between partners may not have engaged in collaboration until they discussed the imbalance and how to resolve it, thus reducing opportunities for collaborative learning. It may also be possible that collaboration on constructions does not require collaborative learning. However as the research aim was exploratory there may be any number of factors and explanations, including the design of the learning experience, the bounded system of the case under study or other factors which influenced the lack of collaborative learning.

Due to insufficient evidence to suggest that learners engaged in collaborative learning it might be anticipated that learners would not have engaged in collaborating on constructions as these were aligned in Table 7.1 and the design of the learning experience. However the first case study found that learners did collaborate on constructions. Although not the focus of inquiry, in the second case study (Chapter 6) the findings suggest that a sense of embodied social co-presence with other learners (rather than embodied social presence) supported collaboration on constructions.

The first case study also identified an additional perceived educational affordance: 'public/private learning environments' which could be used to support or limit the sharing of artefacts throughout the construction process. The findings suggest that within a persistent environment, public/private learning environments can be leveraged to support the construction of shareable artefacts. This perceived educational affordance, along with embodied social co-presence and sense of immersion may also support distributed constructionism, particularly collaboration on constructions. This is discussed in more detail in the following sub-section on distributed constructionism.

Based on the findings of these two case studies, the proposed alignment of pedagogy and technology has been refined to include 'public/private learning environments' and 'embodied social co-presence' as key perceived educational affordances with which to support constructionist learning experiences in NGO-VWs (Table 7.2). While collaborative learning has been removed from Table 7.2 this does not indicate that this affordance cannot be leveraged during a constructionist learning experience, instead it reflects the evidence of the first case study and indicates an area for further study.

Table 7.2 Developed alignment of constructionism and the perceived educational affordances of non-goal orientated virtual worlds

Constructionism	Perceived educational affordances	
Construct personally meaningful artefacts	Creation of persistent objects	Construction
Actively explore, test and extend understanding		
Opportunity to programme		Programming
Shareable artefact		Persistence
	Public/private learning environments	
<i>Bricolage</i>	Flexibility	
<i>In-situ</i>	Embodied social presence	
'Invisible' technology	Immersion	
Collaborating on constructions	Embodied social co-presence	

7.2.2 Barriers to engagement

Constructionist learning environments are designed to lower the barriers to learners' engagement. However NGO-VWs are not designed for constructionist activities and may therefore present learners with many barriers to overcome before they can engage in constructionist learning. The sub-sections below discuss SLurtles as a solution to the high-floor construction tools in NGO-VWs, the identification of barriers to constructionist learning experiences and approaches to lowering these barriers.

7.2.2.1 SLurtles

Construction and programming were two barriers identified by several authors as presenting learners with a steep learning curve before they can engage in the construction of personally meaningful artefacts (Dickey, 2005b; Sanchez, 2007, 2009b; Cheal, 2009). As construction and programming are key aspects of constructionist learning experiences (Hoyles et al., 2002), in order to meet the research aim, SLurtles were designed as programmable construction tools for use with S4SL, an external, low-floor, graphical programming environment (Chapter 3).

Underpinning the design of SLurtles are the constructionist principles of low-floors, high-ceilings and wide-walls. The findings of the first case study (Chapter 5) demonstrate that SLurtles provided learners with a low-floor programmable construction tool with which they were able to create a variety of complex artefacts. While initial constructions were easy, more complex constructions required more complex programmes and with this came a sense of challenge, hard fun and achievement. Although most learners had little or no previous programming or virtual world experience, they were able to collaborate at distance to create complex artefacts with SLurtles.

While the findings have shown that SLurtles provide a low-floor, high-ceiling and wide-wall construction tool, much of the data is drawn from learners' perceptions. Further research is needed to understand the points at which the floor, ceiling and walls stop and begin to limit what learners may achieve. This may be undertaken in comparison to other in-world tools or other constructionist environments such as Scratch. However the need for such research also highlights a potential limitation in the discourse surrounding constructionist tools; that is how to measure floors, ceiling and walls and whether these are comparable between tools. Such a debate is beyond the scope of the research in this thesis, however it is an issue which needs to be clearly addressed by the field.

There were also barriers to learners' engagement with SLurtles and these highlight the need to consider the redesign of S4SL as an application accessible from within the NGO-VW. Automatic rather than manual transfer of scripts and bi-directionality may also enhance learners' experience of using SLurtles to support their learning. However the limitations of this research restrict any redevelopment of the application.

Although designed for *Second Life*, SLurtles have the potential to be used in a number of other NGO-VWs developed through the OpenSim project. Although presented in terms of *Second Life*, the design concepts behind SLurtles could also be implemented for the development of similar tools in other NGO-VWs such as *Active Worlds*.

In *Mindstorms*, Papert (1980) advocated "the construction of educationally powerful computational environments that will provide alternatives to traditional classrooms and traditional instruction" (p182). With SLurtles providing the low-floor programmable construction tool with which learners can engage in constructionist learning activities, NGO-VWs may provide such an educationally powerful computational environment.

7.2.2.2 Barriers encountered

Most of the learners who participated in the research had little or no previous experience of programming or virtual worlds. Through a review of the literature a range of potential barriers to education in NGO-VWs were identified (Chapter 2). Yet these tend to be based on the reflections of participant-researchers, rather than those reported by learners. In addition, the literature offers no clarification on which barriers learners are likely to experience when specifically engaging in constructionist learning experiences in NGO-VWs.

Through both the first and second case studies barriers, as described by learners, were identified and tentative outcomes to these barriers have been suggested. Technical barriers were found to have a wide range of outcomes, from limiting engagement in the learning

experience to programming and the disassociation of learners from their avatars. However these barriers are often temporary and described in the first case study as quickly overcome or irrelevant as learners engaged with SLurples.

Personal barriers were experienced by learners in both case studies. The first highlighted that learners had expectations of what they would and would not be able to achieve at the start of the learning experience based on their past experiences. There was also a sense of imbalance between some partners and this was associated with increasing independent work, lack of communication and a sense of loneliness within the NGO-VW. However once this was identified and addressed the experience changed with increasing collaboration and communication. While a range of personal barriers were identified in the second case study, few were clearly associated with outcomes.

Learners who experienced barriers to using their avatar may not associate themselves with their avatar. This may limit learners' sense of embodied social presence within the environment and in turn potentially limit the sense of *in situ* construction. However the second case study found that those without a positive connection to their avatar still experienced a sense of co-presence when engaged in collaborative activities with another learner.

As programming is central to the design of the learning experience, barriers to programming require careful consideration during the design of constructionist learning experiences in NGO-VWs. This study found evidence to suggest that barriers to problem solving could affect programming. As programming is a central aspect of constructionist learning, if the barriers which are specific to NGO-VWs cannot be overcome, the use of NGO-VWs for constructionist learning may require careful reconsideration.

7.2.2.3 Approaches to lowering barriers

Barriers to engagement are important in any learning context but demand particular attention in constructionist learning experiences, which aim to provide learners with low-floor tools to engage with as they explore, test and extend their understanding. The second case study demonstrated that by addressing barriers in the design of the learning experience it was possible to limit their impact. This section highlights four approaches to reducing technical skill barriers in NGO-VWs which could limit learners' engagement, that were considered in the redesign of the learning experience between the two case studies:

- Allow additional time to practice
- Provide in-world resources
- Avoid unnecessary skills

- Integrate the technology into a wider course of study

The first approach was to provide learners with additional time to practice technical skills. Savin-Baden et al. (2011) identify that learners without prior experience of NGO-VWs may require more time than anticipated to become familiar with the environment in order to fully engage in learning. While providing additional time for learners to familiarise themselves with NGO-VW skills may reduce the barriers encountered during the learning experience, it may not be possible to allocate sufficient time for all learners to achieve the necessary skill levels. There is also the question as to when additional time should be provided, for example before the main learning experience or in supplemental sessions which run in tandem with the main learning experience.

In the first case study there was limited time to explain the permission system, which was identified by several participants as a barrier. To address this problem, during the initial introduction of SLurtles to learners in the second case study, particular attention was paid to the permission system. By providing a particular focus on the mechanisms within *Second Life* to share both objects and scripts in the design of the learning experience, the permission system was not identified as a barrier by learners in the second case study. However as there was no additional time available during the course, other aspects of the introduction had to be shortened to facilitate this change.

The second approach was to provide learners with in-world resources. As there was no additional time available on the course, other approaches to provide learners with opportunities to practice skills was needed. Leveraging the perceived educational affordance of flexibility, a decision was made to provide learners with in-world resources *in-situ*. In the first case study no explicit opportunities had been created for learners to practice their camera skills and the findings demonstrated that this skill was a barrier to learners' engagement. Thus learners were provided with a short independent activity with step-by-step instructions to complete the activity and practice their camera controls. As there was no evidence to suggest that learners identified the camera controls as a barrier to the learning experience in the second case study, it would appear that this barrier was reduced.

SLurtles also provided learners with an in-world resource without which learners stated that they would not have been able to create what they did. As previously stated, SLurtles provided a low-floor, high-ceiling and wide-wall tool which supported learners during the construction process. However programmes had to be transferred from the external S4SL into *Second Life* which was a barrier for some. To address this problem it has been recommended in this thesis that the future development of S4SL should provide an in-world resource.

The third approach is to avoid unnecessary skills. By considering which skills learners need in order to successfully achieve the learning aims, unnecessary skills which may increase cognitive load can be avoided. As highlighted in the review of the literature (Chapter 2), while engaging in programming as part of a learning experience may present computer science undergraduates with a low-floor, English Literature undergraduates with no previous programming experience may experience this as a particularly high-barrier (Sanchez 2009b; Allison et al., 2010). The skills that learners need to master, in order to engage in a learning experience, need to be carefully considered based on the context of the learning experience. This context will include the course or module aims and learners' past experience. If programming is necessary in order to engage in the learning experience but learners have no previous experience, low-floor tools such as S4SL may be used. Alternatively the learning experience may need to be redesigned to provide opportunities to achieve the learning aims without engaging in programming.

Finally, if the use of NGO-VWs is integrated more widely into a course, rather than used as a once-off learning experience, learners will have more opportunity to gain and apply the technical skills. The research presented in this thesis focuses on a learning experience which, for the majority of participants, was their first learning experience in a NGO-VW. If NGO-VWs are integrated into a wider course of study, requiring learners to engage in the NGO-VW over a series of tasks, learners may have ample opportunity to overcome technical skill barriers such as camera controls before engaging in a SLurtle-based learning experience. Evidence to support this is already emerging in related research undertaken in *OpenSim* with children in primary school. By the time these learners came to engage in a SLurtle-based constructionist learning experience they had already used the NGO-VW during the school year (Devlin, 2012). The more automated learners become in using the interface the more they will become immersed in the learning experience as the computer becomes 'invisible'.

7.2.3 Distributed constructionism and avatars

Resnick (1996) describes distributed constructionism as taking three forms: discussing, sharing and collaborating on constructions. Evidence from the first case study (Chapter 5) suggests that learners engaged in all three forms of distributed constructionism, facilitated through the creation of persistent objects and embodied social presence.

In traditional constructionist environments, distributed constructionism is typically facilitated through asynchronous communication tools and the up/down-load of artefacts. While this supports the sharing and discussing of artefacts, the construction of artefacts is limited as learners are unable to work on the same digital resource at the same time. By comparison, NGO-VWs support the synchronous sharing, discussing and co-construction of artefacts *in-situ*.

In particular, evidence from the second case study suggests that through their avatars, learners have a sense of being co-present with others which supported their co-construction of artefacts.

There are a number of features of NGO-VWs which are essential in the sharing, discussing and co-constructing of artefacts: avatars, communication tools, multiple users and the simulated environment. It is however the avatar which is unique to virtual worlds, without which learners have no sense of co-presence with others. Thus it is argued that the sense of co-presence supported through avatars is particularly beneficial to the co-construction of artefacts in a distributed constructionist learning experience.

7.2.4 Limitations

Qualitative case study research in an educational setting is a messy process involving uncontrollable and unidentifiable factors which may influence the outcomes of the research. While the research undertaken in this thesis has been rigorous, there are two specific limitations which should be taken into consideration: data collection, generalisation of findings and bounds of the case studies.

There were limited opportunities for data collection, beyond the previously discussed limitations of case study research in general (Chapter 4). The first case study was limited by the lack of observational data available and as a result the data collection technique was revised for the second case study. While observational data remained relatively small, the second case study was particularly limited by the number of participants available for interview. Of the final 25 research participants, only nine took part in the interviews. While they formed a representative sample of the larger group, there was insufficient data to draw any firm conclusions.

The results of this study provide valuable insights into constructionism in action in NGO-VWs. However the extent to which generalisations can be made is limited by the bounds of the case study. For example, with a similar group of learners in a similar context and the same learning experience, the barriers and associated outcomes identified in this research might reoccur. However it is likely that there are many individual factors that could have influenced the findings which cannot be accounted for. For example, although the learning experience was designed to be completed at distance, learners could meet face-to-face. It is unknown to what extent learners met with their partner or others face-to-face and in-world. More broadly, as noted in Chapter 3, a SLurtle learning experience may take a variety of forms depending on the context. For example there may be multiple learners using one computer. In such a context a

very different set of barriers could be identified and the role of the avatar may be reduced to that of a navigation tool or all members of the group may feel embodied by the avatar.

These limitations highlight some aspects of the messy nature of case study research, in which a range of unidentified and uncontrollable factors may or may not influence the outcomes of the study. This does not suggest that the findings do not form a valuable contribution to the field. As described by Hargreaves (1997), educators may identify similar features between a case study and their own context, identify the most relevant findings from the research and apply those in their own educational setting.

7.3 Further outcomes

In addition to the stated aims of the research, this thesis has furthered the discourse on data collection and ethical approaches in NGO-VWs. Chapter 4 highlighted that there are opportunities to enhance traditional data collection techniques when conducted in-world, yet literature on the area is sparse. Discussion of the potential opportunities, constraints, techniques and implications of conducting interviews and observations in-world illustrates the importance of researchers discussing both successful and not so successful approaches to data collection in-world.

While face-to-face interviews were the primary medium of data collection in the research presented in this thesis, in-world interviews provided access to participants otherwise unavailable. However there are possible implications to adopting this approach. For example, voice-based, in-world interviews and face-to-face interviews may result in very different responses to interview questions. Additionally it was not possible to control the physical location of the participant and as a result some interviews were paused due to distractions.

Although the technology provided additional opportunities to conduct interviews, observation in-world was limited. Two approaches to collecting observational data were trialled in the research presented in this thesis. The first case study collected the logged text-based communication of participants, however only five participants provided these to the researcher for analysis. One reason for this may have been the use of voice-based communication which could not be recorded as easily, while some participants forgot to record their communication. As participants can edit text logs before handing them over to the researcher they are also potentially unreliable records of the conversations that took place.

The second case study relied on participant-observation in which the researcher recorded the conversations that took place near or with the researcher whilst online. While this increased the reliability of the record, it decreased the potential quantity of data available. This was

restricted by the researcher's available time to be in-world with participants as well as only being able to record conversations within a certain distance of the researcher's avatar.

Using *Second Life* also limited the opportunities to collect observational data as server logs are unavailable. By comparison the use of *OpenSim* would provide the researcher with a rich data set for analysis, including a log of all text-based communication and actions of users. While this would provide a particularly rich source of data, it still would not be possible to identify when the participant moved between S4SL and the NGO-VW, or their actions in S4SL. Screen capture could provide an alternative approach, however this would depend on the participant reliably recording their screen.

Chapter 4 also discussed the traditional ethical issues of obtaining informed consent, privacy protection and identity, in the context of educational research in the non-traditional NGO-VW environment. This highlighted a number of ethical concerns such as obtaining informed consent in an environment where users may wish to keep their physical and virtual world identities separate. While this was not an issue in the current study it presents both an ethical concern and potential limitation to future research which may use participants who the researcher does not meet face-to-face.

7.4 Future Research

The research presented in this thesis aimed to develop an understanding of constructionism in NGO-VWs. Out of necessity it has addressed broad aspects of the alignment of pedagogy and technology. Further work is now required to develop the initial understanding of the alignment between pedagogy and technology, focusing on features of the pedagogy and the perceived educational affordances of the technology.

As previously stated, the findings generally support the proposed alignment of pedagogy and technology. However embodied social presence, immersion, collaborative learning and public/private learning environments are four perceived educational affordances which have been identified for further study in the context of a constructionist learning experience. For example, while there was evidence of collaboration and learning there was limited evidence of collaborative learning. In some cases groups that experienced an imbalance between partners may not have engaged in collaboration until they discussed the imbalance and how to resolve it, thus reducing opportunities for collaborative learning. It may also be possible that collaboration on constructions does not require collaborative learning. However as the research aim was exploratory there may be any number of factors and explanations, including the design of the learning experience and the context.

The findings of both case studies are of course limited to the bounds of the systems studied, with the context determining the final design of the learning experience. Thus in a different context there may be different findings. However as the primary aim of the research presented in this thesis was to explore constructionism in action in NGO-VWs, these studies provide the foundations for others to build upon. For example the findings need to be examined in other contexts to explore which factors may or may not be context specific.

The discussion of the findings from both exploratory and instrumental case studies has lead to a number of suggested areas for future research, as described in Chapters 5 and 6 respectively. However the discussion of both case study findings in this chapter raises two further areas for research:

It has been argued that the sense of co-presence supported through avatars is particularly beneficial to the co-construction of artefacts in a distributed constructionist learning experience. Future research may explore this further with learners engaging in distributed constructionism through both NGO-VWs and traditional constructionist environments such as *Scratch* to compare their experiences.

Finally the construction of SLurtles as a low-floor construction tool, has highlighted the need for further research to understand the points at which the floor, ceiling and walls stop and begin to limit what learners may achieve. This may be undertaken in comparison to other in-world tools or other constructionist environments such as *Scratch*. However the need for such research also highlights a potential limitation in the discourse surrounding constructionist tools; that is how to measure floors, ceiling and walls and whether these are comparable between tools. Such a debate is beyond the scope of the research in this thesis, however it is an issue which needs to be clearly addressed by the field.

7.5 Conclusion

This thesis has identified and validated constructionism as an appropriate pedagogy to underpin learning experiences in NGO-VWs. To achieve this, SLurtles were designed to support learners' engagement in purpose designed constructionist learning experiences. SLurtles provide learners with an empowering programmable low-floor, high-ceiling and wide-wall construction tool with which learners can create a wide range of complex artefacts. The definition of virtual worlds, as well as the introduction and definition of the term 'perceived educational affordances', addresses limitations in the discourse of existing literature and supports the identification of appropriate pedagogies for use in this technology. While the alignment of constructionism and the technology is still developing, this thesis provides a foundation for future research on constructionist learning experiences in NGO-VWs.

References

- Ackerman, E. (2004). Constructing knowledge and transforming the world. In M. Tokoro & L. Steels (Eds.) *A learning zone of one's own: Sharing representations and flow in collaborative learning environments*, Oxford: IOS Press, 15-37
- Ackerman, E. & Strohecker, C. (1999). Build, launch, convene: Sketches for constructive-dialogic learning environments. MERL - A Mitsubishi electric research Laboratory Retrieved 25th October 2009, from <http://www.merl.com/papers/TR99-30/>
- Adams, A., Astruc, L., Garrido, C. & Sweeney, B. (2011). Situated learning in virtual worlds and identity reformation. In A. Peachey & M. Childs (Eds.), *Reinventing Ourselves: Contemporary Concepts of Identity in Virtual Worlds*, London: Springer, 274-
- Ahmad, N. S. H. N., Wana, T. R., & Jiang, P. (2010). Learning health through virtual world: comparative between UK and Malaysia. *Procedia-Social and Behavioral Sciences*, 9, 11-20. In Allison, C., Miller, A., Sturgeon, T., Nicoll, J. R. & Perera, I. (2010). Educationally enhanced virtual worlds. *Proceedings of IEEE Frontiers in Education Conference (FIE 2010)*.
- American Educational Research Association (2000). *Ethical standards of the American Educational Research Association*. Retrieved 17th September 2009, from http://www.aera.net/uploadedFiles/About_AERA/Ethical_Standards/EthicalStandarEt.pdf
- Ang, K. H. & Wang, Q. (2006). A case study of engaging primary school students in learning science by using Active Worlds. In R. Philip, A. Voerman & J. Dalziel (Eds.), *Proceedings of The First International LAMS Conference 2006: Designing the Future of Learning*, 5-14. 6-8th December 2006, Sydney: LAMS Foundation
- Annetta, L., Klesath, M., and Holmes. S. (2008) V-learning: How gaming and avatars are engaging online students. *Innovate*, 4(3). Accessed on 14th June 2010, from <http://www.innovateonline.info/index.php?view=article&id=485>
- Bakardjieva, M., & Feenberg, A. (2000). Involving the virtual subject. *Ethics and Information Technology*, 2, 233-240.
- Baker, E. A., Homan, S., Schonhoff, R. & Kreuter, M. (1999) Principles of practice for academic/practice/community research partnerships. *American Journal of Preventative Medicine*, 16(3), 86-93
- Baker, S. C., Wentz, R. K. & Woods, M. M. (2009). Using virtual worlds in education: *Second Life* as an educational tool. *Teaching of Psychology*, 36, 59-64.
- Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development*, 53(1), 86-107.
- Barrett, T. (2005). Understanding problem-based learning. In Barrett, T., Mac Labhrainn, I., Fallon, H. (Eds) *Handbook of Enquiry & Problem Based Learning*. Galway: CELT, 13-25.

- Barrows, H. and Tamblyn, R. (1980) *Problem-based Learning: An Approach to Medical Education*. New York: Springer
- Bartle, R. (1999). *Early MUD History*. Accessed on 23rd January 2008 from <http://www.mud.co.uk/richard/mudhist.htm>
- Bartle, R. (2004). *Designing virtual worlds*. Indianapolis, IN: New Riders Publishing.
- Bartlett, L. (1991). The dialectic between theory and method in critical interpretive research. *British Educational Research Journal*, 17(1) 19-33
- Bassey, M. (1999). *Case Study Research in Educational Settings*. Buckingham, UK: Open University Press
- Bell, J., Dinova, M. & Levine, M. (2010). VWRAP for Virtual Worlds Interoperability. *IEEE Internet Computing*, 14(1), 73–77.
- Bell, M. W. (2008). Towards a definition of “virtual worlds”. *Journal of Virtual Worlds Research*, 1(1), Retrieved January 24, 2009, from <http://journals.tdl.org/jvwr/article/view/283/237>
- Bell, M. W., Castronova, E. & Wagner, G. G. (2011). Virtual assisted self interviewing (VASI): An expansion of survey data collection methods to virtual worlds by means of VDCI. *Journal of Virtual Worlds Research*, 3(3). Accessed on 5th June 2011 from <https://journals.tdl.org/jvwr/article/view/761/1780>
- Bellotti, F., Berta, R., De Gloria, A., & Primavera, L. (2010). Supporting authors in the development of task-based learning in serious virtual worlds. *British Journal of Educational Technology*, 41(1), 86-107.
- Bennetsen, H. (2006) *Augmentation vs Immersion*. Accessed 30th January 2011 from [http://slcreativity.org/wiki/index.php?title=Augmentation vs Immersion](http://slcreativity.org/wiki/index.php?title=Augmentation_vs_Immersion)
- Boellstorff, T. (2008), *Coming of Age in Second Life: An Anthropologist Explores the Virtually Human*. Princeton, NJ: Princeton University Press.
- Boote, D. N. & Beile, P. (2005). Scholars before researchers: On the centrality of the dissertation literature review in research preparation. *Educational Researcher*, 34(6), 3-15
- Bosk, C. L. & de Vries, R. G. (2004). Bureaucracies of mass deception: institutional review boards and the ethics of ethnographic research. *The ANNALS of the American Academy of Political and Social Science*, 595(1), 249-263
- Boulos, M. K. N., Hetherington, L. & Wheeler, S. (2007). *Second Life: An overview of the potential of 3-D virtual worlds in medical and health education*. *Health Information and Libraries Journal*, 24, 233-245
- Braman, J., Dudley, A., Colt, K., Vincenti, G. & Wang, Y. (2011). Gaining insight into the application of *Second Life* in a computing course: Students’ perspectives. In Proceedings 4th International Conference, OCSC 2011, part of HCII 2011 A. A. Ozok and P. Zaphiris (Eds.) *Online Communities and social computing* Held: Orlando FL: July 2011; Berlin: Springer-Verlag

- British Educational Research Association (2004). *Revised ethical guidelines for educational research*. Retrieved 17th September 2009, from <http://www.bera.ac.uk/files/guidelines/ethica1.pdf>
- Bronack, S., Sanders, R., Cheney, A., Riedl, R., Tashner, J., & Matzen, N. (2008). Presence pedagogy: Teaching and learning in a 3D virtual immersive world. *International Journal of Teaching and Learning in Higher Education*, 20(1), 59-69
- Brown, E. & Cairns, P. (2004). A grounded investigation of game immersion. In *Proceedings of the Conference on Human Factors in Computing Systems (CHI 2004)* (pp1279-1300). New York: ACM Press
- Bruckman, A. (1997). MOOSE Crossing: Construction, community, and learning in a networked virtual world for kids. PhD Thesis. Cambridge, MA: Massachusetts Institute of Technology
- Bruckman, A. & Resnick, M. (1996). The MEDIAMOO project: Constructionism and professional community. In Y. Kafai & M. Resnick (Eds.), *Constructionism in practice: Designing thinking, and learning in a digital world*, New Jersey: Lawrence Erlbaum Associates, 207-222
- Burrell, G. & Morgan, G. (1979). *Sociological paradigms and organisational analysis*. London: Heinemann Educational
- Burgess, M. L., Slate, J. R., Rojas-LeBouef, A., & LaPrairie, K. (2010). Teaching and learning in *Second Life*: Using the Community of Inquiry (Col) model to support online instruction with graduate students in instructional technology. *The Internet and Higher Education*, 13(1), 84-88.
- Butler, D. (2007). A constructionist view on what it means to be digitally literate. *Nordic Journal of Digital Literacy*, 2, 61-77.
- Campbell, C. (2009). Learning in a different life: Pre-service education students using an online virtual world. *Journal of Virtual World Research*, 2(1), 3-17
- Carley, K. & Palmquist, M. (1992). Extracting, Representing, and Analyzing Mental Models. *Social Forces*, 70(3), 601-636.
- Carlson, L., Gregory, S. & Tynan, B. (2011). An Australian and New Zealand scoping study on the use of 3D immersive virtual worlds in higher education. *Australasian Journal of Educational Technology*, 27(1), 1-15
- Carr, W. & Kemmis, S. (1986). *Becoming Critical: Education, Knowledge and Action Research*. London: Falmer Press
- Castronova, E. (2001). Virtual worlds: A first-hand account of market and society on the cyberian frontier. *CESifo Working Paper Series*, 618. Accessed on 17th September 2009, from <http://ssrn.com/abstract=294828>
- Castronova, E. (2005). *Synthetic Worlds*. Chicago: The University of Chicago Press
- Charmaz, K. (2005) Advancing social justice research. In N. K. Denzin & Y. S. Lincoln (eds.) *The Sage handbook of qualitative research*. (3rd ed., pp.507-536) Thousand Oaks: Sage

- Cheal, C. (2009). Student perceptions of a course taught in *Second Life*. *Innovate: Journal of Online Education*, 5(5).
- Cheng, L., Farnham, S. & Stone, L. (2002). Lessons learned: Building and deploying shared virtual environments. In R. Schroeder (Ed.) *The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments*. London: Springer-Verlag
- Cheong, D. (2010). The effects of practice teaching sessions in *Second Life* on the change in pre-service teachers' teaching efficacy. *Computers & Education* 55(2), 868-880.
- Childs, M. (2008). Using a Mediated Environments Reference Model to evaluate learners' experiences of *Second Life*. In Proceedings of the Sixth International Conference on Networked Learning, 5th & 6th May (pp. 38-45).
- Childs, M. (2010). *Learners' Experiences of Presence in Mediated Environment*. (Doctoral thesis) University of Warwick, Warwick UK
- Childs, M., Gweno, W. & Schnieders, H. L. (2012). "This above all: To thine own self be true": Ethical considerations and risks in conducting higher education learning activities in the virtual world *Second Life*. *Interactive Learning Environments*, 20(3), 253-269
- Childs, M. & Kuksa, I. (2009) "Why are we in the floor?" Learning about theatre design in *Second Life*, Proceedings of the Edlearn 09 International Conference on Education and New Learning Technologies, Barcelona, Spain, 6th to 8th July 2009, 1134 – 1145
- Chodos, D., Naeimi, P. & Stroulia, E. (2009). An integrated framework for simulation-based training on video and in a virtual world. *Journal of Virtual Worlds Research*, 2(1). Accessed on 15th January, 2010 from <https://journals.tdl.org/jvwr/article/view/375/450>
- Choi, B. & Baek, Y. (2011) Exploring factors of media characteristic influencing flow in learning through virtual worlds. *Computers & Education*, 57(4), 2382-2394.
- Clarke, J. & Dede, C. (2007). MUEs as a powerful means to study situated learning. In C. A. Chinn, G. Erkens and S. Putambekar (Eds.) *The 2007 computer-supported collaborative learning (CSCL) conference*. New Brunswick, NJ: International Society for the Learning Sciences, 141–144
- Clarke, J., Dede, C. & Dieterle, E. (2008). Emerging Technologies for Collaborative, Mediated, Immersive Learning. In J. Voogt and G. Knezek (Eds.) *International Handbook of Information Technology in Primary and Secondary Education*. New York: Springer
- Coffman, T., & Klinger, M. B. (2007). Utilizing virtual worlds in education: The implications for practice. *International Journal of Human and Social Sciences*, 2(1), 29-33.
- Cohen, L., Manion, L. & Morrison, K. (2000). *Research Methods in Education* (5th ed.). London: Routledge Falmer
- Cohen, L., Manion, L. & Morrison, K. (2007). *Research Methods in Education* (6th ed.). London: Routledge

- Conneely, C., Lawlor, J. & Tangney, B. (2012). Technology, teamwork and 21st century skills in the Irish classroom. In Marshall, K. (Ed.) *Shaping our future: How the lessons of the past can shape transformation*. Dublin: Liffey Press
- Conole, G., Dyke, M., Oliver, M. & Seale, J. (2004). Mapping pedagogy and tools for effective learning design. *Computers & Education*, 43(1-2), 17-33
- Conrad, M., Pike, D., Sant, P., & Nwafor, C. (2009). Teaching Large Student Cohorts in *Second Life*. In *Proceedings of the First International Conference on Computer Supported Education (CSEDU)*, Lisboa.
- Crellin, J., Duke-Williams, E., Chandler, J. & Collinson, T. (2009). Virtual worlds in computing education. *Computer Science Education*, 19(4), 315-334
- Creswell, J. W. (2002). *Educational research: Planning, conducting and evaluating quantitative and qualitative research*. New Jersey: Merrill Prentice Hall
- Creswell, J. W. (2003). *Research Design: Qualitative, quantitative and mixed methods approaches*. (2nd ed). London: Sage
- Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). London: Sage
- Crider, M. (2006). Living and Learning in *Second Life*: A Firsthand Exploration and Tour of a User-Created Virtual World. Games, Learning, and Society Conference. Madison, WI, July 2006.
- Csikszentmihalyi, M. (1997). *Finding flow: The psychology of engagement with everyday life*. New York: Basic Books
- Dalgarno, B. & Lee, M.J.W. (2010). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology*, 41(1), 10-32
- Dawley, L. (2009). Social network knowledge construction: emerging virtual world pedagogy. *On the Horizon*, 17(2), 109-121.
- De Freitas, S., Rebolledo-Mendez, G., Liarokapis, F., Magoulas, G. & Poulouvasilis, A. (2010). Learning as immersive experiences: Using the four-dimensional framework for designing and evaluating immersive learning experiences in a virtual worlds. *British Journal of Educational Technology*, 41(1), 69-85
- De Lucia, A., Francese, R., Passero, I. & Tortora, G. (2009). Development and evaluation of a system enhancing *Second Life* to support synchronous role-based collaborative learning. *Software: Practice and Experience*, 39(12), 1025-1054
- De Lucia, A., Francese, R., Passero, I. & Tortora, G. (2009b). Development and evaluation of a virtual campus on *Second Life*: The case of SecondDMI. *Computers & Education*, 52(1), 220-233
- Dede, C. (1996). The evolution of constructivist learning environments: Immersion in distributed, virtual worlds. *Constructivist learning environments: Case studies in instructional design*, 165-175

- Dede, C. (2004). If Designed Based Research is the Answer, What is the Question? *The Journal of the Learning Sciences*, 13(1), 105-114.
- Delwiche, A. (2006). Massively multiplayer online games (MMOs) in the new media classroom. *Educational Technology & Society*, 9(3), 160-172.
- Delwiche, A. (2008). Keep on rockin' in the free (virtual) worlds: Why user-generated content matters. Accessed on 05/09/2011 from: <http://flowtv.org/2008/07/keep-on-rockin%E2%80%99-in-the-free-virtual-worlds-why-user-generated-content-mattersaaron-delwiche-trinity-university/>
- Denzin, N. K. & Lincoln, Y. S. (Eds.) (2008) *The landscape of qualitative research*. London: Sage
- Derrington, M. (2011). Setting up a virtual world for teaching English language: Why Open Sim? In A. Peachy (Ed.), *Proceedings of Researching Learning in Immersive Virtual Environments (ReLIVE 2011)*, Milton Keynes, 43-52
- Deutschmann, M. & Panichi, L. (2009). Talking into empty space? Signalling involvement in a virtual language classroom in *Second Life, Language Awareness*, 18(3-4), 310-328.
- Devlin, S. (2012). *Taking geometry virtual: Leveraging the affordances of a virtual world to teach primary school children geometry using a constructionist approach*. (Unpublished Masters thesis). Trinity College Dublin, Dublin Ireland.
- Dick, B. (1998) *Convergent interviewing: a technique for qualitative data collection* [On line]. Accessed on 17th May 2010 from <http://www.scu.edu.au/schools/gcm/ar/arp/iview.html>
- Dickey, M. D. (2003). Teaching in 3D: Pedagogical affordances and constraints of 3D virtual worlds for synchronous distance learning. *Distance Education*, 24(1), 105-121.
- Dickey, M. D. (2005a). Three-dimensional virtual worlds and distance learning: Two case studies of Active Worlds as a medium for distance education. *British Journal of Educational Technology* 36(3), 439-451
- Dickey, M. D. (2005b). Brave new (interactive) worlds: A review of the design affordances and constraints of two 3D virtual worlds as interactive learning environments. *Interactive Learning Environments*, 13(1-2), 121-137
- Dickey, M. D. (2011). World of Warcraft and the impact of game culture and play in an undergraduate game design course. *Computers & Education* 56(1), 200-209.
- Dieterle, E. & Clarke, J. (2009). Multi-User Virtual Environments for Teaching and Learning. In M. Pagani (Ed.), *Encyclopedia of Multimedia Technology and Networking, Second Edition*, 1033-1041
- Dittmer, J. (2010). Immersive virtual worlds in university-level human geography courses, *International Research in Geographical and Environmental Education*, 19(2), 139-154
- Dodge, B. (1997). Some thoughts about WebQuests. Retrieved May 19, 2008, from <http://webquest.sdsu.edu/aboutwebquests.html>
- Downe S. (2008) Metasynthesis: a guide to knitting smoke. *Evidence Based Midwifery*, 6(1), 4-8

- Dreher, C., Reiners, T., Dreher, N., & Dreher, H. (2009). Virtual Worlds as a Context Suited for Information Systems Education: Discussion of Pedagogical Experience and Curriculum Design with Reference to *Second Life*. *Journal of Information Systems Education*, 20(2), 211-224
- Dreher, C., Reiners, T., Dreher, N., & Dreher, H. (2009b). 3D virtual worlds as collaborative communities enriching human endeavours: Innovative applications in e-Learning. In *Digital Ecosystems and Technologies, 2009. DEST'09. 3rd IEEE International Conference on* (pp. 151-156). IEEE.
- Dreher, H., Reiners, T., Dreher, C., & Dreher, N. (2009c). 3D Spaces in Software Engineering: From K-12 to Life Long Learning. In *World Conference on Educational Multimedia, Hypermedia and Telecommunications* (Vol. 2009, No. 1, pp. 4103-4112).
- Eckelman, M. J., Lifset, R. J., Yessios, I., & Panko, K. (2011). Teaching industrial ecology and environmental management in *Second Life*. *Journal of Cleaner Production*, 19(11), 1273-1278.
- Edwards, L. D. (1998). Embodying mathematics and science: Microworlds as representations. *Journal of Mathematical Behaviour*, 17(1), 53-78
- Edwards, P., Domínguez, E. & Rico, M. (2008). A Second Look at *Second Life*: Virtual Role-play as a Motivational Factor in Higher Education. In K. McFerrin et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2008* (pp. 2566-2571). Chesapeake, VA: AACE.
- Edwards, E., Elliot, J. & Bruckman, A. (2001). AquaMOOSE 3D: Math learning in a 3D multi-user virtual world. In *ACM CHI 2001 Conference on Human Factors in Computing Systems*, Seattle, Washington, USA, 2001
- Elliot, J., Adams, L. & Bruckman, A. (2002). No magic bullet: 3D video games in education. In *Proceedings of ICLS 2002*; Seattle, WA, Oct. 23-26, 2002
- Elliot, J. & Bruckman, A. (2002). Design of a 3D interactive math learning environment. In *Proceedings of Design of interactive systems: Processes, practices, methods and techniques*. June 25-28th 2002 London.
- Emanuel, E. J. & Grady, C. (2006). Four paradigms of clinical research and research oversight. *Cambridge quarterly of healthcare ethics* 16, 82-96
- Ess, C. & the AoIR ethics working committee (2002). *Ethical decision-making and Internet research: Recommendations from the AoIR ethics working committee*. Retrieved 30th September 2009, from <http://www.aoir.org/reports/ethics.pdf>
- Esteves, M., Fonseca, B., Morgado, L., & Martins, P. (2009). Using *Second Life* for problem based learning in computer science programming. *Journal of Virtual Worlds Research* 2(1). Accessed on 15th January, 2010 from <https://journals.tdl.org/jvwr/article/view/419/462>
- Esteves, M., Fonseca, B., Morgado, L., & Martins, P. (2010). Improving teaching and learning of computer programming through the use of the *Second Life* virtual world. *British Journal of Educational Technology*, 42(4), 624-637.

- Eysenbach, G. & Till, J. E. (2001). Ethical issues in qualitative research on internet communities. *BMJ* 323, 1103-1105
- Ezzy, D. (2002) *Qualitative analysis: Practice and innovation* London: Routledge
- Faiola, A. & Smyslova, O. (2009). Flow experience in *Second Life*: The impact of telepresence on human-computer interaction. In A.A. Ozok and P. Zaphiris (Eds.) *Online Communities*. Berlin: Springer pp. 574-583
- Feenan, K. (2011). 2011 conference summary. In *Proceedings of Virtual Worlds Best Practices in Education*, March 2011.
- Feurzeig, W. (2007). Towards an culture of creativity: A personal perspective on Logo's early years, legacy, and ongoing potential. In I. Kalaš (ed.) *Proceedings of EuroLogo 2007*. Bratislava, August 2007
- Firat, M. (2010). Learning in 3D virtual worlds and current situation in Turkey. *Procedia-Social and Behavioral Sciences*, 9, 249-254.
- Francino, F. & Guiller, J. (2011). "Is That Your boyfriend?" An Experiential and Theoretical Approach to Understanding Gender-Bending in Virtual Worlds. In A. Peachey & M. Childs (Eds.), *Reinventing Ourselves: Contemporary Concepts of Identity in Virtual Worlds*, London: Springer, 153 – 176.
- Frankel, M. S. & Siang, S. (1999) *Ethical and legal aspects of human subjects research on the internet*. Retrieved June 21, 2010, from <http://www.aaas.org/spp/sfrr/projects/intres/report.pdf>
- Gamage, V., Tretiakov, A. & Crump, B. (2011). Teacher perceptions of learning affordances of multi-user virtual environments. *Computers & Education* 57(4), 2406-2413
- Gee, J. P. (2007). Learning and Identity: What Does it Mean to be a Half-Elf? In *What Video Games Have to Teach Us About Learning and Literacy*. Basingstoke: Palgrave Macmillan.
- Gee, J. P. (2003). *What Video Games Have to Teach us About Learning Literacy*. New York: Palgrave Macmillan
- Gerstein, J. (2009). Beyond the game: Quest Atlantis as an online learning experience for gifted elementary students. *Journal of Virtual World Research* 2(1). Accessed on 15th January, 2010 from <https://journals.tdl.org/jvwr/article/view/403/458>
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin Company
- Girvan, C. & Savage, T. (2010). Identifying an appropriate pedagogy for virtual worlds: A Communal Constructivism case study. *Computers & Education*. 55(1), 342-349.
- Girvan, C., Tangney, B. & Savage, T. (2010). SLurtle Soup: a conceptual mash up of constructionist ideas and virtual worlds. In *Proceedings of Constructionism 2010*. Paris, August 2010.

- Girvan, C. & Savage, T. (2011). Conducting text-based interviews in virtual worlds. In Proceedings of *ReLIVE 2011*. Milton Keynes, UK
- Girvan, C. & Savage, T. (2012) Ethical considerations for educational research in a virtual world. *Interactive Learning Environments* 20(3) p.239-251.
- Girvan, C. & Savage, T. (in press) Guidelines for conducting text based interviews in virtual worlds. In Childs, M. and Peachey, A. (Eds.) *Understanding Learning in Virtual Worlds* UK: Springer.
- Girvan, C., Tangney, B. & Savage, T. (in press). SLurtles: A tool to support constructionist learning in *Second Life*. *Computers & Education*
<http://dx.doi.org/10.1016/j.compedu.2012.08.005>
- Glaser, B. G. & Strauss, A. L. (1967). *The Discovery of Grounded Theory*. Chicago: Aldine
- Goel, L., Junglas, I., & Ives, B. (2009). Virtual Worlds as Platforms for Communities of Practice. *Knowledge Management and Organizational Learning*, 4(3), 180-196.
- Good, J., Howland, K. & Thackray, L. (2008). Problem-based learning spanning real and virtual worlds: a case study in *Second Life*. *ALT-J*, 16(3), 163-172.
- Grenfell, J. & Warren, I. (2010). Virtual worlds to enhance student engagement. *The international journal of technology, knowledge and society*, 6 (1), 25-40
- Grimes, J. M., Fleischman, K. R. & Jaeger, P. T. (2009). Virtual guinea pigs: Ethical implications of human subjects research in virtual worlds. *International Journal of Internet Research Ethics*. 2(1), 38-56
- Grimes, J. M., Fleischman, K. R. & Jaeger, P. T. (2010). Research ethics and virtual worlds. In C. Wankel & S. K. Malleck (Eds.), *Emerging ethical issues of life in virtual worlds*. Charlotte NC: Information Age Publishing
- Guba, E.G. (1981) Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology Journal*, 29, 75–91.
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research*. Thousand Oaks, CA: Sage. 105-117
- Gwet, K. L. (2008). Computing inter-rater reliability and its variance in the presence of high agreement. *British Journal of Mathematical and Statistical Psychology* (2008), 61, 29–48
- Hassell, M., Goyal, S., Limayem, M. & Boughzala, I. (2009). Being there: An empirical look at learning outcomes in 3D virtual worlds. In proceedings *AMCIS 2009 (15th American Conference on Information Systems)*. San Francisco, United States
- Hatch, J. A. (2002). *Doing qualitative research in educational settings*. Albany: State University of New York Press

- Hawkridge, D. & Wheeler, M. (2009). Tutoring at a distance, online tutoring and tutoring in *Second Life*. In proceedings *EDEN (European Distance and E-Learning Network)*. Leuven, Netherlands
- Hayes, E. R. (2006). Situated learning in virtual worlds: The learning ecology of *Second Life*. In *AERC Conference Proceedings* pp. 154-159. Retrieved March 3, 2009, from <http://www.adulterc.org/proceedings/2006/proceedings/hayes.pdf>
- Herring, S. (1996). Linguistic and critical analysis of computer mediated communication: Some ethical and scholarly considerations. *The Information Society*, 12(2), 153-168
- Hetherington, R., Bonar-Law, J., Fleet, T., & Parkinson, L. (2008). Learning in a Multi-User Virtual Environment. In proceedings *IEEE Visualisation, 2008 International Conference*, pp. 99-105.
- Hew, K. F. & Cheung, W. S. (2010). Use of three-dimensional (3-D) immersive virtual worlds in K-12 and higher education settings: A review of the research. *British Journal of Educational Technology*. 41(1), 33-55.
- Hitchcock, G. & HughesD. (1995) *Research and the Teacher*. London: Routledge
- Ho, C. M. L. (2010). What's in a question? The case of students' enactments in the *Second Life* virtual world, *Innovation in Language Learning and Teaching*, 4(2), 151-176
- Hobbs, M., Gordon, M. & Brown, E. (2006). *A virtual world environment for group work*. Retrieved March 16, 2010, from <http://www.formatex.org/micte2006/Downloadable-files/oral/A%20Virtual%20World.pdf>
- Hollins, P. & Robbins, S. (2008). The educational affordances of multi-user virtual environments (MUVE). In proceedings *ReLIVE 2008 (Researching Learning in Virtual Worlds)*, 172-180
- Hollins, P. & Robbins, S. (2009). The educational affordances of multi-user virtual environments. In D. Heider (ed.), *Living Virtually: Researching New Worlds*. New York: Peter Lang Publishing, 257-270
- Holmes, B., Tangney, B., FitzGibbon, A., Savage, T., & Mehan S. (2001) Communal Constructivism: Students constructing learning for as well as with others. Proceedings of *SITE 2001*. Retrieved August 23, 2007, from <http://www.cs.tcd.ie/publications/techreports/reports.01/TCD-CS-2001-04.pdf>
- Honey, M., Connor, K., Veltman, M., Bodily, D. & Diener, S. (2012). Teaching with *Second Life*: Hemorrhage management as an example of a process for developing simulations for multiuser virtual environments. *Clinical Simulation in Nursing*, 8(3), 79-85
- Hoyles, C., Noss, R. (2003). What can digital technologies take from and bring to research in mathematics education? In: Bishop, A.J., Clements, M.A., Keitel, C., Kilpatrick, J., Leung, F.K.S. (Eds.), *Second International Handbook of Mathematics Education*, Dordrecht: Kluwer Academic Publishers, 323-349.
- Hoyles, C., Noss, R. & Adamson, R. (2002). Rethinking the Microworld idea. *Journal of Educational Computing Research*, 27(1), 29-53.

- Huang, Y., Backman, S. J. & Backman, K. F. (2010). Student attitude toward virtual learning in *Second Life*: A flow theory approach. *Journal of Teaching in Travel & Tourism*, 10(4), 312-334
- Hwang, J., Park, H., Cha, J. & Shin, B. (2008). Effects of object building activities in *Second Life* on players' spatial reasoning. In proceedings *Second IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning*, pp. 62-69
- Inman, C., Wright, V. H. & Hartman, J. A. (2010). Use of *Second Life* in K-12 and higher education: A review of research. *Journal of Interactive Online Learning*, 9(1), 44-63
- Jamaludin, A., Chee, Y. S. & Ho, C. M. L. (2009). Fostering argumentative knowledge construction through enactive role play in *Second Life*. *Computers & Education*, 53(2), 317-329.
- Jarmon, L. (2009). Pedagogy and learning in the virtual world of *Second Life*. In P. Rogers, G. Berg, J. Boettcher, C. Howard, L. Justice & K. Schenk (Eds.) *Encyclopaedia of distance and online learning*. (2nd ed.,) (pp.1610-1619) Hershey, PA: IGI Global.
- Jarmon, L., Traphagan, T., Mayrath, M. & Trivedi, A. (2009). Virtual world teaching, experiential learning, and assessment: An interdisciplinary communication course in *Second Life*. *Computers & Education*, 53(1), 169-182
- Jarmon, L. & Sanchez, J. (2008). The Educators Coop: A virtual world model for real world collaboration. Proceedings of the *American Society for Information Science and Technology*, 45, 1-10
- Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., & Walton, A. (2008). Measuring and defining the experience of immersion in games. *International Journal of Human-Computer Studies*, 66(9), 641-661.
- Jennings, N., & Collins, C. (2007). Virtual or virtually U: Educational institutions in *Second Life*. *International Journal of Human and Social Sciences*, 2(3), 180-186.
- John, P. & Sutherland, R. (2005). Affordance, opportunity and the pedagogical implications of ICT. *Educational Review*, 57(4), 404-413
- Johnson, C. M., Corazzini, K. N. & Shaw, R. (2011). Assessing the feasibility of using virtual environments in distance education. *Knowledge Management & E-Learning: An International Journal*, 3(1), 5-16
- Johnson, L., Laurence, F., Levine, A. and Smith, R. (2007). *The 2007 Horizon Report*. Austin, Texas: The New Media Consortium
- Johnson, L. & Levine, A. H. (2008). Virtual worlds: Inherently immersive, highly social learning spaces. *Theory Into Practice*, 47(2), 161-170
- Johnson, L., Smith, R., Willis, H., Levine, A., and Haywood, K. (2011b). *The 2011 Horizon Report*. Austin, Texas: The New Media Consortium

- Kafai, Y. B. (2006). Constructionism. In R. K. Sawyer (Ed.) *The Cambridge Handbook of the Learning Sciences*. (pp35-46) Cambridge: Cambridge University Press.
- Kafai, Y. B. & Resnick, M. (1996). *Constructionism in Practice: Designing, thinking and Learning in a Digital World*. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.
- Kahn, K. (2007) Should LOGO keep going forward 1? *In Proceedings of EuroLogo 2007*. Edited by I. Kalaš . Bratislava, August 2007
- Kanuka, H. & Anderson, T. (2007). Ethical issues in qualitative e-learning research. *International journal of qualitative methods* 6(2), 20-38.
- Kant, I. (2005). *The moral law: Groundwork of the metaphysic of morals* (H. J. Paton, trans.). Abingdon, Oxfordshire: Routledge.
- Kemp, J. & Livingstone, D. (2006). Putting a *Second Life* “metaverse” skin on learning management systems. *Proceedings of Second Life Education Workshop 2006*, 13-18.
- Kemp, J. W., Livingstone, D. and Bloomfield, P. R. (2009) SLOODLE: Connecting VLE tools with emergent teaching practice in *Second Life*. *British Journal of Educational Technology* 40 (3), 551-555.
- Ketelhut, D. J. (2007). The Impact of Student Self-efficacy on Scientific Inquiry Skills: An Exploratory Investigation in *River City*, a Multi-user Virtual Environment. *Journal of Science Education and Technology*. 16(1), 99-111.
- Ketelhut, D.J., Clarke, J., Nelson, B. & Dukas, G. (2008). Rethinking pedagogy: using multi-user virtual environments to foster authentic science learning. *Proceedings of the International conference of the learning sciences*, Utrecht Netherlands
- Ketelhut, D. J., Nelson, B. C., Clarke, J. and Dede, C. (2010), A multi-user virtual environment for building and assessing higher order inquiry skills in science. *British Journal of Educational Technology*, 41: 56–68
- Kirriemuir, J. (2007). *An update of the July 2007 “snapshot” of UK Higher and Further Education Developments in Second Life*. Bath: Eduserv.
- Kirriemuir, J. (2010). Virtual world activity in UK universities and colleges (Spring 2010). Accessed on 26/9/2010 from <http://virtualworldwatch.net/wordpress/wp-content/uploads/2010/05/Snapshot-8.pdf>
- Kirschner, P. A. (2002). Can we support CSCL? Educational, social and technological affordances for learning. In P. A. Kirschner (Ed.), *Three worlds of CSCL: Can we support CSCL* (pp.7-47). Heerlen: Open University of the Netherlands.
- Kluge, S., & Riley, L. (2008). Teaching in Virtual Worlds: Opportunities and Challenges. *Issues in Informing Science and Information Technology*, 5, 127-135.
- Knorr, R. M., Bronack, S. C., Switzer, D. M. & Medford, L. F. (2011). Methodology of a Novel Virtual Phenomenology Interview Technique. *Journal of Virtual Worlds Research* 3(3).

- Kolb, D. A. (1984). *Experiential learning: experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall.
- Konstantinidis, A., Tsiatsos, T., Demetriadis, S. & Pomportsis, A. (2010). Collaborative learning in OpenSim by utilising Sloodle. *IEEE*
- Korlov, M. (2011). Next stop: OpenSim! *T.H.E. Journal* 38(1) 46-48
- Kreijns, K., Kirschner, P. & Jochems, W. (2003) Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behavior*, 19(3), 335–353.
- Krippendorff, K. (2004). *Content analysis* (2nd edition). London: Sage Publications
- Kuksa, I. & Childs, M. (2010). But a walking shadow: designing, performing and learning on the virtual stage, 35(3), 275-291
- Kvale, S., & Brinkmann, S. (2009). *InterViews: learning the craft of qualitative research interviewing* (2nd edition). London: Sage Publications.
- Landis, J. R. & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics* 33(1), 159–174.
- Lawlor, J., Conneely, C. & Tangney, B. (2010). Towards a pragmatic model for group-based, technology-mediated, project-orientated learning – an overview of the B2C model. In M. D. Lytras, P. Ordenez De Pablos, D. Avison, J. Sipior, Q. Jin, W. Leal, L. Uden, M. Thomas, S. Cervai and D. Horner (Eds.) *Technology Enhanced Learning: Quality of Teaching and Educational Reform*, Berlin: Springer, 602-609.
- Lee, A., & Berge, Z. L. (2011). *Second Life* in Healthcare Education: Virtual Environment's Potential to Improve Patient Safety. *Knowledge Management & E-Learning: An International Journal (KM&EL)*, 3(1), 17-23
- Lee, P.D. (2009) Using *Second Life* to Teach Operations Management. *Journal of Virtual Worlds Research*, 2(1), 3-15.
- Lehdonvirta, V. (2010). Virtual worlds don't exist: Questioning the dichotomous approach in MMO studies. *The International Journal of Computer Game Research*, 10(1), Accessed on 4th September 2011 from <http://gamestudies.org/1001/articles/lehdonvirta>
- Lemon, M., & Kelly, O. (2009). Laying *Second Life* foundations: Second chance learners get first life skills. Proceedings of *ascilite (Australasian Society for Computers in Learning in Tertiary Education) 2009*, Auckland. Accessed on 15th January 2010 from <http://www.ascilite.org.au/conferences/auckland09/procs/lemon.pdf>
- Leong, P., Joseph, S. R. H. & Boulay, R. (2010). Applying constant comparative and discourse analysis to virtual worlds research. *Journal of Virtual Worlds Research*, 3(1), 1-26, Accessed on 5th June 2011 from <https://journals.tdl.org/jvwr/article/view/815/880>

- Lin, P., Eisenberg, M. B. & Marino, J. (2010). "Hi! I'm Harvey, A Consent Bot": How automating the consent process in SL addresses challenges of research online. *Proceedings of iConference '10*, February 3-6, 2010, Illinois: ACM.
- Lipman, M. (2003). *Thinking in Education*. (2nd ed.). Cambridge: Cambridge University Press.
- Lowendahl, J. M. (2011). *Hype Cycle for Education, 2011*. Gartner, Inc.
- Maher, M. L., Liew, P. S., Gu, N., & Ding, L. (2005). An agent approach to supporting collaborative design in 3D virtual worlds. *Automation in Construction*, 14(2), 189-195.
- Maloney, J., Burd, L., Kafai, Y., Rusk, N., Silverman, B. & Resnick, M. (2004). *Scratch: A sneak preview*. In Y. Kambayashi, K. Tanaka & K. Rose (Eds.), *Proceedings of The Second International Conference on Creating, Connecting, and Collaborating Through Computing* (pp.104-109). Kyoto: Kyoto University.
- Majewski, G., Usoro, A., & Khan, I. (2011). Knowledge sharing in immersive virtual communities of practice. *VINE*, 41(1), 41-62.
- Mallan, K., Foth, M. Greenway, R. & Young, G. T. (2010). Serious playground: using *Second Life* to engage high school students in urban planning, *Learning, Media and Technology*, 35(2), 203-225
- Margeston, D. (1997) "Why is Problem-based Learning a Challenge?" In D. Boud, and G. Feletti (Eds.), *The Challenge of Problem-based Learning*. London: Kogan Page
- Marsh, J. (2010). Young children's play in online virtual worlds. *Journal of Early Childhood Research*, 8(1), 23-39
- Mascitti, I., Fedele, F., Di Marco, D., Fasciani, D., Feituri, M. & Stefanelli, C. (2011). Teaching and learning in-world: Lessons learnt from the AVATAR and the ST.ART projects. In *Proceedings of IEEE 14th International Conference on Interactive Collaborative Learning (ICL 2011)*.
- Martin, S., Diaz, G., Sancristobal, E., Gil, R., Castro, M. & Peire J. (2011). New technology trends in education: Seven years of forecasts and convergence. *Computers & Education*, 57(3), 1893-1906
- Mayrath, M. C., Traphagan, T., Heikes, E. J. & Trivedi, A. (2011). Instructional design best practices for *Second Life*: a case study from a college-level English course. *Interactive Learning Environments*, 19(2), 125-142
- McArdle, G. & Bertolotto, M. (2012). Assessing the application of three-dimensional collaborative technologies within an e-learning environment, *Interactive Learning Environments*, 20(1), 57-75
- McCaffery, J., Miller, A., Allison, C. & Yu, T. (2011). Virtual worlds as a platform for 3D application development. In A. Peachy (Ed.), *Proceedings of Researching Learning in Immersive Virtual Environments (ReLIVE 2011)*, Milton Keynes, 141-153
- McKee, H. A. & Porter, J. E. (2009) Playing a good game: Ethical issues in researching MMOGs and virtual worlds. *International Journal of Internet Research Ethics*, 2(1), 5-37

- McVey, M. H. (2008). Observations of expert communicators in immersive virtual worlds: implications for synchronous discussion, *ALT-J*, 16(3), 173-180
- Meadows, M. S. (2008). *I, avatar: The culture and consequences of having a Second Life*. Berkley: New Riders
- Mercer, N. (2000). *Words and minds: How we use language to think together*. London: Routledge
- Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass
- Metcalf, S. J., Clarke, J. & Dede, C. (2009). Virtual Worlds for Education: River City and EcoMUVE, *MiT6 International Conference*. Accessed on 23/12/2011 from web.mit.edu/comm-forum/mit6/papers/Metcalf.pdf
- Mezirow, J. (1996). Contemporary paradigms of learning. *Adult Education Quarterly*, 46, 158-172
- Middleton, A. J. & Mather, R. (2008). Machinima interventions: innovative approaches to immersive virtual world curriculum integration, *ALT-J*, 16(3), 207-220
- Minocha, S. & Reeves, A. J. (2010). Design of learning spaces in 3D virtual worlds: an empirical investigation of *Second Life*, *Learning, Media and Technology*, 35(2), 111-137
- Minocha, S. & Roberts, D. (2008). Laying the groundwork for socialisation and knowledge construction within 3D virtual worlds. *ALT-J*, 16(3), 181-196.
- Minocha, S., Tran, M. & Reeves, A. (2010). Conducting empirical research in virtual worlds: Experiences from two projects in *Second Life*. *Journal of Virtual Worlds Research*, 3(1), 3-21.
- Moschini, E. (2008). 'The *Second Life* Researcher Toolkit. An Exploration of in-World Tools, Methods and Approaches for Researching Educational Projects in *Second Life*'. Proceedings of the *Researching Learning in Virtual Environments Conference, ReLIVE08*. Milton Keynes, UK, November 2008.
- Moschini, E. (2010) The *Second Life* researcher toolkit – An exploration of in-world tools, methods and approaches for researching educational projects in *Second Life*. In A. Peachy, J. Gillen, D. Livingstone & S. Smith-Robbins (Eds.) *Researching Learning in Virtual Worlds*. London: Springer
- Nardi, B. A., Ly, S. & Harris, J. (2007). Learning Conversations in World of Warcraft. *40th Annual Hawaii International Conference on System Sciences, 2007. (HICSS 2007)* Jan. 2007
- Norman, D. A. (1999). Affordances, conventions, and design. *interactions*, 6(3), 38-43
- Olasoji & Henderson-Begg (2011). Summative Assessment in *Second Life*: a Case Study. *Journal of Virtual Worlds Research*, 3(3), 1-26, Accessed on 5th June 2011 from <https://journals.tdl.org/jvwr/article/view/1460/1783>
- Oliver, M. (2005). The problem with affordance. *E-learning*, 2(4), 402-413.

- Ondrejka, C. (2008). Education Unleashed: Participatory Culture, Education, and Innovation in *Second Life*. In K. Salen, *The Ecology of Games: Connecting Youth, Games, and Learning*. Cambridge, MA: The MIT Press, 2008. 229–252.
- Paliokas, I., Arapidis, C. & Mpimpitsos, M. (2011). PlayLOGO 3D: A 3D Interactive Video Game for Early Programming Education: Let LOGO Be a Game, In Proceedings of *Games and Virtual Worlds for Serious Applications (VS-GAMES), 2011 Third International*, pp.24-31, 4-6 May 2011
- Papadamou, T., Gavrilakis, C., Tsolakidis, C & Liarakou, G. (2010). Education for sustainable development through the use of *Second Life*: The case of a virtual museum for sharks. In M. D. Lytras, P. Ordenez De Pablos, D. Avison, J. Sipior, Q. Jin, W. Leal, L. Uden, M. Thomas, S. Cervai and D. Horner (Eds.) *Technology Enhanced Learning: Quality of Teaching and Educational Reform*, Berlin: Springer, 316-323
- Papademetri-Kachrimani, C. (2012). Is this Constructionism? A case of young children, mathematics and powerful ideas. In Proceedings of *Constructionism 2012*, (pp.94-103), Athens, Greece.
- Papert, S. (1972) On making a theorem for a child. In Proceedings of the *ACM annual conference*, August, 1972, (pp.345-349) Boston, Massachusetts, United States
- Papert, S. (1980). *Mindstorms: Children, computers and powerful ideas* New York: Basic Books
- Papert, S. (1980s). *Constructionism vs. instructionism*. Retrieved January 10, 2008, from http://papert.org/articles/const_inst/const_inst1.html
- Papert, S. (1991). Situating constructionism. In I. Harel & S. Papert (Eds.), *Constructionism* (pp.1-14). Hillsdale, NJ: Lawrence Erlbaum Associate
- Papert, S. (1993). *Mindstorms: Children, computers and powerful ideas* (2nd edition). New York: Basic Books
- Parrinder, G. (1982). *Avatar and Incarnation*. New York: Oxford University Press
- Pasquinelli, E. (2010) The illusion of reality: Cognitive aspects and ethical drawbacks: The case of *Second Life*. In C. Wankel and S. Malleck (eds.) *Emerging Ethical Issues of Life in Virtual Worlds*, North Carolina: Information Age Publishing, 197 – 216
- Pauwels, E. (2007). *Ethics for researchers: Facilitating research excellence in FP7*. Brussels : European Commission.
- Pence, H. E. (2008). Student-organized concerts in a virtual world. *Music Reference Services Quarterly*, 11(1), 73-76
- Penfold, P. (2009). Learning through the world of *Second Life*—A hospitality and tourism experience, *Journal of Teaching in Travel & Tourism*, 8(2-3), 139-160
- Perera, G. I. U. S., Allison, C., Sturgeon, T. & Nicoll, J. R. (2009). Towards Successful 3D Virtual Learning - A Case Study on Teaching Human Computer Interaction. In Proceedings *4th International Conference for Internet Technology and Secured Transactions*, London, 2009

- Petrakou, A. (2010). Interacting through avatars: Virtual worlds as a context for online education. *Computers & Education*, 54(4), 1020-1027.
- Pfeil, U., Ang, C. S. & Zaphiris, P. (2009). Issues and challenges of teaching and learning in 3D virtual worlds: real life case studies, *Educational Media International*, 46(3), 223-238
- Piaget, J. (1978). *The development of thought: Equilibration of cognitive structures* (R. Arnold trans.) Oxford: Blackwell
- Rao, S. & Perry, C. (2003). Convergent interviewing to build a theory in under-researched areas: principles and an example investigation of Internet usage in inter-firm relationships. *Qualitative market research*, 6(4), 236-247
- Rapanotti, L., Minocha, S., Barroca, L., Boulos, M. N., & Morse, D. R. (2012). 3D Virtual Worlds in Higher Education. In A. Olofsson, & J. Lindberg (Eds.), *Informed Design of Educational Technologies in Higher Education: Enhanced Learning and Teaching*, 212-240
- Reinhard, C. D. (2010). Interviews within experimental frameworks: How to make sense of sense-making in virtual worlds. *Journal of Virtual Worlds Research*, 3(1), 3-25
- Resnick, M. (1993). Behaviour construction kits. *Communications of the ACM*, 36(7), 64-71
- Resnick, M. (1996). Distributed constructionism. In D. C. Edelson & E. A. Domeshek (Eds.) *Proceedings of the 1996 International Conference on Learning Sciences*, 280-284
- Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastwood, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B. & Kafai, Y. (2009). Scratch: Programming for all. *Communications of the ACM*, 52(11), 60-67
- Richards, L. (1999). *Using NVivo in qualitative research*. London: Sage
- Richardson, A., Hazzard, M., Challman, S. D., Morgenstein, A. M. and Brueckner, J. K. (2011). A "Second Life" for gross anatomy: Applications for multiuser virtual environments in teaching the anatomical sciences. *Anatomical Sciences Education*, 4, 39-43
- Ricoeur, P. (2004) *The conflict of interpretations: Essays in hermeneutics*. (ed. D. Ihde) London: Continuum
- Robbins, S. (2006). "Image slippage": Navigating the dichotomies of an academic identity in a non-academic virtual world. *Proceedings of Second Life Education Workshop 2006*, 35-38
- Robertson, J. & Kipar, N. (2010). Learning together and alone in virtual worlds. In K. Sheehy, R. Ferguson and G. Clough (Eds.) *Virtual Worlds: Controversies at the Frontier of Education*. New York: Nova Science Publishers, 67-84
- Rosenbaum, E. (2008). Scratch for *Second Life*. In S. Veeragoudar Harrell (Chair & Organizer), *Virtually there: Emerging designs for STEM teaching and learning in immersive online 3D microworlds*. Symposium in *Proceedings of the International Conference on Learning Sciences – ICLS 2008*. Utrecht, The Netherlands: ICLS. Abstract retrieved February 1, 2010, from <http://www.fi.uu.nl/en/icls2008/144/paper144.pdf>

- Roth, W-M (2004). Qualitative research and ethics. *Forum: Qualitative social research* 5(2). Retrieved June 17th 2010, from <http://www.qualitative-research.net/fqs/>
- Salmon, G. (2009). The future for (second) life and learning. *British Journal of Educational Technology*, 40(3), 526-538
- Salomon, G. (1994). *Distributed cognition*. Cambridge: Cambridge University Press
- Sanchez, J. (2007). *Second Life: An Interactive Qualitative Analysis*. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2007*. Chesapeake, VA: AACE, 1240-1243
- Sanchez, J. (2009). A social history of virtual worlds. *Library Technology Reports*, 45(2), 9-12
- Sanchez, J. (2009b). Barriers to student learning in *Second Life*. *Library Technology Reports*, 45(2), 29-34
- Sancho, P., Torrente, J. & Fernandez-Manjon, B. (2009). Do multi-user virtual environments really enhance student's motivation in engineering education? *39th IEEE Frontiers in Education Conference, 2009. (FIE '09)* 18-21st Oct. 2009.
- Santo, S. (2008). Teaching in *Second Life: A virtual world*. *Proceedings of ascilite (Australasian Society for Computers in Learning in Tertiary Education)*, Singapore. Accessed on 25th February, 2009 from <http://orgs.usd.edu/gpctss/Submissions2008/Santo2008.pdf>
- Savin-Baden, M. (2008). From cognitive capability to social reform? Shifting perceptions of learning in immersive virtual worlds. *ALT-J*, 16(3), 151-161
- Savin-Baden, M., Gourlay, L., Tombs, C., Steils, N., Tombs, G. & Mawer, M. (2010) Situating pedagogies, positions and practices in immersive virtual worlds, *Educational Research*, 52(2) 123 – 133
- Savin-Baden, M., Tombs, C., Poulton, T., Conradi, E., Kavia, S., Burden, D. & Beaumont, C. (2011). An evaluation of implementing problem-based learning scenarios in an immersive virtual world. *International Journal of Medical Education* 2, 116-124
- Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith, C. Bereiter (Eds.) *Liberal education in a knowledge society*. Chicago: Open Court Publishing
- Scardamalia, M. & Bereiter, C. (1994). Computer support for knowledge-building communities. *The journal of the learning sciences*, 3(3), 265-283.
- Scardamalia, M. & Bereiter, C. (2003). Knowledge building environments: Extending the limits of the possible in education and knowledge work. In A. DiStefano, K. E. Rudestam, & R. Silverman (Eds.) *Encyclopedia of distributed learning*. Thousand Oaks, CA: Sage Publications
- Scardamalia, M., & Bereiter, C. (2006). Knowledge Building: Theory, pedagogy, and technology. In K. Sawyer (Ed.) *Cambridge handbook of the learning sciences*. Cambridge: Cambridge University Press

- Schroeder, R. (2002). Social interaction in virtual environments: Key issues, common themes, and a framework for research. In *The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments*. London: Springer-Verlag
- Schroeder, R. (2008). Defining Virtual Worlds and Virtual Environments. *Journal of virtual worlds research*, 1(1), Retrieved January 24, 2009, from <https://journals.tdl.org/jvwr/article/view/294/248>
- Schroeder, R. (2011). Being There Together: Social Interaction in Shared Virtual Environments. Oxford: Oxford University Press.
- Sheehy, K., Ferguson, R., & Clough, G. (2007). Learning and teaching in the panopticon: Ethical and social issues in creating a virtual educational environment. *International Journal of Human and Social Sciences*, 2(2), 89-96
- Singh, N. & Lee, M. J. (2009). Exploring perceptions toward education in 3-D virtual environments: An introduction to "Second Life". *Journal of Teaching in Travel & Tourism*, 8(4), 315-327
- Smith, K. (in press). Universal life: the use of virtual worlds among people with disabilities. *Universal Access in the Information Society*, doi: 10.1007/s10209-011-0254-8
- Stake, R. E. (1995). *The Art of Case Study Research*. London: Routledge
- Stake, R. E. (2005). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (eds.) *The SAGE handbook of qualitative research (3rd ed)* (pp.443-466) London: Sage
- Strauss, A. L. & Corbin, J. (1994). Grounded theory methodology: An overview. In N. K. Denzin & Y. S. Lincoln (eds.) *Handbook of qualitative research*. Thousand Oaks: Sage
- Tangney, B., Oldham, E., Conneely, C., Barrett, S., Lawlor, J. (2010) Pedagogy and processes for a computer engineering outreach workshop – the B2C model. *IEEE Transactions on Education* 53(1) 53-60
- Taylor, T. L. (2002). Living digitally: Embodiment in virtual worlds. In R. Schroeder (Ed.) *The Social Life of Avatars: Presence and Interaction in Shared Virtual Environments*. London: Springer-Verlag
- Trinity College Dublin (2009). *Policy on Good Research Practice*. <http://www.tcd.ie/about/policies/assets/pdf/TCDGoodResearchPractice.pdf>
- Tuckman, B. W. (1994). *Conducting Educational Research*. London: Harcourt Brace College Publishers.
- Turkle, S. (1997). *Life on the screen: Identity in the age of the Internet*. New York: Touchstone.
- Vasileiou, V. N. & Paraskeva, F. (2010). Teaching role-playing instruction in *Second Life*: An exploratory study. *Journal of Information, Information Technology, and Organizations*, 5.
- Vogel, D., Guo, M., Zhou, P., Tian, S., Zhang, J., & Suzhou, P. R. (2008). In Search of *Second Life* Nirvana. *Issues in informing science and information technology*, 5, 11-28.

- von der Emde, S., Schneider, J., & Kotter, M (2001). Technically speaking: Transforming language learning through virtual learning environments (MOOs). *The Modern Language Journal*, 85(2), 210-225
- Vrellis, I., Papachristos, N.M., Bellou, J., Avouris, N. & Mikropoulos, T.A. (2010). Designing a Collaborative Learning Activity in *Second Life* - An Exploratory Study in Physics. *2010 IEEE 10th International Conference on Advanced Learning Technologies (ICALT)*, 210-214, 5-7 July 2010
- Vygotsky, L. S. (1986). *Thought and language*. (L. Semenovitch, Trans.) Cambridge, MA: MIT Press. (Original work published 1934).
- Walker, V. L. (2009). 3D virtual learning in counsellor education: Using *Second Life* in counsellor skill development. *Journal of Virtual Worlds Research*, 2(1), 1-14. Accessed on 15th January, 2010 from <https://journals.tdl.org/jvwr/article/view/423/463>
- Warburton, S. (2009). *Second Life* in higher education: Assessing the potential for and the barriers to deploying virtual worlds in learning and teaching. *British Journal of Educational Technology*, 40(3), 414-426
- Warburton, S. & Perez-Garcia, M. (2010). 3D design and collaboration in massively multi-user virtual environments (MUVEs). In D. Russell (Ed.) *Cases on collaboration in virtual learning environments: Processes and interactions*. Hershey, PA: IGI Global
- Webb, A. (2011). *Teaching literature in virtual worlds: Immersive learning in English studies*. Oxford: Routledge
- Wehner, A. K., Gump, A. W. & Downey, S. (2011). The effects of *Second Life* on the motivation of undergraduate students learning a foreign language. *Computer Assisted Language Learning*, 24(3), 277-289
- Weijer, C., Goldsand, G. & Emanuel, E. J. (1999). Protecting communities in research: current guidelines and limits of extrapolation. *Nature Genetics* 23, 275-280
- Wertsch, J. V. (1991). *Voices of the mind: A sociocultural approach to mediated action*. London: Harvester Wheatsheaf
- Whitton, N. & Hollins, P. (2008). Collaborative virtual gaming worlds in higher education, *ALT-J*, 16(3), 221-229
- Wiecha, J., Heyden, R., Sternthal, E. & Merialdi, M. (2010). Learning in a virtual world: Experience with using *Second Life* for medical education. *Journal of Medical Internet Research*, 12(1), e1
- Williams, A. & Bedward, J. (2002). Understanding girls' experience of physical education: Relational analysis and situated learning. In Penney (Ed.) *Gender and physical education: contemporary issues and future directions*. London: Routledge
- Winn, W. (2005). What we have learned about VR and learning and what we still need to study. *Proceedings from Virtual Reality International Conference*. Retrieved March 14, 2008, from <http://depts.washington.edu/edtech/laval.doc>

- Wrzesien, M., & Alcañiz Raya, M. (2010). Learning in serious virtual worlds: Evaluation of learning effectiveness and appeal to students in the E-Junior project. *Computers & Education*, 55(1), 178-187.
- Yee, N., Bailenson, J. N., Urbanek, M., Chang, F. & Merget, D. (2007). The unbearable likeness of being digital: The persistence of nonverbal social norms in online virtual environments. *CyberPsychology & Behaviour*, 10(1), 115-121
- Yeh, A. (2010). Three primary school students' cognition about 3D rotation in a virtual reality learning environment. In L. Sparrow, B. Kissane, & C. Hurst (Eds.) *Shaping the future of mathematics education: Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia*, 3-7 July 2010, Fremantle, Western Australia: MERGA
- Yellowlees, P., & Cook, J. (2006). Education about hallucinations using an internet virtual reality system: a qualitative survey. *Academic Psychiatry*, 30(6), 534-539.
- Yin, R. K. (2003). *Applications of case study research*. Thousand Oaks, CA: Sage
- Yin, R. K. (2009). *Case study research: Design and methods*. Thousand Oaks, CA: Sage
- Zastrocky, M., Harris, M., Lowendahl, J. M., De Azevedo Filho, W. A., Claunch, C., Weiss, G. J., McGurkin, P., Gootzit, D., Tully, J., Fiering, L., Latham, L., Schlegel, K., Drakos, N & Andrews, W. (2007). *Hype Cycle for Higher Education, 2007*. Gartner Inc.
- Zhang, Q., Marksbury, N. & Heim, S. (2010). A case study of communication and social interactions in learning in *Second Life*. In *Proceedings of the 43rd Hawaii International Conference on System Science*, p.1-9, January 05-08, 2010
- Zigurs, I., & Zhang, C. (2010). An Inductive Analysis of Factors Affecting Student Attitudes toward a Virtual World Learning Environment. In *Proceedings AMCIS 2010*. Paper 271

Appendix A

This appendix provides a summary of the 86 peer-reviewed articles analysed during the development of the definition of virtual worlds presented in Chapter 2.

Author	Pub Year	World	Application	Definition / description	Codes
Ahmed et al	2010	VW		Definition	• Simulated • Multiple users • Online
Baker et al	2009	VW		Description	• Avatar • Interact with people • Interact with objects
Bell	2008	VW		Definition	• Avatar • Synchronous • Persistence • Facilitated by networked computers
Bell et al	2011	VW		Definition	• Avatar • Synchronous • Persistence • Facilitated by networked computers
Bellotti et al	2010	SVW	Other	Definition	• Simulated • 3D • Immersive • Educational
Boulos et al	2007	VW		Description	• Simulated • Online • Avatar • Multimedia
Braman et al	2011	VW	<i>Second Life (SL)</i>	Description	• Online • Avatar • Interact with environment • Synchronous • 3D • Communication • Build
Burgess et al	2010	MUVE		Definition	• Avatar • 3D

Campbell	2009	VW	SL	Description	• Online • Avatar • 3D
Castronova	2005	synthetic world		Definition	• Multiple users • Interact with environment • Persistent
Cheong	2010	VW	SL	Description	• Avatar • Interact with people
Childs	2008	MUVE		Description	• Simulated • Synchronous • Communication
Coffman & Klinger	2008	MUVE	SL	Description	• Multiple users • 3D
Condic	2009	VW	SL	Description	• Avatar • Interact with people • Communication • Build
Conrad et al	2009	VW	SL	Description	• Online • Interact with people • 3D • Communication • Build
Crellin et al	2009	VW	SL	Description	• Simulated • Persistence • 3D • No goal
Dalgarno & Lee	2010	IVW	Active Worlds (AW) & SL	Both	• Multiple users • Avatar • Interact with objects • Interact with environment • 3D • Communication • Immersive
Dawley	2009	VW		Description	• Simulated • Online • Avatar • Interact with people • 3D • Communication • Build • No goal

de Freitas et al	2010	VW	SL	Description	• Avatar • Synchronous • 3D • Immersive
de Lucia et al 2009b	2009	VW		Description	• Multiple users • 3D • No goal
Dede	1996	VW		Description	• Simulated • Avatar • Facilitated by networked • Immersive
Deutschman n & Panichi	2009	MUVE	SL	Description	• Online • Interact with people • Interact with objects • Synchronous • Multimedia • Communication • Build • No goal
Dickey	2003	VW		Both	• Avatar • Facilitated by networked computers • 3D • Communication
Dickey	2005	VW	AW	Description	• Avatar • Facilitated by networked computers • 3D • Communication
Dickey	2005 b	VW	AW & Other	Description	• Avatar • 3D • Communication
Dickey	2011	VW	AW & SL	Description	• Simulated • Multiple users • 3D
Dittmer	2010	IVW		Description	• Simulated • Avatar • Game
Dreher et al	2009	VW		Both	• Online • 3D • Multimedia • Immersive • No goal

Dreher et al	2009 b	VW	SL	Both	• Online • Avatar • 3D • Multimedia • Build • Immersive • No goal
Dreher et al	2009 c	VW	SL	Description	• Avatar • Immersive • No goal
Eckelman et al	2011	VW	SL	Description	• Online • Build • No goal
Esteves et al	2011	VW	SL	Description	• Multiple users • Online • Avatar • Interact with objects • Synchronous • Persistence • 3D • Communication • Build
Firat	2010	VW		Description	• Facilitated by networked computers • 3D • Communication
Gamage et al.	2011	MUVE		Description	• Avatar • Interact with people • Facilitated by networked computers • 3D • Build • No goal
Gerstein	2009	MUVE	Other	Description	• Multiple users • Avatar • Interact with objects • 3D • Communication • Educational

Girvan & Savage	2010	VW		Description	• Multiple users • Online • Avatar • Interact with people • Persistence • 3D • Communication • Immersive
Goel et al	2009	VW	SL	Description	• Simulated • Online • Avatar • Interact with people • Persistence • 3D • Communication • Build • No goal
Grenfell & Warren	2010	MUVE		Description	• Multiple users • Online • Avatar • Interact with people • Interact with objects • Communication • Immersive • Educational
Hassell et al	2009	VW		Description	• Online • Avatar • Interact with people • 3D • Communication
HawkrIDGE & Wheeler	2009	MUVE	SL	Description	• Avatar • No goal
Hayes	2006	social VW	SL	Description	• Online • Avatar • Interact with people • Persistence • 3D • No goal

Hetherington et al	2008	MUVE	SL	Description	• Multiple users • Online • Interact with people • Synchronous • Persistence • 3D • Build • No goal
Hew & Cheung	2010	VW		Description	• Avatar • Interact with objects • 3D • Communication • Build • Immersive
Ho	2010	VW	AW&SL	Description	• Multiple users • Interact with people • Synchronous • 3D • Immersive
Hobbs et al	2006	VW	SL	Description	• Online • 3D • Build
Honey et al	In press	MUVE & VW	SL	Both	• Multiple users • Online • Avatar • Interact with objects • Interact with environment • 3D Communication
Huang et al	2010	VW		Description	• Synchronous • 3D • Multimedia • Game
Hwang et al	2008	Virtual reality	SL	Description	• Online • 3D • Build • Game
Inman et al	2010	IWW		Description	• Interact with people • Synchronous • Communication
Jarmon & Sanchez	2008	Social VW	SL	Description	• Interact with people • No goal • Build

Jarmon	2008	VW	SL	Description	• Multiple users • Online • Avatar • Interact with people • 3D • Build
Jennings & Collins	2007	VW	SL	Description	• Simulated • Communication • Build • No goal
Johnson & Levine	2008	VW	AW&SL	Description	• Online • Build • No goal
Johnson et al	2011	Virtual environment	SL	Description	• Simulated • Avatar • Interact with people • Interact with objects • Synchronous • Communication
Kluge & Riley	2008	VW		Description	• Online • Avatar • 3D
Kuksa & Childs	2010	IVW	SL	Description	• Avatar • Interact with people • Interact with objects • Build
Lee & Berge	2011	Virtual environment	SL	Description	• Avatar • Interact with people • 3D
Lemon & Kelly	2009	MUVE	SL	Definition	• Multiple users • Online • Synchronous • Persistence • 3D • Graphical
Leong et al	2010	VW		Description	• Multiple users • Online • 3D
Maher et al	2005	VW	AW	Description	• Multiple users • Interact with people • 3D • Communication

Majewski et al	2011	IVW		Description	• Simulated • Avatar • Interact with people • 3D • Communication
Mallan et al	2010	VW		Both	• Multiple users • Avatar • Interact with objects • Synchronous • Persistence • 3D • Immersive
Marsh	2010	VW	Other	Description	• Online • Avatar • Interact with people • Persistence • 3D • Immersive • 2D
Mayrath et al	2011	VW	SL	Description	• Avatar • 3D • Build • Graphical • No goal
McVey	2008	IVW	SL	Description	• Avatar • Synchronous • Communication
Middleton & Mather	2008	IVW	SL	Description	• Build • Interact with people • Interact with objects • Interact with environment • Synchronous • Persistence

Minocha & Reeves	2010	VW / synthetic world		Description	• Multiple users • Avatar • Interact with people • Interact with environment • Synchronous • Persistence • Facilitated by networked computers • 3D • Communication • Immersive
Minocha & Roberts	2008	VW		Description	• Simulated • Online • Avatar • 3D • Multimedia • Immersive
Minocha et al	2010	VW / synthetic world		Description	• Simulated • Online • Avatar • Synchronous • 3D • Multimedia • Communication • Immersive
Olasoji & Henderson-Begg	2011	MUVE	SL	Definition	• Synchronous • No goal
Ondrejka	2008	VW		Description	• Simulated • Multiple users • 3D • Build
Pence	2008	VW	SL	Description	• Online • Avatar • Interact with people • 3D • Build
Penfold	2009	VW	SL	Description	• Simulated • Online • Avatar • Interact with people • Persistence • 3D • Build • No goal • Game

Pfeil et al	2009	VW	SL	Description	• Multiple users • Avatar • Interact with people • Persistence • 3D • Communication • Build
Reinhard	2010	VW	Other	Definition	• Online • Avatar • Persistence • Facilitated by networked computers • No goal • Game
Richardson et al	2011	MUVE	SL	Description	• Avatar • Interact with people • Interact with objects • Interact with environment • Communication • Build
Santo	2008	VW	SL	Description	• Online • Avatar • Synchronous • Communication • Immersive • Graphical
Schroeder	2008	VW		Description	• Multiple users • Interact with people • Interact with environment • Persistence • No goal • Immersive • Graphical
Sheehy et al	2007	VW		Description	• Avatar • Synchronous • 3D • Communication

Singh & Lee	2009	VE	SL	Both	• Simulated • Interact with people • Interact with environment • Synchronous • 3D • Communication • Immersive • Graphical
Vogel et al	2008	VW	SL	Description	• Online • Communication • Build
Warburton & Perez Garcia	2010	VW	SL	Both	• Interact with environment • 3D • Immersive • Graphical
Warburton	2009	VW		Description	• Multiple users • Avatar • Interact with environment • Synchronous • Persistence • Facilitated by networked computers • Immersive
Wehner et al	2011	VW		Both	• Multiple users • Online • Interact with environment • Synchronous • 3D • Immersive • Graphical
Wrzesien & Raya	2010	SVW	Other	Definition	• 3D • Educational
Yellowlees & Cook	2006	VW	SL	Description	• Simulated • Online • 3D
Zigurs & Zhang	2010	VWLE	SL	Definition	• Simulated • Avatar • Interact with people • Interact with objects • Educational

Appendix B

Appendix B presents the module descriptor in which the learning experience was implemented.

Module Code	CS7036
Module Title	Technologies for Teaching and Learning
Pre-requisites	None
ECTS	10
Chief Examiner	-
Teaching Staff	-
Delivery	The teaching & learning methods utilised in the module include a mixture of formal lectures, practical sessions and workshops.
Aims	The aims of this module are to raise awareness and develop understanding of a number of innovative technologies used in the area of technology and learning and engage in concrete experiences with these technologies.
Learning Outcomes	Upon successful completion of the module students should be able to: • analyse, through experience, how relevant pedagogical theories can be embodied in different technological artefacts. • integrate, through experience, pedagogically inspired technical artefacts into teaching and learning. • develop and use of a number of learning technologies.
Syllabus	Simulations; Constructionist learning tools; Hypertext; Online environments for learning; WebQuests; Web 2.0 technologies; Wikis; Pod casting; Virtual worlds
Assessment	Students are required to design, implement and critically reflect upon learning scenarios facilitated by some of the technologies covered in the module.
Bibliography	1. Barab, S. A., Kling, R., & Gray, J. H. (Eds.). (2004). <i>Designing Virtual Communities in the Service of Learning</i>. Cambridge: Cambridge University Press. 2. Salmon, G. (2000). <i>E-Moderating: The key to teaching and learning online</i>. London: Kogan Page. 3. Grabe, M., & Grabe, C. (2001). <i>Integrating Technology for Meaningful Learning</i> (3rd ed.). Boston & New York: Houghton Mifflin. 4. Gredler, Margaret E., <i>Learning and Instruction, Theory into Practice</i>, Prentice Hall, 2000 5. Jonassen, D. H. (2000). <i>Computers as Mindtools for Schools:</i>

	<i>Engaging Critical Thinking</i> (2nd ed.). Upper Saddle River, NJ: Prentice-Hall, inc. 6. Papert, S. (1993). <i>Mindstorms: Children, Computers and Powerful Ideas</i> (2nd ed.). Cambridge, MA: Basic Books.
Website	-

Appendix C

Appendix C presents the formal descriptor of the learning experience as presented to the students on the module:

Constructionist Learning in a Virtual World: SLurtles

Description

In pairs create an interactive “installation” made up of scripted SLurtle blocks.

This will require scripting the supplied SLurtles to create the necessary SLurtle blocks and then scripting those blocks to add interactivity.

All scripting to be done in Scratch_4SL

At least (50%) of the collaboration between the pair should take place at a distance via SL. (* When multiple pairs are present in the same part of the SL course island at the same time you are advised to use chat/IM rather than voice for communication. *)

Each individual should produce a digital presentation that **reflects** upon how their personal learning experience in this project (and segment of the course) related to constructionism and any other relevant pedagogical theories covered in the course.

Each pair should produce a digital reflection which synthesises the individual reflections.

Marking Scheme

- | | |
|-----|--|
| 65% | Sophistication and inventiveness of the installation |
| 25% | Depth of the individual’s reflection . |
| 15% | Depth of the group’s reflection . |

(Reflections should avoid being a simple narrative descriptive account of what happened.)

Submission and Demonstration

All work to be presented in class on XX.

Links to all digital reflections to be loaded to your web portfolio by the same date and details of the individual and group reflections to be e-mailed to the course lecturer

Group Formation

An initial assignment of people to pairs has been carried out. Changes should be negotiated with the course lecturer. Pairs may of course co-operate with other pairs but assessment is on a pair basis only.

Appendix D

Appendix D presents the participant information sheet referred to in Chapter 4 and participant consent form used in the first case study:

Participant Information Sheet

You are invited to take part in a research project exploring learning in virtual worlds. It is important that you read this information sheet and ask any questions you feel necessary. Any questions you may have during or after the study should be sent to Carina Girvan (girvanc@tcd.ie).

As increasing numbers of educators from varying fields being to use virtual worlds for teaching and learning, there is a need to explore specific pedagogies in this new technology. This study aims to explore constructionism in the virtual world of *Second Life*. The study is being conducted by Carina Girvan and is supported by Brendan Tangney and Tim Savage from the Centre for Research in IT in Education at Trinity College, Dublin.

As part of your course you will take part in a lecture on Constructionism, followed by a workshop using Scratch 4SL and *Second Life*. This will be followed by an assignment providing you with an opportunity to take part in a constructionist learning activity using Scratch 4SL and *Second Life*. During this part of the course you are invited to participate in the research project. Participation in the project is completely voluntary and will not affect the assessment of your assignment or progress on the remainder of the course. If you or anyone in your family has a history of epilepsy you may participate at your own risk. You may refuse to answer any question and can withdraw from the research project at any time.

If you wish to take part in the research project you will be asked to attend the lecture and workshop and complete the assignment as required by the course. You will be shown how to record your text based communication in *Second Life* which you will be asked to record during the activity and once the assignment has been submitted you will be asked to give to the researchers those elements that relate directly to the learning activity. Following the submission of the assignment you will be given a questionnaire and invited to take part in a semi-structured interview with other members of your course which should take no more than 30 minutes. The interview will be audio recorded for subsequent transcription which in turn will be coded to remove personally identifying information such as real life names and avatar names. In addition your submitted assignment, including reflections, will be collected for analysis as part of the research project.

If you do not wish to take part in the research project you will still be required to attend the lecture and workshop and complete the assignment as required by the course.

As you will be aware, under the terms of service Linden Labs may choose to record the interactions of users in *Second Life*. However we will be unable to access this information.

Participants are likely to benefit from the additional opportunity to explore this section of the course during the interview. In addition, participants should be able to gain insight into the research process prior to conducting their own research projects as part of the course.

Following data collection and initial analysis of the data, participants will be invited to a presentation of the early findings of the study prior to the end of their course. The class mailing list will be used to keep participants informed as to the outcomes of the study into the future.

This project follows the guidelines set by both Trinity College Dublin and the School of Computer Science and Statistics, including appropriate ethical approval from the latter. Any personal information collected as part of the study will be stored in accordance with the Data Protection Act at Trinity College, Dublin. No marks awarded as part of the formal course assessment will be stored for the purposes of this study. In the unlikely event that any information pertaining to illegal activities should emerge during the study, the researchers will be obliged to report it to the appropriate authorities. There may be lectures, PhD theses, conference presentations or peer-reviewed journal articles written as a result of this project. No personally identifying information will be used in analysis, publication or presentation of data and findings.

If you have any questions before, during or after the project, please do not hesitate to contact Carina Girvan at Trinity College, Dublin: girvanc@tcd.ie or 01 896 3812.

Participant Consent Form

Project: Constructionism in a Virtual World

Researchers: Carina Girvan, Tim Savage, Brendan Tangney

Project background: As increasing numbers of educators from varying fields being to use virtual worlds for teaching and learning, there is a need to explore specific pedagogies in this new technology. This study explores constructionism in the virtual world of *Second Life*.

Procedures: As part of your course you are required to take part in lectures on Constructionism, a workshop on Scratch 4SL and complete an assignment using Scratch 4SL in *Second Life*. If you take part in this study you will be asked to record your text based communication within *Second Life* during the activity and give those sections that relate directly to the learning activity to the researchers at your discretion. You will also be asked to complete a short questionnaire and take part in a group interview of approximately 30min, following the submission of your assignment. The interview will be audio recorded and transcribed. The transcription will be coded to remove personally identifying information such as names. In addition your submitted project and reflections will be collected and analysed as part of the research project.

Publication: There may be lectures, PhD theses, conference presentations or peer-reviewed journal articles written as a result of this project. No personally identifying information will be used in analysis, publication or presentation of data and findings.

Benefits: As a participant you may benefit from the opportunity to participate in and observe a research project in action, as you are required to conduct research as part of your course. You may also benefit from the additional opportunity to discuss constructionism during the interview.

Declaration:

- I am 18 years or older and am competent to provide consent.
- I have read or had read to me the information sheet and consent form.
- I have had the opportunity to ask any questions and had them answered.
- I understand that I may ask any questions about the research project before, during and after my participation.
- I understand that I am under no obligation to take part in this project and that a decision not to participate will not affect my assessment now or in the future.
- I understand I have the right to withdraw from this project at any stage and that doing so will not affect my assessment.
- I understand that the text based communication collected as part of this research will not be used to affect the results of my assessment.
- I understand that interview and questionnaire data will not be used to affect the results of my assessment.

- I understand that the results of this research project may be published in the forms outlined above and any data used will be in such a way that does not reveal my identity.
- I understand that identity includes reference to both my real life identity and avatar identity.
- I understand that if I or anyone in my family has a history of epilepsy then I am proceeding at my own risk.

Participant's name:

Participant's signature:

Date:

Researcher's signature:

Date:

Project contact details: Carina Girvan

Centre for Research in IT in Education

School of Computer Science and Statistics

Trinity College Dublin

girvanc@tcd.ie

01 896 3812

Appendix E

Appendix E presents an overview of participants in the first case study.

Table E.1 Overview of participants

ID	Age	Gender	Tech level	Previous SL experience
1a1	25	1	3	2
1a2	46	2	1	2
1b1	57	2	3	1
1b2	31	1	2	2
2a1	32	1	3	2
2a2	31	1	3	2
2b1	43	2	1	1
2b2	53	1	3	1
3a1	>30	1	3	2
3a2		2	1	2
3b1	29	2	2	2
3b2	25	2	3	2
4a1	29	1	3	2
4a2	49	1	3	2
4b1	55	2	3	2
4b2	48	1	1	2
5a1	32	1	3	2
5a2	47	1	2	2
5b1	29	1	2	2
5b2	41	2	3	1
6a1	36	1	1	2
6a2	25	1	3	2
6b1	24	1	3	2
6b2	35	2	3	2

Notes:

Gender: 1 = female
 2 = male

Technical level: As part of the course learners were asked to self-assess their technical ability for the purpose of the formation of pairs.

- 1 = Can read and write code
- 2 = Can read/understand code to a limited extent
- 3 = No previous experience with code

Previous SL experience: 1 = yes
2 = no

Totals:

24 participants
15 female
9 male

12 pairs
1 all male
4 all female
7 mixed

Self-rated technical level:

5 could read and write code (1)
4 could read or understand code to a limited extent (2)
15 had no previous experience with code (3)

9 pairs of mixed technical levels (1 and 2 are never in the same group)
3 pairs with no previous experience of code

Second Life experience:

4 participants had previous experience of *Second Life*
20 had no previous experience

14 participants interviewed:

7 female
7 male

1 in all male pair
2 in all female pair
11 in mixed pairs

3 technical level 1
2 technical level 2
9 technical level 3

4 had previous experience of *Second Life*
10 had no previous experience

Appendix F

Appendix F presents the final codes, minor themes, and sub-categories of the categories ‘Thinking’ (Table F.1), ‘Group Work’ (Table F.2), ‘Learning environment and design’ (Table F.3) and ‘Learning’ (Table F.4) which emerged through the constant comparative analysis of the first case study reported in Chapter 5.

Table F.1 Category of 'Thinking', sub-categories, minor themes and codes.

Category	Sub-category	Minor theme	Code
Thinking			Aims
			Alternative approaches
			Break through
			Building with maths
			Change way of thinking
			Considering alternatives
			Different solutions within group
			Experimentation
			Feedback
			Finding solutions
			Follow the rules
			Influence of own background
			Instruction
			Problem solving
			Reflection
			Rethinking
			SLurtle appearance
			SLurtle – engage in thinking
			SLurtle movement
			Stop and think
			Thinking
			Thinking how to teach partner
			Trial and error
			Unexpected
			Way of thinking
	Programming		Careful scripting
			Couldn't stop running script
			Engaging
			Existing knowledge not necessary
			Interaction with space
			Logic
			No way to observe partner's screen
			Observation
			Programming
			Programming easy
			Programming enjoyable
			Programming frustrating

			S4SL abstract
			S4SL easy to use
			S4SL lacked comments
			SLurtle - 3D output
			SLurtle building concrete/observable
			SLurtles engaging
			SLurtles support versioning
			Value of approach to introduce programming
			Versioning using SLurtles
	Barriers	Constraints and limitations	Avoid building – deleting
			Avoid building – permissions
			Camera controls difficult
			Collaboration hindered by SL constraint
			Complexity of idea
			Design of presentation space increased level of skill necessary
			Distance constrained collaboration
			Expectations
			External tools used to overcome limitations of SL tools
			Increased achievement level
			Influence of real life
			Limitations became an advantage
			Partner limited me
			Prim limit
			Problem is a challenge to overcome
			S4SL interface
			S4SL – no test run
			S4SL outside SL
			SL permissions
			SL skills - barrier
			SLurtle loss
			SLurtles not ‘physical’
			SLurtle object creation – from centre
			SLurtle positioning
			Technical problems – distraction
			Technical problems – outside SL
			Time available limited achieving aim
			Transferring script to SLurtle - mechanical
			Variety of SLurtle blocks did (not) limit
			Worked with constraints
			Avatar movement

		Enablers	Challenge
			Enabled
			LSL difficult
			Partner supported rather than constrained
			S4SL broadly enabled despite constraints
			S4SL ease of use
			SL skills low floor
			SLurtle direction
			SLurtle – easy to build
			SLurtle – link to turtle geometry
			SLurtle – supported process
			SLurtle associated skills – higher floor initially
			SLurtles lower floor to building
			Textures to resolve misunderstandings

Table F.2 Category of 'group work' and associated sub-categories and codes.

Category	Sub-category	Code
Group work	(Im)balance	(Im)balance in group
		Communication down
		Expectations
		Group worked well
		Hold partner back
		Independent work
		Learned from partner
		Limited by partner
		Lonely
		Partner experience intimidating
		Perception of own ability compared to partner
		Programmer dominated
	Communication	Avatar & communication
		Communication
		Confusion
		Conversation length
		Discussion
		External tools
		Misunderstanding
		Partner preferred talk
		Pay attention
		Text
		Text easy
		Text slow
		Voice
	Collaboration	(A)synchronous collaboration
		Avatar supports collaboration
		Collaboration
		Collaboration hindered by SL constraint
		Collaboration on unfamiliar task
		Face-to-face collaboration
		Insight into collaboration
		Online collaboration
		Partner influence
		Real life influence
		Roles
		Sharing scripts
		Unable to observe partner
		Virtual an obstacle to collaboration
		Worked well together

Table F.3 The categories of 'learning environment' and 'design', their sub-categories, minor themes and codes.

Category	Sub-category	Minor theme	Code
Learning environment			3D
			Avatar - Identity
			Avatar – sense of presence/inhabiting
			Avatar supports experience
			Immersion - avatar
			Immersion – SL
			Immersion – SLurtle
			Influence of presentation space 'Physical' mediated through avatar
Design			Avatar supports building
			Complexity
			Creative
			Design
			Design influences
			Design theme or concept
			Develop idea
			Disappointment
			Expectations
			Exploring
			Exploring SLurtles
			Frustration
			Idea
			Initial ideas
			Planning
			Playing
			Sense of achievement
			Starting afresh
			Structured exploration
			Unchanging
			User perception
			User experience
	Public		Avoiding other groups
			Influence of other groups – not looking
			Influencing others
			Invisible
			Looking at other groups' work
			Make public
			Public
			Walls
		Motivation	Challenges
			Design influence
			Fun
			Influence of looking at other groups' work
			Influence of outsider perception
			Influencing others

			Motivation
			Others visiting
			Personal sources of motivation
			Seeing other groups' work
		Socialising	Avatar – sense of presence
			Avatar supports socialising
			Avoiding other groups
			Etiquette
			Others visiting
			Pressure
			Socialising

Table F.4 Category of 'learning' and related sub-categories and codes.

Category	Sub-category	Code
Learning	Learning in order to participate	SL skill learning
		Learning S4SL to SL skills
	Learning through the learning experience	Insight into collaboration
		Learning about reflection
		Learning about self
		Learning beyond programming
		Portable knowledge
		SLurtle building
		Teacher identity
	How they learned	Avatar & viewing angles support learning
		Learning from partner
		Learning together
		More knowledgeable other
		Partner affected learning
		Partner influence
		Reflection
		Sharing ideas between partners
		Visiting other groups - learning

Appendix G

Appendix G presents an overview of participants in the second case study:

Table G.1 Overview of participants

ID	Age	Gender	Tech level	Previous SL experience
1-1	47	2	2	1
1-2	45	2	3	2
1-3	46	2	3	2
2-1	34	2	3	unknown
3-1	unknown	2	1	unknown
3-2	25	1	3	2
4-1	31	2	3	2
4-2	37	1	3	2
5-1	27	2	3	2
5-2	37	2	3	2
6-1	43	1	3	2
6-2	27	1	3	2
7-1	26	1	3	2
7-2	41	2	2	2
8-1	31	2	1	2
9-1	28	1	3	2
9-2	49	1	3	2
10-1	30	2	2	2
10-2	25	1	3	2
11-1	26	1	3	2
11-2	27	1	3	unknown
12-1	34	2	2	2
12-2	31	1	3	2
13-1	30	1	3	2
13-2	30	1	3	2
14-1	50	2	2	1

Notes:

Gender: 1 = female
 2 = male

Technical level: As part of the course learners were asked to self-assess their technical ability for the purpose of the formation of pairs.

- 1 = Can read and write code
- 2 = Can read/understand code to a limited extent
- 3 = No previous experience with code

Previous SL experience: 1 = yes
2 = no

Totals:

25 participants
13 female
12 male

11 pairs
2 all male
4 all female
6 mixed

1 group of three (all male)

1 individual (male)

Self-rated technical level:

2 could read and write code (1)
4 could read or understand code to a limited extent (2)
19 had no previous experience with code (3)

5 groups of mixed technical levels (1 and 2 are never in the same group)
7 pairs with no previous experience of code

Individual self-rated technical level as 3 (no experience)

Second Life experience:

2 participants had previous experience of *Second Life*
20 had no previous experience
3 unknown

9 participants interviewed:

4 female
5 male

1 technical level 1
1 technical level 2
7 technical level 3

None had any previous *Second Life* experience

Appendix H

Appendix H presents the tabulated results of the quantitative analysis of ‘barriers’ codes from interviews in the second case study reported in Chapter 6. Table H.1 presents the results of the cross-tabulation of codes by interview participant within the context of ‘barriers’. The symmetric cross-tabulation of codes by codes within the context of ‘barriers’, is presented across three tables. The first of these (Table H.2) presents the cross-tabulation of all codes by duration and outcome codes. The second table (Table H.3) presents the cross-tabulation of all codes by two barrier types: Learning experience and personal. The final table (Table H.4) presents the cross-tabulation of all codes by technical barriers.

Table H.1 Cross-tabulation of barrier codes by interview participant

	11	21	41	71	81	92	101	102	111
Duration	2		2	3	1		1	1	1
Initial	1		1	3	1		1	1	1
Ongoing	1		1						
Outcome	7	7	9	4				3	2
Disassociation			3						1
Collaboration	1			1					
Communication									1
Design	1	6	1	2					
Engagement in learning experience	2	1	1	1				1	
Highlight barriers not encountered with SLurtles	1								
Peer support			1						
Problem solving	1							1	
Programming	1		3					1	
Type	13	9	17	9	1	7	1	7	14
Learning experience	1	3							
Size of construction space		1							
SLurtle	1								
Task		2							
Personal	2	6	5	5	1	7	1	2	6
Expectations	1	1	2						1
Group dynamics - individuals	1							1	
Past experience				1		2			1
Perception of own ability		2				3		1	
Perception of SL			1		1				1
Perception of SLurtles		1				1	1		1
Physical			2						
Thinking in the abstract				4					2
Time pressure		2				1			
Technical	10		12	4				5	8
Cognitive overload			1					1	2
Computer				1				2	
Multiple steps	1		1						
S4SL	1		1	1					
S4SL to SLurtle			1					1	
SL avatar			4	1				1	2
SL building	1								
SL Chat									2
SL Objects - no heading	1								
SL voice	1								
User error	5		4						
Virtual				1					2

Table H.2 Cross-tabulation of barrier codes part 1.

	Duration	Initial	Ongoing	Outcome	Disassociation	Collaboration	Communication	Design	Engagement ...	Highlight barriers ...	Peer support	Problem solving	Programming
Duration													
Initial		X							1				
Ongoing			X			1							
Outcome													
Disassociation					X				1				2
Collaboration			1			X							
Communication							X						
Design								X					
Engagement in learning experience		1			1				X				2
Highlight barriers not encountered with SLurtles										X			
Peer support											X		
Problem solving												X	1
Programming					2				2			1	X
Type													
Learning experience													
Size of construction space								1					
SLurtle								1					
Task									1				
Personal													
Expectations								1			1		
Group dynamics - individuals			1			1						1	
Past experience								1					
Perception of own ability								2					
Perception of SL		1			1								
Perception of SLurtles		2						1					
Physical													
Thinking in the abstract		2						2					
Time pressure								2					
Technical													
Cognitive overload									1				1
Computer									1				
Multiple steps		1											
S4SL								1					
S4SL to SLurtle		1											
SL avatar		2	1		4				1				2
SL building										1			
SL Chat							1						
SL Objects - no heading												1	1
SL voice													
User error					2				1				1
Virtual						1							

Table H.3 Cross-tabulation of barrier codes part 2.

	Type	Learning experience	Size of construction space	SLurtle	Task	Personal	Expectations	Group dynamics – individuals	Past experience	Perception of own ability	Perception of SL	Perception of SLurtles	Physical	Thinking in the abstract	Time pressure
Duration															
Initial											1	2		2	
Ongoing															
Outcome															
Disassociation											1				
Collaboration								1							
Communication															
Design							1		1	2		1		2	2
Engagement ...															
Highlight barriers ...															
Peer support							1								
Problem solving								1							
Programming															
Type															
Learning experience															
Size of construction space			X												
SLurtle				X											
Task					X										
Personal															
Expectations							X				1				1
Group dynamics - individuals								X							
Past experience									X					1	
Perception of own ability										X					1
Perception of SL							1				X				
Perception of SLurtles												X			
Physical													X		
Thinking in the abstract									1					X	
Time pressure							1			1					X
Technical															
Cognitive overload															
Computer															
Multiple steps															
S4SL															
S4SL to SLurtle															
SL avatar							1				2				
SL building															
SL Chat															
SL Objects - no heading															
SL voice															
User error											1				
Virtual									1						

Table H.4 Cross-tabulation of barrier codes part 3.

	Type	Technical	Cognitive overload	Computer	Multiple steps	S4SL	S4SL to SLurtle	SL avatar	SL building	SL chat	SL Objects - no heading	SL voice	User error	Virtual
Duration														
Initial					1		1	2						
Ongoing								1						
Outcome														
Disassociation								4						
Collaboration														
Communication														
Design						1								
Engagement ...			1	1				1						
Highlight barriers ...									1					
Peer support														
Problem solving											1			
Programming			1					2			1		1	
Type														
Learning experience														
Size of construction space														
SLurtle														
Task														
Personal														
Expectations								1						
Group dynamics - individuals														
Past experience														1
Perception of own ability														
Perception of SL								2					1	
Perception of SLurtles														
Physical														
Thinking in the abstract														
Time pressure														
Technical														
Cognitive overload			X											
Computer				X									2	
Multiple steps					X		1							
S4SL						X							1	
S4SL to SLurtle					1		X						2	
SL avatar								X						
SL building									X					
SL Chat										X				
SL Objects - no heading											X		1	
SL voice												X		
User error					2		1	2				1	X	
Virtual														X

Appendix I

Appendix I presents the tabulated results of the quantitative analysis of ‘avatars’ codes from interviews in the second case study reported in Chapter 6. Table I.1 presents the results of the cross-tabulation of avatar codes by interview participant. Table I.2 presents the cross-tabulation for all avatar codes in a symmetric matrix.

Table I.1 Cross-tabulation of avatar codes by interview participant

	11	21	41	71	81	92	101	102	111
Behaviour	2	4		1	2	1	3		
Emotional response to other avatars behaviour		2			1				
Etiquette	1	1		1	1	1	2		
Compared to RL behaviour		1					1		
Social interaction	9	5		8	5	6	3	1	8
Control						3			
Identity	2	2			1		1		5
Closed	1	1							
Knowing who		1			1		1		5
Open	1								
Representation	7	3		8	4	3	2	1	3
Co-presence	3	3		5	2	2	2	1	3
Presence	3			3					
Recognition of other avatars	1				2	1			
Tool	8	6	11	13	5	1	7	4	22
Barrier			3					3	5
Design artefact for avatar		3							
Personal connection positive	4	2		10	3				3
Personal connection negative			8				4	1	7
Automation	1	1		1	1				
Learning					1	1			1
Unexpected feature	1								
Viewing angle									5
With which to act in VW	3			2			3		1

Table 1.2 Cross-tabulation of avatar codes

	Behaviour	Emotional response to other avatars behaviour	Etiquette	Compared to RL behaviour	Social interaction	Control	Identity	Closed	Knowing who	Open	Representation	Co-presence	Presence	Recognition of other avatars	Tool	Barrier	Design artefact for avatar	Personal connection +ve	Personal connection -ve	Automation	Learning	Unexpected feature	Viewing angle	With which to act in VW
Behaviour																								
Emotional response to other avatars behaviour		x	2									1						1						
Etiquette		2	x	1								2						2						
Compared to RL behaviour			1	x													1							
Social interaction																								
Control						x						1	1											
Identity																								
Closed								x					1					1						
Knowing who									x			2	1											
Open										x														
Representation																								
Co-presence		1	2			1			2			x	1					3						2
Presence													x					3		1				3
Recognition of other avatars						1		1	1			1		x				1						
Tool																								
Barrier																x			7				1	
Design artefact for avatar				1													x							
Personal connection +ve		1	2					1				3	3	1				x		2			1	3
Personal connection -ve																7			x				2	1
Automation													1					2		x				
Learning																					x			
Unexpected feature																						x		
Viewing angle																1		1	2				x	
With which to act in VW												2	3					3	1					x

Appendix J

Appendix J presents the tabulated results of the quantitative analysis of ‘barriers’ and ‘avatars’ codes from the second case study reported in Chapter 6. Table J.1 presents the frequency of codes at reflections and the number of units, Table J.2 presents the frequency of codes by participant number and Table J.3 presents the cross-tabulation of codes by codes. The results shown in Table J.4 provide an overview of the analysis of ‘avatars’ codes from both reflections and participant-observations.

Table J.1 Frequency of codes at reflections and units

Category	Sub-category	Code	Reflections	Units
Duration				
		Initial	3	3
Outcome				
		Collaboration	2	3
		Communication	3	3
		Engagement in the learning experience	1	2
		Problem solving	1	1
		Programming	2	2
Type				
	Personal			
		Expectations	5	5
		Group dynamics – individual	1	1
		Past experience	3	3
		Perception of SL	2	2
		Perception of SLturtles	1	1
		Physical	2	2
		Thinking in the abstract	2	2
		Time	3	3
	Technical			
		Computer	5	5
		S4SL	1	2
		SL avatar	1	1
		SL chat	1	1

Table J.2 Cross-tabulation of codes assigned to reflections, by participants.

	Participants not interviewed						Participants interviewed						
	5-2	6-1	6-2	12-1	13-1	13-2	1-1	4-1	7-1	8-1	9-2	10-1	10-2
Duration													
Initial		1							1	1			
Outcomes													
Collaboration			2						1				
Communication			1	1		1							
Engagement in the learning experience								2					
Problem solving									1				
Programming					1								1
Type													
Personal													
Expectations		1	1					1	1		1		
Group dynamic - individual							1						
Past experience		1			1			1					
Perception of SL						1				1			
Perception of SLturtles													1
Physical			1					1					
Thinking in abstract									1				1
Time								1	1				1
Technical													
Computer				1	1	1			1			1	
S4SL								2					
SL avatar								1					
SL chat			1										

Table J.3 Cross-tabulation of barrier codes from reflections

	Duration	Initial	Outcomes	Collaboration	Communication	Engagement in the learning experience	Problem solving	Programming	Type	Personal	Expectations	Group dynamic - individual	Past experience	Perception of SL	Perception of SLurtles	Physical	Thinking in abstract	Time	Technical	Computer	S4SL	SL avatar	SL chat
Duration																							
Initial		X					1				1			1			1						
Outcomes																							
Collaboration				X	1											1							1
Communication				1	X									1									1
Engagement in the learning experience						X															1	1	
Problem solving		1					X										1						
Programming								X					1		1		1						
Type																							
Personal																							
Expectations		1									X												
Group dynamic - individual												X											
Past experience								1					X										
Perception of SL		1			1									X									
Perception of SLurtles								1							X		1						
Physical				1												X							
Thinking in abstract		1					1	1							1		X						
Time																		X					
Technical																							
Computer																				X			
S4SL						1															X		
SL avatar						1																X	
SL chat				1	1																		x

Table J.4 Cross-tabulation of avatar codes by data source

	Participant-observations		Reflections	
	Participants not interviewed		Participant interviewed	
	9-2	13-2	2-1	
Social interaction				
Representation				
Co-presence	1			
Tool				
Barrier				1
Personal connection +ve		1	1	