2019

Investigating the Design and Implementation of Educational Multi User Virtual Environments in Second Life applied to Information Sciences

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This thesis is presented as part of the requirement for the conferral of the degree:
Doctor of Philosophy

University of Wollongong
School of Education

December 2019

Abstract

The research aims to investigate how students' experience with design components of online simulations in Multi User Virtual Environments may relate to learning in higher education, specifically in information sciences. Using a design-based research methodology, the study makes use of a theoretical motivational model specifically for MUVEs, in the development of a set of educational MUVE design principles, their implementation and testing in a higher education classroom setting. From this, a design framework for implementation of simulations in MUVEs in higher education is developed based on research outcomes. The design of the MUVE setting was well accepted by the students supporting the implementation of the comprehensive set of design principles. The outcomes of the study were positive in addressing the problem of teaching complex subject content with students believing the use of the MUVE to develop their understanding of the complex principles superior to traditional teaching of the subject.

Acknowledgments

Finally! This long and challenging journey has come to an end. This journey would not have been possible without the International Postgraduate Tuition Award from University of Wollongong. In addition, I am grateful to all of the following that I have had the pleasure to work with during this journey.

First and foremost, I would like to thank my marvelous supervisors, Associate Professor Sarah Howard and Emeritus Professor Barry Harper. Without their guidance and support, I think this journey would be tougher and longer. You are the best supervisor that all PhD students desire for. “Thanks” is not enough for me to show how grateful and delighted am I to have both of you as my supervisors. Thank you, thank you and thank you.

Next, I would like to take this opportunity to thank all my colleagues at INTI International College Subang. Thank you so much for your understanding, assistance and backing while I am struggling to complete this long journey. First, to the UoW admin team @ INTI, Mun See, Eric, Rohayu, Chee Seng, Peh Fern, Yin Chow, Pei Yiing, Choon Yen, Fiona and Puva for backing me up and share my load when I am away and busy with my thesis. Secondly, to all UoW academic team @ INTI, Shan, Siti, Ruby, Ang, Pawani, Faizal, Faisal, Siok Jen, Zul, Sam and many more for your understanding, sharing your thoughts and experiences with me. Thirdly, special thanks to my boss, Jane for her understanding, sharing with me her experiences and guidance. Also, not to forget my UoW counterpart, Mark, Christian, Willy, Elaine, Liju, Trisha, Michelle, Brett, Gabby, Jodie, Amanda and many more, thanks for your encouragement and useful advice.

Lastly, thanks to my family members who are with me during this long journey. Thanks to my mother – Hai Cheng for listening to me, with your “never give up” quotes and words of encouragement, and helping me to overcome my obstacles. Thanks to my wife - Yenny and my son - Shih Jeat for always being by my side, your daily massage, constant support and love. I love both of you and I have more time for both of you now.

Again, from the bottom of my heart, I wish to say, “THANK YOU, everyone.”

Certification

I, Vin Cent Loh, declare that this thesis submitted in fulfillment of the requirements for the conferral of the degree Doctor of Philosophy, from the University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

Vin Cent Loh
9th December 2019

List of Names or Abbreviations

3D – Three Dimension

MUVE – Multi-User Virtual Environment

SL – Second Life

IS – Information Sciences

DP – Design Principle

DBR – Design-Based Research

SIM – Simulation

L$ – Linden Dollars

ARCS Model – Attention, Relevance, Confidence and Satisfaction Model

4A's Model – The 4 A (Attention, Authenticity, Achievement and Appropriateness) Motivational Model

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Chapter 1

Introduction

1.1 Background

The current research has been driven by the researcher's experience in teaching complex and difficult networking concepts in undergraduate computer science. The traditional process in teaching networking subjects is to present the content and then have students attempt practical sessions in a dedicated laboratory. The practical sessions are intended to illustrate the theory and develop students' necessary practical skills to competently develop good networking solutions. Quality practical tasks are crucial in producing work-ready graduates in the networking field (Chan, 2015). However, the cost of setting up networking practical sessions and maintaining a dedicated networking laboratory with all required physical equipment to experience all necessary skills is high (Li et al, 2008; Gil, Candelas and Jara, 2011; Chan, 2015). Additionally, networking equipment does not lend itself to experimentation errors in design in that the errors can result in damage to very expensive devices during laboratory exercises.

This perceived difficulty of the subject content is supported by Chang (2004) who has argued, "…the principles underlying Computer Networking are intrinsically very profound and complex" (p. 209). Student difficulty with the subject has also been noted by Shao and Maher (2012) who have argued, "many students including computer science students find difficulty in understanding the abstraction of protocols and the complexity of concepts in networking" (p. 92). In the researcher's experience, which includes extensive experience teaching across multiple content areas in information science degrees and diplomas, the student cohorts specifically studying networking subjects display a lack of motivation in mastering the content compared with other subjects and addressing this lack of motivation could very well be the key to improving success in these subjects.

Malone and Lepper, (1987) and more recently, Ciampa (2014), have argued that motivation is crucial for student learning and it is an essential component of learner experience. It acts as a critical prerequisite for student involvement in all types of learning environments. They have proposed that how much students learn from a learning setting is dependent on their level of motivation.

Because of the perceived lack of motivation of the students in this curriculum context, rather than comparing a range of learning designs, the researcher has investigated the teaching approaches that have been claimed to offer high levels of motivation for students.

Simulations have long been associated with learner motivation with, for example, Robison and Watson (2013) arguing that motivation is integral to instructional simulations, "Unlike passively listening to lectures, reading a book, or watching a video, an instructional simulation requires learners to construct responses – often in real time. This is a significant motivational strength integral to instructional simulations" (p. 47). The nature of this curriculum problem, and the perceived lack of motivation in students attempting this subject, together with the assumed characterization of the information science students being addressed as highly competent technology users, has the potential to be a good fit with the use of instructional simulation as a curriculum approach. Alessi and Trollip (2001) have argued that "Instructional simulations are effective in teaching about things and in teaching how to do things" which fit well with this issue. Simulation is extensively used in industry and education where learning and training have risks or costs that can be avoided while learners are developing the skills and knowledge necessary to master the tasks targeted. Learning and implementing networking content and design skills reflect these risks. The motivational and risk minimization affordances of educational simulations have the potential to be an appropriate approach to support the curriculum issue being addressed in this study and one possible way ahead would be to make use of the simulation and motivational features of the most recent form of educational simulations, Multi User Virtual Environments (MUVEs), to support this learning process.

Many early researchers working in the area of virtual environments use in education (Badawy, 2012; Di Blas & Paolini, 2014; Paras and Bizzocchi, 2005; Clarke and Dede, 2005; Ketelhut, Nelson, Clarke and Dede, 2010; Clarke, Dede, Ketelhut, & Nelson, 2006; Berge, 2008; Dieterle & Clarke, 2007) have claimed that with the juncture of learning outcomes together with well-designed interaction mechanisms, an increase in students' motivation in learning is inevitable. MUVEs offer virtual environments, similar to a 3D game, enabling multiple simultaneous users to access virtual content, interact with virtual objects and represent themselves through an online persona called an avatar. MUVEs offer spaces for virtual learning with mechanisms for educators to setup, design and develop learning experiences in the virtual space. The space can be a virtual classroom, simulation, or assessment. With this, students can participate in the virtual ‘classroom’ anytime, anywhere at their own pace (Warburton, 2009; Loureiroa & Bettencourt, 2014; Zhan, 2012) offering an independent learning experience, for example, as a pre-requisite for actual physical lab classes.

In order to investigate the potential of this process to support students in mastering the very complex field of networking in information science, an online simulation in a MUVE platform, in this case using a virtual world application Second Life, was designed, and implemented in order to facilitate students with various backgrounds developing the complex skills necessary for understanding and implementing networking solutions. The application Second Life was chosen as the MUVE for this study as it is well established, has a long history of innovative use in education, at the time of this study was the most mature of current multiuser platforms and the most extensively used in education (Duncan, Miller and Jiang, 2012).

The proposed simulation is able to offer a practical space to solve problems with complex equipment use, access virtual equipment not readily accessible and assist in developing work ready graduates from the information science program (Linden Labs, 2013). The 3D virtual interactive learning environment will be treated as the pre-requisite for physical lab classes.

Robison and Watson (2013) have argued “motivation is complex but it is so foundational to learning that it must be thoughtfully addressed in instructional design” (p42.). From the extensive work on learner motivational design of Malone and Lepper (1987) and Keller’s ARCS model (2009) a four-component motivational framework, using the concepts of Attention, Authenticity, Achievement and Appropriateness, is used to frame the study to support the researchers contention that student motivation is key to improving student success with this complex content.

1.2 Research Questions

The research aims to investigate how students' experience with design components of online simulations in Multi User Virtual Environments may relate to learning in information sciences.

This will be explored through the following questions:

i. What is the relationship of components of motivation to students’ experience in an online simulation?

ii. What are students' perceptions of design elements embodying motivational components in an online simulation?

iii. Can a well-designed MUVE improve learning outcomes for information science students studying complex and abstract concepts such as computer networking?

A set of appropriate design principles will be derived from the well-articulated design principles specific to MUVEs, design principles that support the implementation of authentic tasks and well documented broader design principles for online learning. To address the arguments about motivation and learning by Robison and Watson (2013) additional design principles framed by a motivation model will be adopted. 3D educational games and MUVEs share many design characteristics such as the social and identity features that allow communication between users and digital representation of users using avatars with attributes selections (Hull, Williams and Griffiths, 2013). They have a common history of development and use in education and so the design concepts and associated research in the use of 3D games will also inform the design process of the MUVE simulation.

1.3 Significance

This study is significant because it will: -

1. Offer a set of educational online simulation design principles for the design of MUVEs in the information sciences in higher education, not currently available, for designers to draw on in designing these types of educational settings.
2. Implement a design example with authentic tasks and then test this design within classroom settings using a design-based research paradigm, offering designers a well-tested example for addressing the difficulties of teaching very complex content in the information sciences.
3. Develop a better understanding of students' experience in online simulations to support learning environment designers in offering quality-learning settings for complex concepts in information sciences.

1.4 Thesis Outline

The subsequent chapters are outlined here.

Chapter 2 - Literature Review: This chapter covers the Literature Review of the study reviewing previous studies mainly on how design components of online simulations may impact students' learning motivation in higher education. This chapter addresses online simulations, MUVEs, Second Life and then learning motivational models and argues for a modified model to guide the study.

Chapter 3 – Research Design and Methodology: This chapter argues for the methodology used in the study, the use of the Design Based Research paradigm mainly on the implementation of cyclical design, development, implementation and testing as well as the development of the data collection tools and describes the data analysis process to be used in the study.

Chapter 4 – Iteration 1: This chapter elaborates the development of a solution based on the problem statements and will describe the design and implementation in the MUVE platform in Second Life. This chapter also describes the first implementation of the design based on the proposed design solutions, the data collection and analysis and the outcomes of this first implementation. This chapter will also identify the issues faced in the first implementation and user feedback and describes the redesign based on this information.

Chapter 5 - Iteration 2 Implementation and Outcomes: This chapter describes the implementation of the second iteration, an analysis of the data and makes comparisons between the original and redesigned iteration.

Chapter 6 – Discussion, Conclusion and Recommendations: This chapter will discuss the design, development and implementation of the proposed solution and refined solution. The chapter will include a summary of the final design principles and answers to the research questions.

1.5 Definitions of key terms

Simulation – A virtual model that mimics the real world for the purpose of training, experimentation or education.

Multi User Virtual Environments (MUVEs) - Settings that allow multiple users to access virtual spaces at the same time and interact with others through an avatar.

Second Life - A virtual world application that was launched by Linden Labs in 2003, which allows users to interact with each other through avatars, interrogate objects and spaces and explore the virtual world.

Design-based research - A methodological approach in the field of educational technology, mainly used to develop practical solutions to complex problems through multiple iterations.

3D computer games – Games that are mostly created with computer-generated environments, which are interactive and fantasy in nature, more realistic and more immersive if compared to 2D computer games.

ARCS model – A model that looks at how motivation can influence a person on achieving certain goals with the amount of effort they put in and the existing skills they have.

Malone's Taxonomy of Intrinsic Motivation - A taxonomy that uses both individual motivation and interpersonal motivation that works together for intrinsic motivation in educational environments.

Chapter 2

Literature Review

The research aims to investigate how students' experience with design components of online simulations in Multi User Virtual Environments may relate to learning in information sciences. This chapter addresses online simulations and then motivation. To do this, simulations, online simulations, online 3D games and MUVEs are discussed. This chapter then focuses on, and argues for, the use of Second Life as a specific online simulation platform. Issues of motivation in learning are then examined and discussed in relation to specific components of online simulations to frame the study.

2.1 Simulation and Online Simulation

Computer-based simulations were initially developed by the U.S. Department of Defense (1997) for military training. Simulation is defined as an accurate model of reality, which is attempting to mirror the real world (Sauvé, Renaud, Kaufman and Marquis 2007; Hauge, Barenbrock, and Thoben, 2017). Simulations generally do not involve competition or challenges; therefore, there is also no winner or loser. Simulations can be thought of as representing or simulating real-world phenomena for the purpose of training, analysis, or experimentation. Examples include manned vehicle (virtual) simulators, computer-generated forces (constructive), environment simulators, and computer interfaces between a Distributed Interactive Simulation network (virtual world military simulations) and real (live) equipment (U.S. Department of Defense, 1998, p. 157). From this original use, simulations have been widely used to support specific learning and training needs. Often training addresses real-life situations where specific skills are required to solve problems. Simulations are commonly used in contexts where practice is dangerous, unethical, and too costly or the opportunities are limited. Thus they are commonly used in the medical, military, education and commercial fields (De Freitas, 2006).

The Institute for Simulation & Training, University of Central Florida (IST-UCF) has categorized simulation into three main types (2014): live, virtual and constructive simulations. Live simulations will usually involve humans as the user and real equipment simulating a real-world example. The user would operate the equipment in the real world. Virtual simulations also involve humans as the user and equipment, but the simulation usually happens in a computer-controlled setting and this is the type of simulation considered in this study. Constructive simulation generally does not involve humans or equipment as participants, as this type of simulation is usually driven by several sequencing events.

Online simulations that offer virtual laboratories are used in education and training for science, technology and engineering (STE) students (Potkonjak et al., 2016). However, the virtual laboratories in these fields are relatively new due to the subject domain, which have restricted the use of virtual laboratories as compared to others. The virtual laboratories that have been developed for STE are mainly used as the preliminary step in students' training and education with additional in-depth hands-on session with real world equipment (Potkonjak et al., 2016).

Online simulations have evolved from stand-alone computer-based simulations such as flight simulation, used for pilot training, to networked laboratory computers (Nance and Sargent, 2002). This generation of online simulations was designed to support more than one user at a time (Foronda, Gattamorta, Snowden and Bauman, 2013), which allowed for collaboration in real-time activities, with learners co-located. These simulations were then adapted to be accessible through the Internet by any user, as long as they had the necessary equipment (Broom, Lynch and Preece, 2009) and access resulting in a much broader accessibility for users and the coining of the term Multiuser Virtual Environments or MUVEs, offering a more collaborative level of user interaction in simulations.

2.2 Multi User Virtual Environments

Multi User Virtual Environments (MUVEs) are settings that enable multiple simultaneous users to access virtual spaces, interact with and create virtual artifacts and represent themselves as avatars (Doğan, Cinar & Tuzun, 2018). Computer hardware (Ibanez, Di Serio & Delgado-Kloos, 2014) and Internet speed (Kluge and Riley, 2008; Huang, Backman, Chang, Backman & McGuire, 2013) are the most crucial requirements for "connecting" to virtual worlds. With the evolvement in computer technology, especially the technology in computer graphic processors, and significant increases in access to Internet bandwidth, these environments have become more sophisticated and accessible.

MUVEs have been most commonly used in Education and training, but their collaborative and simulation characteristics have allowed them to be used in a range of other contexts. MUVEs have been used in fields such as entertainment (Livingstone, Kemp & Edgar, 2008) where, for example, users can collaboratively explore a virtual space and at the same time enjoy the ongoing video or music. Bucciero, Guido & Mainetti (2011) have also described the use of MUVEs for marketing through the promotion of their products or brands in the virtual space. Virtual Singapura (2018) is used to visualize a virtual city where detailed information can be attained and discovered while the collaborative features of MUVEs have been leveraged by Gajňáková, Vaculík & Martin Vaško, (2010) to allow users from different location to meet and collaborate in the virtual space. A number of commercial applications have been developed for construction of MUVEs with Reisoğlu, Topu, Yılmaz, Yılmaz and Göktaş (2017) reporting on the platforms most commonly used as Second Life (Linden Labs, 2013), Active Worlds (Merchant, 2015) and Open-Sim (Quintana & Fernández, 2015) while Alsina-Jurnet, Gutiérrez-Maldonado and Rangel-Gómez (2011), Bronack et al. (2006) and Cheng and Ye (2010) have report on a number other tools that have had minimal use either because of lack of features or lack of access to proprietary products.

2.3 3D Online Games and MUVEs

Computer games have had a long history and in many ways have informed simulation design, especially for motivational design and 3D elements. The relationship between 3D Online Games and MUVEs is contested in the literature. Carenys, Moya and Perramon (2017) have argued that there are no clearly defined boundaries between 3D games and simulations and there are no significant differences in the perception of motivation between simulation and games. Sauvé et al. (2007) described a computer game as usually created from imagination that does not refer to the real world. Computer games are developed for play with competitive components and are usually based on users' preferences of, for example, level of difficulty and scenario. Roettl and Terlutter (2018) have described the key characteristics of 3D computer games as interactive, immersive and virtual environments. 3D computer games are mostly created with computer-generated environments, which are interactive and fantasy in nature, they are more realistic and more immersive if compared to 2D computer games. The commercial success of games, and the development of computer and Internet technologies have been influential in leveraging 3D tools for development of simulation environments.

MUVEs are often associated with online 3D games, but MUVEs have some different characteristics. MUVEs are similar to 3D online games in that users can interact with the readymade contents. However, MUVEs also allow users to create, build and also interact with the existing content. Both MUVEs and online games use 3D virtual spaces, but the games developers mostly fix the virtual space for online games so the user does not have the ability to change the environment. At most, players can locate, discover, explore or gather some items in the game but most online games do not allow users to build their own content. By contrast, the virtual space for MUVEs can be amended and added to by users.

Most online games are structured for the user to complete missions or quests. Users have to complete a quest to gain experience and will be moved to higher levels of the game on successful completion of tasks. Users are then able to explore areas of the world that require a high level of skill or knowledge. Some of the quests lead users to obtain some in-game items and some of it can even act as the tutorial for the users to be familiarized with the game.

Games users need to master certain skills and the pace, the accuracy, the decision making are all very crucial for success in online games. For instance, as a "healer" (healer is normally a job class in an online game that will help to recover the health point of others), the user must know when to heal, how to heal, whom to heal and also manage their mana (the power required for the healing skills). By comparison MUVEs required the user to know the basic skills of the system, they must know how to navigate, how to communicate and not necessarily to master them. However, communication skills are crucial in MUVEs as users have to constantly communicate with others (Edirisingha, Nie, Pluciennik & Young, 2009).

However, both MUVEs and 3D online games have many common characteristics as well. One of the common characteristics is the use of avatars to represent the users in the virtual environment or game. This is the mandatory requirement for both systems where users need to get their avatars that represent the individual in virtual environment/game before they can start with the activities. With avatars that represent each individual in a virtual environment/game, the real user identity can be hidden for privacy and safety purpose. Can and Simsek, (2015) have argued that the use of avatars, which are anonymous to the virtual world, reduces users' stress and anxiety and increases users' motivation. Avatars can only be implemented in virtual environment/games but they cannot be implemented as a representation of an individual in a rich media approach, like video demonstrations of the workings of each networking device and then quizzes. The rich media approach can be implemented in any learning management system. For users it is just like attending their normal class by going through the online videos and answering online quizzes. With MUVEs, users can interact with the equipment and have a better look via 360 degree 3D view.

Another common characteristic is the interaction methods between users in both systems allow at least a text-based communication, emoticons and recently this has improved to allow voice communication. Besides, both setups allow users access to the virtual environment where they are allowed to explore the new world and participate in virtual activities such as virtual seminars or undergo virtual lab activities (Wyss, Lee, Domina and Macgillivray 2014).

A study reported by Carenys et al. (2017) aimed to compare the effectiveness of videogames and simulation in higher education settings. This study involved a survey of 132 postgraduate students after they completed playing both the simulation and videogame; the study concluded that there are significant differences between the attributes and motivation of simulation and videogame (Carenys et al., 2017). Carenys et al. (2017) then argued, "These results support the inclusion of videogames as a complement to simulations in higher education accounting and business environments and allow us to propose a blended approach that provides the learner with the 'best of both worlds'" (p. 118).

Carenys and Moya (2016) claimed that the differences between games, videogames and simulation games are not clear, with no standardization of terms used in different articles. Some researchers claimed that games and simulations are different (Carenys et al., 2017) in term of their attributes but some claimed that games and simulations are overlapping (deFreitas & Oliver, 2006) as some games have elements of simulation and vice versa.

2.4 MUVEs in Education and Training

Well-designed MUVEs for educational use should be able to facilitate ready-made objects and personalization and support the use of media (Messinger et al. 2009). They should permit the creation of interactive activities by adding properties to objects or avatars (Dickey 2011). They should also allow users to create identities as avatars for interaction in the environment and other users (Dickey 2011).

There has been a long history of use of MUVEs for educational purposes from the early 2000s. Duncan et al (2012) reviewed over 100 published academic articles on virtual environments in education to develop a taxonomy of virtual world usage in education arguing that MUVEs have shown great potential in teaching and learning. Hew and Cheung (2010) have undertaken an extensive review of over 400 articles on 3D immersive virtual worlds in educational settings from K- higher education, with fifteen empirical studies reviewed in detail, offering a good summary of the current research in this area describing the key uses and finding that most of the current research is descriptive and carried out in the media arts, health and environmental disciplines where simulations can offer insights into 'what if' scenarios.

Many examples of educational application of MUVEs have been well documented in the literature. Early adopters Dede et al. (2005) used MUVEs as a vehicle to study classroom-based situated learning and also to investigate transferring learning from classroom to real world contexts. Edward, Elliott and Bruckman (2001) used MUVEs to help children learn about mathematics and computer programming. The MUVE Quest Atlantis is designed for children aged 9 to 12 to complete activities/mission with not only academic achievements in mind but also social responsibility (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005). In the Quest Atlantis project, which is essentially a MUVE design framework, there were three main design features, education, entertainment and social commitment. Under the first feature "Education: Designing for Understanding", the main focus is learners where it is argued, they should be the main focus in performing an authentic task. The second feature "Entertainment: Designing for Engagement" focused on developing the MUVE with responsive design that encourages full engagement between learners and the MUVE. The third feature "Social Commitments: Designing for Change" focused on developing a MUVE that incorporates social responsive design that combined the elements of playing, working, and helping (Barab et al., 2005). Quest Atlantis has been successfully implemented in different settings such as elementary schools and after-school centres, with Barab et al., (2005) reporting wide spread use of the concept to improve student learning.

Calandra and Puvirajah (2014) used MUVEs in teacher practice training that allowed individuals to experience being a teacher in a virtual world before moving to real world practice. This platform is not a replacement for actual teaching in school but it served as a tool to prepare teachers for real world practice (Calandra & Puvirajah, 2014). They have reported that the tool use did result in a few issues needing to be addressed such as decent hardware and internet connection for running MUVEs, and they did find use of the MUVE might be risking the authenticity of the training With the aims to address the computer hardware and the Internet connection issues in future and the acceptance of the virtual environment by the trainee teachers, the authors planned to more broadly use the platform as a tool for pre-teacher practice training.

Aebersold, Tschannen, Stephens, Anderson and Lei (2012) used MUVEs in the field of nursing training reporting implementation of a virtual hospital in Second Life for training and learning in the clinical setup. The University of Michigan, School of Nursing established a nursing care unit on the fictitious Wolverine Island in Second Life (Aebersold et al., 2012). A number of virtual clinical rooms were setup in the medical building including the virtual patient care room, virtual conference room and virtual nursing station. Three simulations were established to test nursing students on medication safety, communication and priority settings. Aebersold et al. (2012) have reported the outcomes of 15 students taking part in a 10 to 15 minutes virtual simulation in this environment as they interacted with each other through avatars. These students were directed to complete a questionnaire after the simulation and rated the system from 2.5 to 3.1 on a 5-point Likert-type scale. This online simulation allowed participants to participate from anywhere, and also was claimed to create opportunities for other professionals to be involved in the simulations, promoting collaborative learning among different profession.

2.5 Second Life as MUVE of Choice

Reisoğlu et al. (2017) have reported on a meta-review of 3D virtual learning environments examining 167 empirical studies. They reported on the platforms used, design goals, sample size, learning designs, and changes over time of preferred design goals. Various platforms were employed in the reported studies, with by far, the most extensively used platform, the application Second Life. This application was used by 99 of the studies, followed by Active Worlds (21) and Open-Sim (11) (see Alsina-Jurnet et al. 2011; Bronack et al. 2006; Cheng and Ye 2010) with a number other tools reported with minimal use.

Second Life is a MUVE platform, launched by Linden Labs in 2003 (Linden Labs, 2013). As of 2017, it had more than 800,000 active user accounts (Axon, 2017). Second Life is a virtual world that allows users to communicate, navigate and teleport from one place to another (Šipoš & Balen, 2017). Second Life allows users to design, create, manipulate and use their own objects, shops and vehicles in the virtual world (Wang and Burton, 2013).

Second life has facilities to allow users, for example, to buy their own land and build their own properties. With these tools, users are able to create any virtual facilities such as virtual labs, virtual libraries and virtual classes (Linden Labs, 2013). With this flexibility in Second Life, most elements in Second Life could be custom designed for the users' needs, for example, the customization of avatar design, fashion design, architecture design, 3D objects and animation. Users can obtain virtual items in Second Life for free or with the embedded virtual currency, the linden dollars (L$). The use of virtual simulations in Second Life allows students to gather knowledge, which relates to real life scenarios and develop their problem-solving skills in a collaborative environment (Rogers, 2011). It is ideal for simulation of contexts that are dangerous or of high risk, such as clinical simulation or expensive or dangerous equipment use.

In Second Life, learning environments can be designed to include small group discussions, individual and group presentation using PowerPoint within Second Life, and meeting in virtual classroom/lecture theatres. Activities, assignments and tutorials can be attempted at anytime and without students physically meeting each other. Instructors can join students to support and enhance student learning. As an example of an educational online simulation, Broom et al. (2009) allowed groups of nursing students to use online simulation together before clinical placements in the University of Glamorgan to show the complexity of nursing care and also help with clinical practice. Students were separated into several focus groups of 10 each. The students were first asked to understand the given scenario(s) and later given access to the history of the patients by reading the nursing notes. Students were then asked to virtually evaluate patients' current situation, using a multiple-choice quiz and reflecting on their findings using a blog (Broom et al., 2009). In this study, 87% of students perceived that computer simulation to be a suitable tool to assist nursing students gaining new skills before placement. Furthermore, all nursing students agreed that the simulation helped them to apply knowledge in practical contexts (Broom et al., 2009).

Deale (2013) has described a Second Life virtual hotel environment used to train hospitality students to showcase the hotel rooms, site visits, case studies for projects etc. Within this Second Life environment, the instructor can setup the hotel rooms based on the student's needs, i.e. dirty rooms, messy rooms, "wet" rooms etc. The environment can be used for virtual fieldtrips, as long as the virtual space is created and designed based on the requirements. Students and instructors may visit the virtual setup in Second Life together with their classmates at specified time or at the own time. Deale (2013) further reported student responses to use of this Second Life environment. The majority of the students (79.5%) enjoyed interacting with Second Life as a means to adjust and modify the virtual hotel environment for the group project "abstract conceptualization" (Deale, 2013). 92 students (78.6%) believed that Second Life was effective and enjoyable for use in visualizing and assessing how their design projects could be implemented through interactions in Second Life "active experimentation" (Deale, 2013). Deale (2013) argued that students benefit from obtaining experiences online by "visiting" the scenarios virtually, dealing with different scenarios which are difficult to setup and by developing skills in practical sessions.

El Tantawi, El Kashlan & Saeed (2013) have described a Second Life dental education environment, where students undergo a virtual orientation session and access reading materials, and practice clinical procedures. Furthermore, students are able to experience feedback /reaction from the patients with different scenarios. This virtual environment has a very authentic feel as most of the scenarios are based on real case studies. El Tantawi et al. (2013) have reported that all students in this study agreed that their educational experience in Second Life was fun and useful. They reported these students were motivated to use the virtual online simulation in Second Life and they believed that Second Life helped them in their learning.

In Healthcare Education, Rogers (2011) developed a 4-stage virtual simulation in Second Life to enhance teamwork and collaborative problem solving. These stages were: briefing, problem discovery, problem solving and observing and verifying stages. Second Life allowed students to solve problem in a collaborative environment without harming the patients. Scenario creation in Second Life is a characteristic that allows students to solve different problems in a collaborative way. Rogers (2011) reported that Second Life was a good environment for group work where students could easily collaborate with their team members.

In Medical and Health Education, the Virtual Neurological Education Centre (Developed by Lee Hetherington at University of Plymouth, UK) is a simulation where the most common neurological symptoms are exposed to users and this allows the users to understand, from the point of view of the sufferers, how persons suffering from a neurological disability feel (Boulos, Hetherington, & Wheeler, 2007). Another health example, the HealthInfo Island, provided consumer health outreach and library programs in Second Life to residents from year 2006 to 2008. This research aimed to provide training programs to virtual medical communities, provide important consumer health resources and one to one support to Second Life residents (Boulos et al., 2007).

Second Life is a well-established extensively used MUVE that has a long history of innovative use in education with many very recent or current examples and related research being reported in the literature (Deale, 2013; Vrellis, Avouris & Mikropoulos, 2016; Gallego, Bueno & Noyes, 2016; Berger, Jucker & Locher, 2016). It is the most mature of these types of multiuser platforms, allows construction of complex scenarios and environments and is the dominant MUVE in education. For these reasons, Second Life has been chosen as the platform for this study.

2.6 Motivation

Motivation is an essential component of learner experience and success and, for this study, has been identified as a key element influencing the difficulties experienced by students studying complex information science concepts. Wlodkowski (1978, p. 12) describes motivation as "processes that can (a) arouse and instigate behavior; (b) give direction and purpose to behavior; (c) continue to allow behavior to persist; and (d) lead to choosing or preferring a particular behavior" (p. 12). Keller (1987) defined Motivation as what users wish to do, choose to do and commit to do. Robison and Watson (2013) suggested that learning motivation is linked to learners' engagement with tasks, and that other learners and the learning environment can affect this. Malone and Lepper, (1987) have argued that motivation is an essential prerequisite for student involvement in all types of learning environments, proposing that how much students learn from a learning setting is dependent on their level of motivation while Ciampa, (2014) has proposed that motivation is important to keep users focused on their learning, having the right attitude towards the instructor, towards themselves and towards the subjects and learning situation.

2.6.1 Simulations and Motivation.

Motivation is an essential component of learner experience and success and, for this study, has been identified as a key element influencing the difficulties experienced by students studying complex information science concepts. Wlodkowski (1978) describes motivation as "processes that can (a) arouse and instigate behavior; (b) give direction and purpose to behavior; (c) continue to allow behavior to persist; and (d) lead to choosing or preferring a particular behavior" (p. 12). Keller (1987) defined Motivation as what users wish to do, choose to do and commit to do. Robison and Watson (2013) suggested that learning motivation is linked to learners' engagement with tasks, and that other learners and the learning environment can affect this. Malone and Lepper, (1987) have argued that motivation is an essential prerequisite for student involvement in all types of learning environments, proposing that how much students learn from a learning setting is dependent on their level of motivation while Ciampa, (2014) has proposed that motivation is important to keep users focused on their learning, having the right attitude towards the instructor, towards themselves and towards the subjects and learning situation.

Simulations have long been associated with learner motivation with, for example, Robison and Watson (2013) arguing that motivation is integral to instructional simulations "Unlike passively listening to lectures, reading a book, or watching a video, an instructional simulation requires learners to construct responses – often in real time. This is a significant motivational strength integral to instructional simulations" (p. 47).

Dalgarno and Lee (2010) have argued that "The affordances in three-dimensional (3-D) virtual learning environments (VLEs) include the facilitation of tasks that lead to enhanced spatial knowledge representation, greater opportunities for experiential learning, increased motivation/engagement, … compared to tasks made possible by 2-D alternatives" (p. 10) highlighting the inherent motivational aspect of virtual learning environments or simulations.

Özdemir and Öner (2015) have argued that "… It was observed that using simulations and animations in the computer course about hardware of the Classroom Teaching Section, Theological Mathematics Section and Theological Science had a positive effect on the motivation of students…" (p. 53) highlighting simulations had positive effect on student's motivation.

Knogler & Lewalter (2014) have argued that "…the studies helped to empirically identify effective design-features and possible mechanisms of how simulations games may foster both students' appreciation of the value of science and their interest in science-related issues" (p.2), again showing the positive impact claimed on student's motivation with use of simulations for supporting student learning.

As mentioned by the above researchers, MUVEs offer better interaction between users, interactions between users and objects, use of avatars as online representation, better representation of objects in a more realistic view and many more advantages. There is broad agreement that using MUVEs as a simulation environment have positive effects on student motivation over other approaches such as rich media approach, learning via learning management systems, face-to-face classroom teaching, and other 2D alternatives.

2.6.2 Motivational Design and Models.

Robison and Watson (2013) conducted a literature review of motivational design in instructional simulations. They mapped an extensive list of motivational elements against a range of motivational models and research. From this, they concluded that the ARCS motivational model (Keller, 2009) and Malone's Taxonomy of Intrinsic Motivation (Malone & Lepper, 1987) offer the most comprehensive view for motivational design. Both models have been used to investigate or argue for motivational components games and simulations, with the ARCS model predominantly used for simulation and Malone's Taxonomy of Intrinsic Motivation predominantly used for games. Therefore, these two models will be explored for the purpose of the current study.

2.6.2.1 Keller's ARCS Model.

Keller (2009) defined motivational design as "the process of arranging resources and procedures to bring about changes in motivation" (pp 3). Motivational design is applicable to anyone's motivation of doing anything, from one or a different perspective, for instance, student's learning motivation and employees' motivation to work (Keller, 2009). Keller's ARCS model was derived from Keller's Macro Model of Motivation and Performance (1979), which looks at how motivation can influence the amount of effort that someone will put in to achieve certain goals, together with the existing knowledge and skills, which will affect the overall performance of a learner (Keller, 2009). The ARCS model is based on four main components; these are attention, relevance, confidence and satisfaction, which is the acronym of the model. In this model, attention is defined as getting ways to capture and hold users' attention. Relevance is equated to the users need to know the reason why they have to go through the processes, be it a simulation, a game or an online course. Confidence is associated with self believe. Users with high confidence will believe in themselves and that they can surely achieve their goals. Lastly, Satisfaction addresses users' feelings, by allowing them to feel good about their accomplishments.

The ARCS model consists of a systematic design process, which could be used together with instructional design and development models (Keller, 1987). The model is divided into four stages: define, design, develop and evaluate. The define stage involves investigating and understanding the problem, analyzing the audience motivation and preparing the motivational objectives. The design stage involves generating and selecting potential strategies, the develop stage involves looking into motivational elements and integrating them with instruction. Lastly, the evaluate stage involves evaluating the motivational material and accessing the outcome.

Researchers who have reported student learning with virtual environment, for both simulation and 3D games use with a focus on motivation using the ARCS model include Huang (2010), Zhang (2015) and Chang & Chen (2015). Their work is summarized in Table 2.1 to illustrate the range of studies that have been reported and discussed here. All of this work illustrates the central nature of motivation in the use of virtual worlds such as educational simulations and games.

Huang (2010) conducted an evaluation of an online game-based learning environment (GBLE) that focused on learners' motivational processing and cognitive processing. This study involved a survey of 144 undergraduate students after they participated in the online game ''Trade Ruler" that taught the Heckscher–Ohlin Theory on international trade (Huang, 2010). The participants of this study were undergraduate students majoring in education from Midwestern University in the United States. The game started by allowing participants to read and understand the economic theory before starting the actual game, the participants were redirected to the online survey on motivational and cognitive processing after completing the game. The survey is based on the ARCS motivational model components (Keller, 1987) with a 9-point Likert Scale (1 - Absolutely disagree and 9 - Absolutely agree). With mean score of 5.68 for Attention, mean score of 5.51 for Relevance, mean score of 6.20 for Confidence and mean score of 5.28 for Satisfaction where all mean scores were above the average of the 9-point scale. Huang (2010) argued that his result showed that participants were overall feeling positive about the ARCS's components and were motivated to complete the game.

Chang and Chen (2015) conducted a study to determine the motivation for learning in a blended learning environment. The study analysed the learning motivation in three general education digital information literacy courses for higher education in a blended learning environment. The model used in this study was developed using the ARCS theory of motivation and there were 292 participants involved. The overall quantitative and qualitative results of this study show positive student' reaction and participation in the delivery of Information Literacy courses in blended learning environment is encouraging and satisfactory (Chang and Chen, 2015).

Zhang (2015) has proposed an English listening motivation model based on the ARCS model, which was used to increase the motivation for English listening proficiency. The study shows that the ARCS-based-learning-motivational model can stimulate and sustain learners' motivation in English listening proficiency (Zhang, 2015). Much of this literature is exploratory with student perceived experience as the major source of data rather than using a more sophisticated research design and the design principles for motivational design are not addressed in this research so the quality of the MUVE designs are not clear. However, the reported outcomes support the use of motivational design and give some indication of user perceived outcomes for use of these specific MUVEs.

Table 2.1

Summary of other studies on student learning and motivation using the ARCS model

No	Author(s)/Title	Investigation	Outcomes/Results
1	**Huang (2010)**	An exploration of game-based learning to initiate and support learners' goal-setting activities and impact learners' cognitive loads.	• This study confirmed the underlying relationship between learners' motivational processing and cognitive processing in an online game-based learning environment.
2	**Zhang (2015)**	Learners motivation and improving learner's listening proficiency in learner-cantered in higher education	• This study showed that ARCS-based-learning-motivational model can stimulate and sustain learners' listening learners' listening motivation and can give them more confidence.
3	**Chang and Chen (2015)**	This study analyses the learning motivation in three general education digital information literacy courses for higher education in a blended learning environment.	• Overall results from this study showed that students' reaction in participating in the courses is encouraging and satisfactory.

2.6.2.2 Malone's Taxonomy of Intrinsic Motivation.

As argued by Robison and Watson (2013) Malone's Taxonomy of Intrinsic Motivation, together with the ARCS model, offer the most comprehensive view of motivational design. Malone's model suggests that design components to motivate users are challenge, curiosity, and fantasy (Malone, 1981; Malone and Lepper, 1987; Ciampa, 2014). Challenge in Malone's model (1981) is always associated with goals and outcomes. Malone (1981) has argued that a game should have a well-balanced challenging environment, a clear goal and uncertain outcome. Fantasy in Malone's model (1981) clearly states that a game must come with an environment theme or fantasy which is what is normally associated with users' dreams and not the reality of the present in users' daily life. Malone (1981) defines curiosity as the most important component. Game setups should not be too complicated or too simple, with users' experience taken into consideration. Furthermore, the game setups should also be surprising and not something that can be easily predicted by users (Malone, 1981).

Researchers who have reported student learning focused on motivation using Malone's model include Tüzün, Barab & Thomas (2019) and Kapp (2012). The study of Tüzün et al. (2019) aimed to identify motivational elements of an online multi-player educational computer game using Quest Alantis, a multi-user virtual environment for educational activities. This study was based on the conceptual framework largely provided by Malone and Lepper (1987) and mainly focused on allowing children ages 9-12 to complete their educational activities in Quest Alantis. Data was captured through interview and observations of the 20 children (Tüzün et al., 2019). The findings of this study show there were more elements that contribute to student motivation than those proposed in a previous study, the additional elements such as presentation, social relations, playing, learning, achievement, rewards, immersive context, uniqueness, creativity, and context of support.

In the field of motivational theory, Kapp (2012) refers to Malone's theory (Malone, 1981), based upon the intrinsic motivation approach, and investigates why games are so much fun and motivational. Through empirical research on various games, he concluded that three elements are required for games to be intrinsically motivating: challenge, fantasy, and curiosity. These three elements can be defined, then, as the attributes a game requires to produce motivational outcomes. Similar research by Lepper (1988) found four necessary features: control, challenge, curiosity, and contextualization. As discussed later, the debate about which attributes or characteristics a game needs to be effective for learning and motivation remains open.

According to Robison and Watson (2013), these two models have 80% similarity and this is illustrated in table 2.2 that maps the components of the two motivational design models showing the similarities and differences. The major differences come from the original purpose of the two models. Malone's model, although now broadly used as a model for incorporation of motivation in learning, was originally developed to guide the design of educational games so fantasy is a key component and relevance to users learning has not been included in the model because of the nature of games.

Table 2.2

Comparison of ARCS and Taxonomy of Motivation models

Motivational Model	**Keller's ARCS**	**Taxonomy of Motivation**
Components	Attention	Curiosity
	Relevance	-
	Confidence	Providing learner control
	Satisfaction	Challenges
	-	Fantasy

2.7 A Proposed Theoretical Model

Robison and Watson (2013) have argued that the ARCS model, in its current form, is insufficient for motivational design of instructional simulations because of 'the current explication of the applied details', whereas Malone's model was designed specifically for motivational design of games and so includes elements specific to gamification. So both models, by themselves, do not give a full framework to develop a set of design principles for educational simulations. A combination of the two models has been proposed as a new learning motivational model specifically for simulated virtual learning environments such as MUVEs.

The proposed model is called the 4A's learning motivational model. The 4A's learning motivational model consists of four main components: Attention, Authenticity, Achievement and Appropriateness (see Figure 2.1).

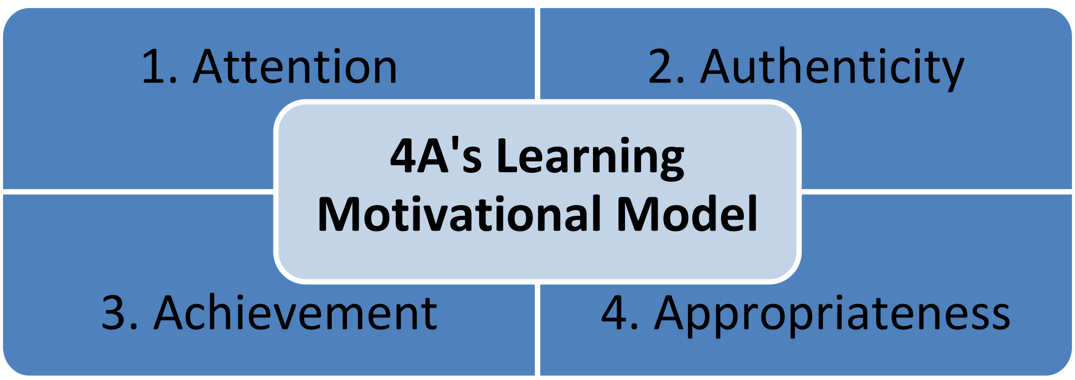


Figure 2.1. 4A's Learning Motivational Model.

For this proposed model, attention focuses on increasing the curiosity in the users and also looking to increase the involvement of users. The second component, Authenticity, is about online simulation incorporating real life examples to enhance the real-life experience. Achievement in the 4A's learning motivational model looks at acknowledgement, self-assurance and rewards, and lastly, appropriateness involves making sure the content and the level of difficulty is suitable and applicable to the users.

The Attention component is derived from the same component in Keller's ARCS model (2009) and the Curiosity component taken from the Malone and Lepper model (1987). The Achievement component is derived from the Confidence and Satisfaction components in Keller's ARCS model (2009). The last component in the 4A's motivational model, Appropriateness is based on the Relevance component in Keller's ARCS model (2009.

The main difference between the 4A's model and Keller's ARCS model (2009) is the Authenticity component, which is not in the ARCS model, but this component is very important when developing online simulation. Malone and Lepper (1987) suggested using fantasy/fictional to keep users motivated when playing games, which does not fit the context of on online learning simulation of a real context. Users in a simulation will look for an authentic setting that is similar to the real situation. For instance, when users are going through a simulation to practice how to operate or understand a complicated machine, the users will expect to see an authentic setup that is identical to the real machinery. Table 2.3 maps the extension of the ARCS and Taxonomy of Motivation models to the 4A model that is to be used in this study.

Table 2.3

Comparison of motivational models and 4A's learning motivational model

Motivational Model	**Keller's ARCS**	**Taxonomy of Motivation**	**4As**
Components	Attention	Curiosity	Attention
	Relevance	-	Appropriateness
	Confidence	Providing learner control	Achievement
	Satisfaction	Challenges	
	-	Fantasy	Authenticity (as opposed to fantasy)

The following section outlines in detail, each of the four components of the 4A model and develops the motivational design principles that flow from each component of the model.

2.7.1 Attention.

Attention keeps users motivated and attached (Malone, 1981; Keller, 1987; Keller, 2009). Wyss et al., (2014) have argued that the more the user spends time on the simulation, the greater the chances of achieving good learning outcomes. As suggested by Keller (1987), when designing a simulation, the designer should not only focus on how to gain users' attention but also focus on sustaining users' attention through the simulation. The components of simulation of curiosity, involvement of the user, authenticity, appropriateness and achievement are now discussed.

2.7.1.1 Curiosity.

When designing the simulations, the designer also needs to keep in mind to raise the curiosity in users. Malone (1981) suggested that curiosity could be raised in two ways, stimulating sensory curiosity and cognitive curiosity. Sensory curiosity refers to attention grabbing from sensory stimuli and cognitive curiosity refers to allowing the users to have their own cognitive thinking from the right amount of "hints" or information (Malone, 1981). Approaches to achieve attention include the following:

Malone and Lepper (1987) have argued that curiosity should start during the introduction of the subject, with the use of, for example, sound, light or colors in the simulation to gain users' sensory curiosity. Then the simulation should continue on with content curiosity that allows users to have just enough information and further their "quest" in the eagerness to find out the truth behind the scene (Malone, 1981). As defined by Sauvé et al. (2007), simulation can be as accurate as the real model and also can be simplified and dynamic which allows developers to have high flexibility when creating more vibrant models and simulation, which will increase the curiosity in users. As argued by Dalgarno and Lee (2010), the most crucial benefit of online simulation is allowing user to interact with interactive objects in virtual space. Placing objects such as video, presentation and interactive 3D objects will allow users to learn from these interactions (Wyss et al., 2014). These interactions will also increase the curiosity in users, In addition, placing the right signboard at the right place not only informs user to visit the right place, this can also increase the user's curiosity especially when they are looking at a very outstanding signboard in a virtual space. User's curiosity can also be aroused through placing the appropriate font size, style and color used in these materials that presented in virtual space (Zhang, 2015). All of these design elements have been considered through the design process for SimuLab.

2.7.1.2 Involvement of the user.

In simulation, involvement of the user is essential. Keller (2009) suggested sustaining active engagement to gain attention, with activities such as role-play, explore, try out, understand and lastly, complete the assign tasks. With this fully hands-on user experience, they will be fully immersed and participate in the simulation which will bring them to the next level of understanding, especially on the simulated scenarios and later users' attention can be easily sustained from the participation. As mentioned by De Freitas (2006), simulation is the practice that will take place in actual situations and skills are required to solve the real life problems. Keller (1987) also proposed to include more recurrent problem solving activities to grab users' attention so it is essential to incorporate real life problems within the simulation.

The design principles that flow from this discussion that will be adopted for the 'Attention' factor are: -

- Capture the learner's attention and maintain it throughout the learner experience and
- Incorporate design elements that stimulate both sensory and cognitive curiosity

2.7.2 Authenticity.

Authenticity is another very important component that will keep users motivated when using the simulation. Malone (1981) suggested that one of the components to keep users motivated when playing games was to use fantasy/fictional environments in games, for example, using the future world as the main game environment. Unlike games, simulations should be designed close to reality and be as authentic as possible (Wang and Burton, 2013). Simulation should not be fictional/fantasy. Users will always look for authentic settings that are similar to the real situation. For example, when users are going through the simulation to practice how to treat a patient in an emergency department of a hospital, the users will expect to see the similar setup compared to an ordinary hospital than just simulate the treatment in a room without anything but only the bed and patient. For instance, a simulation can have a complete set of patients (in different scenarios with different characteristics). With this, students will be able to experience the feedback/reaction from the patients differently (El Tantawi et al., 2013). Approaches for authenticity will be: -

2.7.2.1 Relating the learning activities to user's real-life activities/authentic tasks.

Simulation is heavily used in supporting specific training needs and the practices will take place in actual situations (De Freitas, 2006). A simulation provides more real-life activities and a design based on authentic tasks, which will help the user understand more about what they should and should not do in real life. This also allows users to practice based on the actual context. This will prevent users from making decisions based on over simplistic contexts when they deal with the real situation. Moreover, placing 3D models that have a high level of realism in virtual space can also help user to distinguish what those objects look like in the real world and help user to identify them. So the design of the visual representation of these objects needs to incorporate processes to ensure this high level of reality.

2.7.2.2 To enhance the real-life experience in learning.

Users can experience close to real life activities in a well-designed simulation. They can also experience what cannot be done, hard to be done or cannot be seen in real life. Broom et al. (2009), for example, used online simulation to demonstrate the complexity of nursing care and clinical practices. These activities are very close to the real-life experience. Furthermore, simulation also could further enhance user's learning experience. For example, showing how a car's engine works in real life is very difficult. Just imagine cutting the engine into half to show how it works. Even if this can be done, this action will also cause a big mess to the workshop where allowing the engine fluid splash all over the place. This can easily be replaced by high quality animation in the virtual environment.

The design principles that flow from this discussion for authenticity are: -

- Use authentic settings and tasks
- Relate the learning activities to real life tasks

2.7.3 Achievement.

Achievement makes users feel good about their accomplishment (Keller, 1987; Keller, 2009; Wyss et al., 2014) especially after completing a large task in a simulation. Achievement will lead to self-confidence. Users need to be equipped with high self-confidence for them to be highly motivated when using and re-using a simulation. According to Keller (1987), confident people enjoy learning and users with high self-confidence will believe in themselves for completing assigned tasks. With this, the users' motivation will surely be increased and they will spend more time on the simulation. The more time users spend on a simulation, the higher the chances that they will achieve the designed outcomes (Hodges, 1999). Approaches for achievement are as follow: -

2.7.3.1 Provide feedback, acknowledgment and self-assurance.

A simulation should provide positive feedback when the users complete certain tasks or achieve certain milestones and also provide more informative feedback when the user needs more information to complete the task provided (Keller, 1987). As described by Sailer, Hense, Mandl and Klevers (2013) from a gamification perspective, feedback, which is related to performance, is very crucial to motivation. Game players are likely to be motivated if they obtain immediate feedback in either a positive or negative way. Providing acknowledgement in simulations when users have done something right or completed certain tasks should increase users' confidence and give them assurance to better prepare for the next task. Maintaining self-assurance is vital and must be kept in mind when designing or developing a simulation. Generally, users should start from simple tasks and the difficulties of the task should increase from task to task. This method can slowly build up their self-assurance and users' motivation.

2.7.3.2 Provide pride and reward.

The simulation should allow users to learn new skills and use them when required, and later allow the users who have completed the task to help others who are still doing the task (Keller, 1987). Again, this is equated with what gamification could offer as game players are likely to be motivated if they are offered rewards (Sailer et al., 2013). Users should find this very useful for their learning process and at the same time they will feel proud of themselves.

The design principles that flow from 'Achievement' are: -

- Incorporate feedback for achievement of goals
- Incorporate feedback as support for learner activities

2.7.4 Appropriateness.

Appropriateness is another important component of the 4A's learning motivational model (Keller, 1987; Keller, 2009; Wyss et al., 2014). This component looks into whether the content off a simulation is appropriate or relevant to users' level of knowledge and what they intend to study. According the Keller (1987), users always have questions in their mind, such as "Why do I need to go through this?" "Why do I need to study this?" "Why do I need to go through this simulation?" They are searching for answers to these questions. The simulation must be able to answer these questions to show users what they are going through is appropriate, correct and relevant to what they intend to do. Wlodkowski (1987) also mentioned that appropriateness in his Time Continuum model, comparing the outcome of the instruction with the user's needs and expectations. Approaches for appropriateness are as follow: -

2.7.4.1 Appropriate content.

The content of a simulation should be able to link with the users' needs and future goals (Keller, 1987). The designer should consider including appropriate content in the simulation for current and future users' needs (Keller, 1987). The content used for simulation should be relevant to the topic of the simulation. Appropriate content used in the simulation will allow students to understand the reason behind going through the simulation and they are more likely to complete the task given to them.

2.7.4.2 Appropriate level.

The level of difficulties in simulation should be based on current users' experience and skills (Keller, 1987). The simulation should not be too difficult and also not too simple, and this will affect the users' motivation. If this continues in the entire simulation, either too simple or too difficult to complete the tasks given, users will lose interest in the simulation and using the simulation might come to an end. Simulation designer also needs to know and keep in mind what the users' interests and needs are and try to accommodate as much as possible (Keller, 1987).

The design principles that flow from this discussion that will support 'Appropriateness' and will be used in the design are: -

- Use content that is linked to users' needs and future goals
- Incorporate levels of difficulty matched to users experience and skills

2.8 Design Principles for Authentic Virtual Environments

Each component of the 4A model has specific implications for the design of simulated virtual environments. In order to encompass a full range of key design issues for this study, three layers of design principles have been addressed and will be used in the design of the initial instantiation of the virtual learning environment. The three layers are based firstly on the claimed design principles for Virtual Environments, which have a well-articulated and strong set of underlying assumptions and principles. The second layer of design principles are drawn from the 4A Motivational Model proposed for this study described in detail in section 2.10. The third set of design principles is drawn from the extensive literature and reported practice of design of technology supported learning settings.

2.8.1 General Design Principles for Technology Supported Learning Settings.

Five general design principles for Technology Supported Learning Settings have been drawn from the literature, reported practice, and applied to the design of the learning setting. The first design principle is using different media when designing 3D virtual world. Gül, Gu and Maher (2007) argue that designing an effective 3D world requires different media, using text, 2D images, 3D models, video and etc. The second general design principle is authentic learning which is to design the learning space based on authentic tasks and real-life problem-based learning (Meggs, Greer and Collins, 2010, Reeves, Herrington and Oliver, 2002). The third general design principle is to design the 3D virtual world based on users' skills and backgrounds (Minocha & Reeves, 2010). The designer should consider users' skills and background when designing the learning space. An engaging visual design is also important for modern simulations. It is now expected that the graphics and the visual look and feel of a simulation will be of high quality and realistic (Robison and Watson, 2013) and Berlyne (1971) has argued that attractive visual design is supportive of effective user behavior (as cited in Robison and Watson, 2013).

Lastly, the designer should design a highly interactive learning space (Minocha & Reeves, 2010), which will help to increase the student's attention span when using the 3D virtual world. The designer should meet the users' requirements and have the right level of feedback when designing the 3D virtual space. Furthermore, this can be in the form of social interaction between users to interaction between users and objects in Second Life. It is claimed the existence of interactivity will increase students' attention (Robison and Watson, 2013) when dealing with online simulations in a MUVE platform.

2.8.2 Design Principles for Virtual Environments.

The key design principles for virtual environments that are prevalent in the literature will be used in this simulation implementation. The key design principle, most commonly mentioned, is interactivity. The type of interaction for a virtual environment can be very active and also passive (Nelson & Erlandson 2012). This commonly takes the form of social interaction between users and interaction between users and objects in Virtual Environments.

The second key design principle for Virtual Environments is to incorporate learner support for users with an emphasis on new users. Self-paced tutorials for new users on use of the simulation interface and navigation are commonly incorporated (Nelson & Erlandson 2012). Most of the Multi User Virtual Environment (MUVE) platforms have incorporated this as one of the main features.

The next design principle for Virtual Environments is to support different types of media in the Virtual Environment Platform. Redfern & Naughton (2002) argued that MUVEs should be able to support media such as text, 2D, 3D graphic/image and video. With this, the "developer" has a greater potential to reproduce the authentic content in the virtual space. Nelson & Erlandson (2012) have argued that humans learn better through use of multimedia content as compared to text alone. Most of the MUVE platforms are able to support multiple media and allow the content creator to develop their creative ideas in alternative media.

The use of avatars, digital representations of users in the virtual world is another design principle essential for virtual environments. Chaturvedi, Dolk & Drnevich (2011) have argued for this as an essential principle where the users have a representation of themselves in the MUVE platform. The design should allow users to interact with other users through avatars, and most of the MUVE platforms allow users to customize their avatar based on individual preferences.

2.8.3 Proposed Design Principles based on 4As Motivational Model.

There are several hypothesized design principles drawn from the 4A Motivational Model, which match the inherent simulation design principles, and some that are additional. Each of the 4A model factors offer proposed design principles that have been argued to support the model and these have been discussed in section 2.10 in detail and can be summarised as: -

Drawn from ‘Attention’: -

- Capture the learner’s attention and maintain it throughout the learner experience
- Incorporate design elements that stimulate both sensory and cognitive curiosity

Drawn from ‘Authenticity’: -

- Use authentic settings and tasks
- Relate the learning activities to real life tasks

Drawn from ‘Achievement’: -

- Incorporate feedback for achievement of goals
- Incorporate feedback as support for learner activities

Drawn from ‘Appropriateness’: -

- Use content that is linked to users’ needs and future goals
- Incorporate levels of difficulty matched to users experience and skills

2.8.4 Summary of Principles.

In summary, the initial design principles drawn from the 4A model, the virtual environments literature, and the general design principles for technology supported learning settings from the literature used to develop the simulation for the network design subject being addressed were: -

- Use extensive interactivity
- Capture the learner's attention and maintain it throughout the learner experience
- Incorporate design elements that stimulate both sensory and cognitive curiosity
- Incorporate attractive visual design
- Facilitate learning support and achievement feedback
- Make effective use of a variety of media
- Facilitate user interaction with content and other users
- Use authentic learning settings
- Relate the learning activities to real life tasks
- Use content that is linked to users' needs and future goals
- Incorporate levels of difficulty matched to users experience and skills

Some of the above design principles were drawn from more than one source. For instance the design principles that related to authentic learning setting and real life tasks were based on the design principles from 4As Motivational Model and the extensive literature on authentic learning. The design principles that are proposed to integrate extensive interaction and design in the virtual world with different element (multimedia) were based on design principles for virtual environments and general design principles.

2.9 Assumptions about the participant's technology literacy

Prensky (2001) suggested that the generation born after 1980 are 'digital natives' who are equipped with technology related skills and the generation born after that are 'digital immigrants' who are lacking the technology related skills as compared to the 'digital natives'. However, Bennett, Maton & Kervin (2008) and Kennedy, Judd, Churchward & Gray (2008) have shown that the common assumption that modern tertiary students, or the 'Net Generation' are extremely digitally literate is not an accurate view of students entering tertiary programs and that students technology skills are diverse and significant skills in one area of technology do not necessarily translate to other technologies (Kennedy et al, 2008).

Also, Prensky (2009) later claimed that the gap between 'digital natives' and 'digital immigrants' is getting closer and he then introduced 'digital wisdom' as the replacement of the two terms. Waycott, Bennett, Kennedy, Dalgarno & Gray (2010) suggested that those born after 1990 are more likely to embrace the use of the new technologies as compared to the older generation and engineering students used more tools in formal and informal learning as compared to other cohorts. These groups are claimed to also be good in using the social tools (Margaryan, Littlejohn & Vojt, 2011).

Later, Lim (2017) found that Malaysian students across all discipline studies have very similar technology ownership levels. She also found that Malaysian students across all discipline studies have similar use of the Internet and technology tools specific to social media (Lim, 2017). The researcher's experience after more than 15 years of teaching the targeted networking subject has been that these students are highly competent is using new and complex applications, and so the assumption has been made that these students will have little trouble in using the selected MUVE, Second Life and in particular the learning environment of SimuLab.

2.10 Conclusion

The literature indicates that there is a lack of research in motivating student learning in online simulations, both in terms of the models used and the design principles employed, particularly when using MUVEs as online simulation through applications such as Second Life. A set of design principles have been developed to guide the design of SimuLab, a MUVE for developing knowledge and skills for network design, that incorporates design principles from the proposed 4A's model outlined here, ensuring motivation of learners is core to the design. The proposed 4A's model will then be used as an evaluation and redesign tool to determine the effectiveness of the principles and refine them through a design-based research cycle. One aim of this research is to investigate how students' experience with design components of online simulations in Multi User Virtual Environments may relate to learning in information sciences.

Chapter 3

Research Design and Methodology

This chapter addresses the research design and research methodology that will be used in the study, arguing for a design- based research approach (DBR) as well as the collection of both qualitative and quantitative data. Data collection and data analysis processes will be presented and discussed**.**

3.1 Design-based Research

A design-based research (DBR) approach has been employed in this study to investigate the process of motivating and engaging students in the study of networking in information science through a MUVE designed for this purpose. Van den Akker (1999), one of the pioneers in conducting and promoting DBR argued that design-based research has the practical aim of improving a product as well as the production of generalised knowledge that can contribute to design principles, a major objective of this study. Design-based research is sometimes referred to as developmental research, formative research, or action research (Van den Akker, 1999).

The design-based research approach as described by early adopters of the approach, such as Reeves (2006), is characterized by addressing of complex problems in real contexts in collaboration with practitioners, integration of known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems, and the conduct of rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles. (Reeves, 2000; Reeves, 2006). Design-based research was considered the most appropriate method to use in this higher education setting as it has both practical and scientific outcomes and the participating faculty would be able to see the direct benefits of the research. It is a methodological approach that has been implemented in the field of educational technology, where there is a need to develop practical solutions to complex problems.

Educational technology researchers advocate this approach when conducting practical and socially responsible research as it addresses complex design problems and produces practical outcomes (Burkhardt, 2006; Gravemeijer & Cobb, 2006; Reeves, 2006; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006; Anderson & Shattuck, 2012 and McKenney & Reeves 2014). The overall goal is to solve real problems while at the same time constructing design principles that can inform future decisions. Methods used to obtain data, and their subsequent analysis within the Design-Based Research approach may vary and depend on the questions being investigated. Both qualitative and quantitative methods can be used. Design-Based Research is therefore grounded, adaptable and iterative. Reeves (2006) illustrated the design research approach in educational technology research in four stages.

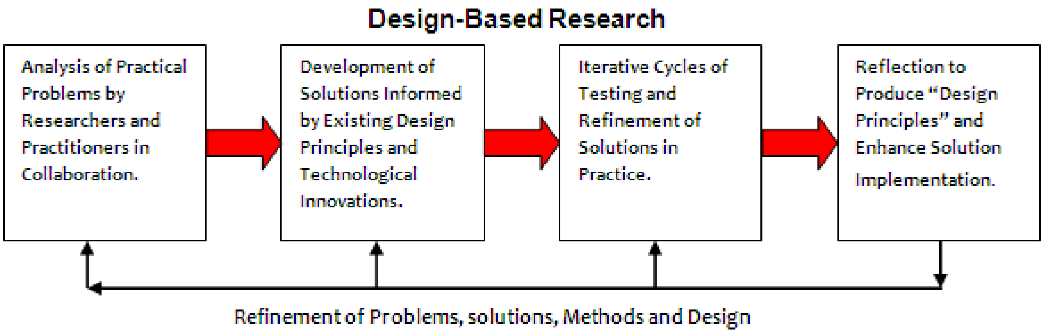


Figure 3.1. Design research approaches (Reeves, 2006, p.59).

The first stage of design-based research identifies the problem faced by researchers and practitioners and analyzes the problem. The second stage focuses on developing a solution to solve the problem based on the analysis from the first stage (Reeves, 2006). After this, the iterative cycle of testing and refinement can be carried out. At times researchers will have to go back to the earlier stages for refinement of the problem, the solution and the design principles before producing the final design principles (Reeves, 2006). The benefits of DBR include allowing identification of real problems, particularly in teaching and learning, and also creating a solution based on a set of design principles. Furthermore, DBR allows testing and refinement of both the solution and the design principles until the acceptable outcomes have been reached (McKenney & Reeves, 2018; Easterday, Lewis & Gerber, 2014; Herrington, McKenney, Reeves & Oliver, 2007; Reeves, 2006).

3.2 Design-based Research in this Research

This research has adopted a design-based research approach, using the seven stages shown in Figure 3.2.

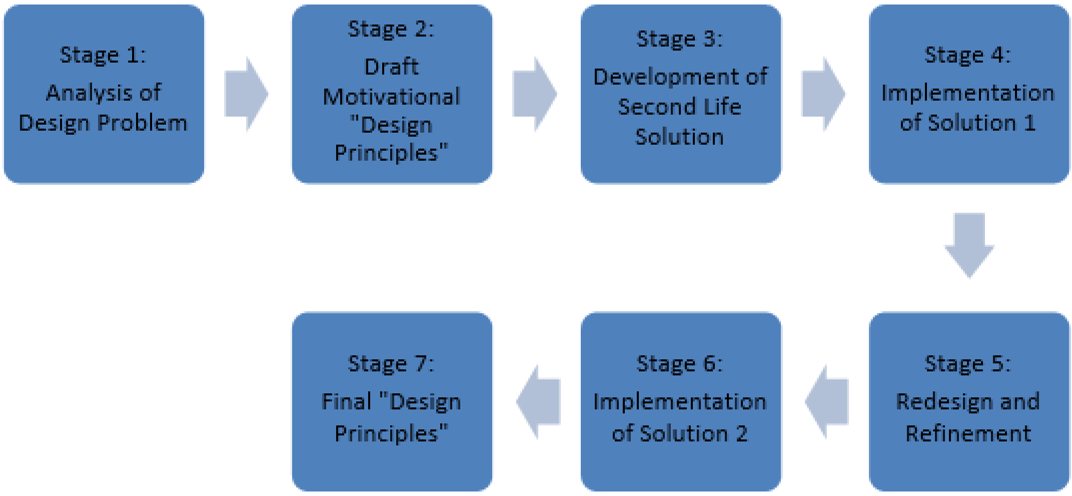


Figure 3.2. Seven stages of design-based research used in this study.

The first stage covers identifying the problems faced from the current practice of the traditional way of conducting information sciences classes on computer networking. This stage has been discussed in section 1.1. At the second stage, based on the analysis of the problem and a comprehensive literature review, the “design principles” are drafted to suit the current situation drawing from the 4A’s motivational model proposed, general educational technology design principles and principles specific to virtual learning environments. At the third stage, the development of the solution stage, a solution is developed in a MUVE developed in Second Life for an Information Sciences subject on computer networking which will allow users to navigate a virtual networking laboratory, go through information related to this subject and interact with the online simulations and the embedded networking content.

At the 1st implementation stage, this newly developed solution will then be used with targeted students in the February 2016 session. The students, at their own pace, will use the solution in a computer laboratory together with other students and/or an instructor/lecturer or at home. At this stage, the results collected using questionnaires and focus group in the 1st implementation will be analyzed. Development of the data collection tools is described in section 3.4.1 for the questionnaires and section 3.4.2 for the focus group discussion questions.

In the redesign and refinement stage, results and feedback from the 1st implementation will be analyzed and will be used to review the design principles and to seek to provide a better solution. Design and development criteria from the analysis stage and also 1st implementation stage will be considered when the enhanced solution is developed for the 2nd implementation. In the 2nd implementation stage, with similar methods used, the 2nd batch of students in the February 2017 session will use the enhanced solution. Again, the results collected from questionnaires and focus group in this 2nd implementation will be analyzed. These results will then be compared with the results of the 1st implementation. Finally, a final set of refined design principles will be developed based on the two cycles of implementation.

3.3 The Study Sample

This research involves computer science and information technology students, specifically those students who are enrolling in their first networking subject (ISIT105/CSIT127) in a University of Wollongong degree presented at INTI International College Subang (IICS), Malaysia. Students enrolled in these degree programs will study the fundamentals of computer science and information technology subjects such as programming, system analysis, database, human computer interaction, networking etc. The computer science and information technology programs have been offered at INTI since 2011 and the participants are mainly from year 1 of these programs.

The students are currently pursuing a degree program in their respective fields. At INTI, students pursuing IT and CS degree programs are required to enroll in ISIT105 - Communications and Networks or CSIT127 - Networks and Communications. All students enrolled in this course will be invited to participate voluntary in the survey. For the first implementation, the researcher is targeting at least 40 students to participate in this exercise, preferably 20 students from each group. The researcher will also target at least 40 students for the second implementation. All these students will participate in the online simulation, questionnaires and focus group discussion.

3.4 Data Collection

The researcher will use a pragmatic mixed method approach by collecting quantitative data via questionnaires and assessment outcomes as well as qualitative data via focus groups and assessment outcomes. Venkatesh, Brown & Sullivan (2016) have argued that mixed-methods research allows researchers to benefit from the combination of the strengths of quantitative and qualitative methods. Ågerfalk (2013) suggested that research should start with either a quantitative approach or a qualitative approach or the other way round to achieve equal status of both approaches.

3.4.1 Questionnaires.

All students that participate in the online simulation will be asked to complete two questionnaires, one prior to the online simulation and the other one after the online simulation. The first questionnaire (pre-questionnaire) will investigate participants' demographic details and prior experience in playing computer games, using simulation and using Second Life. The second questionnaire (post-questionnaire) will investigate questions related to students learning and aspects of the simulation using the four motivational components of the 4A model. The questionnaires will measure students' perception of components of motivation after using the online simulation in the first and second implementation.

The researcher developed the research tools by drawing from a range of previous studies (Keller and Suzuki, 2004; Huang, 2010; Chang and Chen, 2015) and Keller's (2009) Instructional Material Motivation Survey used by other researchers to obtain data in the field of learning motivation and supplemented these tools with additional questions related to learning motivation especially questions related to Keller's ARCS (2009) and Malone (1981) models. Huang (2010) developed a series of questions based on Keller's ARCS model to investigate student perception of an educational game. Questions adopted from Huang's study included, 'The way the information is arranged in the game helped keep my attention' and ' It is clear to me how the content of the game is related to things I already know' to gauge students perceptions of one aspect of the design and to determine students perception of links to their previous knowledge.

Chang and Chen (2015) developed a questionnaire to investigate the motivation for learning in a blended learning environment with 292 participants. They developed a set of five statements under each of the headings of attention, confidence, relevance and satisfaction. Thirteen of these statements were deemed to be suitable to investigate students views of the MUVE developed for this study and were incorporated into the second questionnaire.

There were 20 statements in the questionnaires. Out of the 20 statements, 15 of them were developed based on the ARCS model (Keller and Suzuki, 2004; Keller, 2009; Huang, 2010; Chang and Chen, 2015). Five other statements were based on the "Authenticity" factor under the researcher's 4A motivational model. Table 3.1 shows the 20 statements that will be used to collect data on student's perception of the components of learning motivation. The tools developed were trialed in a pilot study prior to the main study to ensure the questionnaires were unambiguous and robust.

Table 3.1

Statements used to gauge learning motivation

Attention	Q1. The content in "SimuLab" captured my interest and stimulated my curiosity. Q2. The multimedia elements used in Online Simulation motivated me and aroused my attention. Q3. The variability of instructional strategies helped keep my attention. Q4. The way the content is arranged in "SimuLab" helped keep my attention. Q5. I like using online simulation for my learning more than face-to-face instruction.
Authenticity	Q1. The content of the online simulation was authentic. Q2. The online simulation used real life examples. Q3. The online simulation provided sufficient/enough real life examples. Q4. The equipment in online simulation was easier to use compared with real life. Q5. The activities in the online simulation would be hard to implement in real life.
Achievement	Q1. I could control the success of learning outcomes. Q2. I can establish the direction of self-learning after using online simulation. Q3. I am confident that I can make good use of the knowledge in Computer Networking. Q4. Completing the online simulation gave me a satisfying feeling of accomplishment.

	Q5. I got useful learning experience from the online simulation.
Appropriateness	Q1. The content in SimuLab met my learning needs and goals. Q2. SimuLab used real life examples to illustrate the knowledge in computer networking. Q3. It is clear to me how the content in SimuLab is related to things that I already know. Q4. I have integrated the knowledge and skills that I learned in SimuLab into studies and daily life. Q5. I could relate the content that I learned in SimuLab to my study and daily life.

3.4.2 Focus Group.

Krueger and Casey (2014) define focus group discussion as a structured discussion that gathers participants' views on very specific issue within a safe environment. The aim of conducting a focus group discussion is to have a better understanding on how a group of people thinks about an issue or idea (Krueger and Casey, 2014). Selected participants will be invited to participate in the focus group discussion, mainly to gather the qualitative data on the online simulation particularly for learning motivation. There will be at least four focus groups for this research and each focus group will consist of five selected students who have participated in the online simulation. The focus group discussion will be conducted after each implementation of the online simulation.

The questions for focus group discussions were developed based on the 4A's learning motivational model as stated in table 3.2 and additional questions about their experience in using SimuLab, additional support needed and how they perceived SimuLab after using it. The main reason for conducting focus group discussions is to have further understanding of the statistical data from questionnaires and also to allow participants to propose additional ideas to enhance the online simulation.

Table 3.2

Questions for Focus Group

Factors	Questions
Attention	Did you find the content in SimuLab captured your interest? Why or why not?
Authenticity	Did you find the online simulation in SimuLab authentic or not? Why?
Achievement	Do you feel you can confidently apply what you have learned in the online simulation? Why or why not?
Appropriateness	Do you feel the online simulation was presented in an appropriate way? Why or why not? Was it relevant to ISIT105? Why or why not?
	Do you feel you will use what you learned from this lesson in the networking subject? If yes, how? If no, why not?
Other General Questions	In your own word, could you describe this online simulation in SL?
	Can you share some of your experiences in using this online simulation?
	What was the most important thing you learned in this online simulation?
	What benefits do you perceived with this online simulation?
	What concerns do you have regarding the use of this online simulation?
	What additional support do you wish you had in the online simulation and from whom?
	What improvement or changes do you hope to see in this online simulation?
	Do you have any additional comments or questions about this research study?

3.4.3 Assessment of Learning Outcomes.

In both Iterations, the subject lecturer Mr. Shanmuga conducted a quiz a few weeks after the students had completed the online simulation. The subject quiz results were a measure of the learners' knowledge of the topics addressed in the MUVE simulated virtual networking laboratory. This data collected from the assessment will be analyzed using t-tests and comparisons will be made with previous cohorts of students before the use of the simulation in this subject). The quiz covered chapter 1 and 2 of the subject with the following topics: -

- Types of networks
- Networking Hardware
- Network Topologies
- OSI Model

3.5 Data Analysis

Questionnaire data will be analyzed using descriptive statistics, which describe the main features of the data. Independent sample t-tests (Levene's test) will also be used to statistically test and compare two different groups of data, for example the comparison between data collected from the first as well as second implementation. Furthermore, the data collected from the assessment will also be analyzed using t-tests. The quantitative analysis will assist in answering the following research questions: -

i. What is the relationship of components of motivation to students' experience in an online simulation?

ii. What are students' perceptions of design elements embodying motivational components in an online simulation?

In this context the questions the focus group questions were based on the 4A's learning motivational model themes, so this process could be considered as initial thematic analysis of the potential responses. Braun & Clarke (2006) defined thematic analysis as "a method for identifying, analysing and reporting patterns (themes) within data" (p. 79). Focus group data will be transcribed into digital format and this information, collected from the focus group. This information will be already categorized into theme based on the 4A's learning motivational model based on the pre-categorization of the questions asked. The information will then be analyzed using scissor-and-sort technique (Stewart & Shamdasani, 2014). This is a time-saving technique for analyzing transcripts in focus group discussions. For this study all relevant coded transcripts will be cut out and grouped according to 4A's learning motivational model using word processing software to support and incorporate into the analysis (Stewart & Shamdasani, 2014). These information will be used during development of the second iteration. The main reason for the researcher to conduct focus group discussion was to allow participants to propose additional ideas or features for SimuLab and to elaborate on their answers to the questionnaires where they felt they wanted to add additional information. The learning measures data, in the form of a class assessment, will be used to address the final research question: -

iii Can a well designed MUVE improve learning outcomes for information science students studying complex and abstract concepts such as computer networking?

3.6 Ethical considerations

This research will involve students who are currently enrolled in computer science and information technology undergraduate courses. This research will not involve any risk of emotional distress or physical harm to the participants. As the requirement set by University of Wollongong, the researcher has submitted the ethics application form together with the research instruments (consent form, participant information sheet for students, two sets of questionnaires, focus group questions, recruitment email to lecturer, recruitment letter, etc.) to the university's Human Research Ethics Committee. The ethics approval was received in January 2016. The research instruments submitted for this study were also approved for use.

The details of this project will be explained to all participants and their voluntary participation will be sought. Participants who have agreed to be involved in this research will be advised that they have the respective right to withdraw from the involvement in any data-gathering processes. Participants will also be advised that the information they provide will not be disclosed to any other member of their organization. All Information collected from the participants will remain confidential and be presented in the form of aggregated data or anonymous quotations with any potentially identifying details removed.

3.7 Conclusion

This chapter argues for the research method being used, outlining the benefits of using DBR and how DBR will be applied. Furthermore, this chapter details how the protocols were developed and how they will be administered including questionnaires, observations, focus group and interviews. Also, the participants have been described as well as how they will interact with the data collection processes and the methods used in data analysis have also been discussed.

Chapter 4

Iteration 1

This chapter addresses the first iteration of the online simulation laboratory (SimuLab) in Second Life through detailing the design of the learning setting and administration of the data collection and analysis. This includes administration of a pre-questionnaire before using the online simulation, post-questionnaire after using the simulation, focus groups discussion and an assessment task. The participants were undergraduate students taking introduction to networking subjects. The data collected from the questionnaires has been analysed using descriptive statistics, while, for the data collected from focus groups, theme analysis was applied and for the assessment task descriptive statistics were used.

4.1 Online Simulation Laboratory (SimuLab)

4.1.1 Design Principles Implementation.

The design process for SimuLab involved initially structuring the learning space to emulate a network laboratory within a simulated building that contained a variety of learning materials and support for the students studying a networking subject, drawing on the stated design principles listed in section 2.8 as an integral part of this process. Then the stated design principles were used to drive the design and implementation of the various elements of the simulation. Each design principle was considered specifically when designing the overall simulation and then the design of each element drew on individual principles. Table 4.1 illustrates the linkages between each design principle and examples of the manifestation of that design principles within the simulation.

The Second Life platform allows high levels of customization of the virtual space by using the inbuilt Linden Scripting Language. The researcher was assisted in the design process, by default, as many of the virtual environment design principles are embedded in Second Life as part of the application design. For example, the design principle for virtual environment "Use of avatar", Second Life compels users to select their own avatar, which is the digital representation of a user in the virtual world that allows users to have a representation of themselves in the MUVE platform and a mechanism to interact with other users supporting the design principle of high levels of interactivity.

Table 4.1 lists the design principles used to develop the MUVE SimuLab and describes the manifestation of each principle in the simulation.

Table 4.1

Design Principles and manifestation of the design principles in SimuLab

Design principles	**Manifestation in Design**
1.Use extensive interactivity	SimuLab incorporates more than 30 interactive objects that can be interrogated for their characteristics and function and can interact with each other as elements of a network design. SimuLab also incorporates Avatar interaction with the environment.
2. Capture the learner's attention and maintain it throughout the learner experience	SimuLab makes use of a strong visual presence through a navigable space that represents a networking laboratory and incorporates the use of a personal Avatar to represent the learner. Learner tasks were designed to encourage investigation by challenging learners to solve networking problems.
3. Incorporate design elements that stimulate both sensory and cognitive curiosity	Different types of multimedia elements are used throughout the building such as sound, video and visually appealing images.
4. Incorporate attractive visual design	SimuLab incorporates visual elements that are designed to catch the user's eye and to present a strong visual presence for all of the elements of the simulation. Colors have been used to good effect in representing signs, objects and interactive elements to ensure the environment looks and feels like a networking laboratory.
5. Incorporate feedback for achievement of goals	The interactive objects and simulation setup in SimuLab provides feedback to users when accessed. Additionally an

	internal quiz and scoreboard incorporates achievement feedback in the second iteration.
6. Incorporate feedback as support for learner activities	A Facebook group, in-built tutorials and face-to-face instruction have been incorporated to introduce users to SimuLab and support use.
7. Make effective use of a variety of media	A wide range of multimedia elements have been used throughout the building such as sound, video and strong colours of images support the visual appeal of the simulation.
8. Facilitate user interaction with content and other users	The arrangement of SimuLab not only promotes the interaction between students and the virtual objects/settings but also students and students. Additionally objects interact with each other as part of the process of students designing a network.
9. Use authentic learning settings	SimuLab incorporates setting of an authentic networking laboratory, with all proper network equipment settings, exhibited and used. Tasks are set that are authentic networking tasks and an exhibition corner to exhibit network equipment.
10. Relate the learning activities to real life tasks	SimuLab is setup to allow students interaction where they can choose objects from the simulation board and interact with the equipment by just clicking on the equipment in the selected network.
11. Use content that is linked to users' needs and future goals	The content used in SimuLab allow students to choose which elements they would like to see/play with and understand from which will help them to understand the networking concept that will be required for this year 1 subject.
12. Incorporate levels of difficulty matched to	The course content used in SimuLab is based on the subject "Communications and Networks" syllabus that is

users experience and skills	suitable for year 1 students as an introductory course to a computer-networking subject.

To further illustrate the design implementation, the design principle for virtual environments of "Incorporate feedback as support for learner activities (principle 6)"; Second Life has incorporated detailed tutorials for new users. These tutorials on the interface and navigation help the new user in using and navigate through the new virtual environment. Furthermore, the researcher has incorporated learner support in using SimuLab through a Facebook group that was used to support users for any SimuLab related issues. This allowed users to ask any questions related to SimuLab and online simulation in the group. In addition, the researcher used this Facebook group to disseminate important information about SimuLab, including any issues with access and timing of the use of SimuLab.

As mentioned in the general design principles, "Make effective use of a variety of media (principle 7)", the simulation lab has incorporated all the five media defined under the term multimedia, that is video, image, text, sound and animation. The simulation lab is equipped with text from slideshows, video and sound from YouTube videos, animation from the simulation and the images/graphics from 3D models.

The design principles that draw from the 4A Motivational Model have been incorporated in the simulation. The most noteworthy design principle is incorporating of "interactivity (principle 1)" in the SimuLab. Similarly to other MUVEs, Second Life promotes social interaction between users. SimuLab and its facilities were open to all Second Life users with users being able to interact between each other; and any objects in the SimuLab.

The third design principle drawn from the 4A Motivational Model is "to offer authentic learning activities (principle 9)" in the SimuLab. The setting of SimuLab mirrors an authentic networking laboratory where most of the network equipment is placed, exhibited and used in the network settings. Users can select network settings freely from the menu and work on the status of the network equipment to understand the consequences of their action. Some of these actions are prohibited in the real networking laboratory because of the potential for damage to expensive equipment, but users are able to see the consequences of this sort of action in this simulation.

Lastly, the fourth design principle drawn from the 4A Motivational Model is to "incorporate levels of difficulty matched to users experience and skills (principle 12)". The content used in the online simulation follows the year 1 networking subject syllabus from the University of Wollongong Computer Science and Information Technology programs, and the online simulation is targeted for year one students from both programs. The subject lecturer has confirmed that the content and topics used in SimuLab are relevant to their studies and suitable for the users' level of study, confirming the implementation in SimuLab of this design principle.

4.1.2 Design Implementation.

It is very important to incorporate the appropriate level of contents for SimuLab as mentioned in one of the design principles "incorporate levels of difficulty matched to users experience and skills (principle 12)". The course content used in SimuLab is based on the subject ISIT105 - Communications and Networks syllabus that is suitable for year 1 students as introductory course to computer networking subject. The topics covers in the SimuLab as follow: -

- Definition of computer networks.
- Peer-to-Peer Networks (P2P)
- Client/ Server Networks
- OSI Model - 7 layers
- NETWORKING HARDWARE – Hub, switches, and routers
- LAN (Local Area Network)
- MAN (Metropolitan Area Network)
- WAN (Wide Area Network)

SimuLab is located in a virtual 2-storey building in Second Life. Figure 4.1 shows the view from outside of the Simulation Lab, with the sign of the SimuLab Logo. This design supports the concept of authentic learning settings. Figure 4.2 shows the view from the entrance to the Simulation Lab. The ground floor of the building is used to showcase all lecture slides and videos. Students are able to read the PowerPoint slides related to the above topics in Second Life (online) or choose to download the slides and go through them offline elsewhere. On the same floor, Figure 4.3 shows YouTube Video streaming at the Simulation Lab. Videos related to networking are shown in this floor. Students are able to view the video onsite by clicking on the video in SimuLab, obtain the video link or view in YouTube. With the different types of multimedia elements used in the first floor of the building such as sound, video and different colour of images, the researcher has incorporated the use of a variety of media that also supports another design principle, which is “Incorporate design elements that stimulate both sensory and cognitive curiosity (principle 3)”. The main purpose of this floor is an introduction and a recalling session for these students, where the students are transitioned from normal face-to-face class to the new learning experience in a virtual environment. That is incorporation of the design principle of user support for use of the application.

Figure 4.1. View from outside of the Simulation Lab, with the sign of SimuLab Logo.

Figure 4.2. View from the entrance to the Simulation Lab, ground floor.

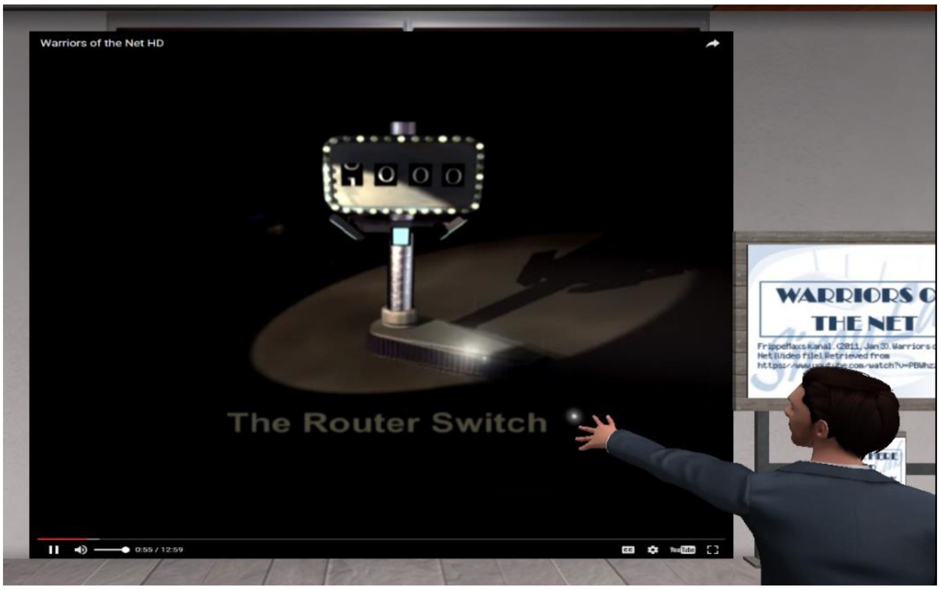


Figure 4.3. Video (YouTube) streaming at the Simulation Lab, ground floor.

On the first floor of the building the researcher has setup an area to exhibit network equipment like routers, switches, hub etc. This setup has taken into consideration the design principle “use authentic settings (principle 9)”. These 3D models are specially designed and modeled based on the real equipment such as Linksys router and Cisco switch. Students can click on the equipment to zoom in to have a closer look at the object.

The more interactive setup on this floor is the simulation area as shown in Figure 4.4 and 4.5. Students are able to select the type of network they wish to interact with by clicking on the simulation board. After clicking on the board, they have to select the type of network (i.e. LAN type 1, LAN type 2 or WAN) from the pop-up menu. After selection, the selected network will appear on the big table beside the board. Students managed to interact with the equipment by just clicking on the equipment. The equipment on the table can be turned on or off and once the state of equipment has changed, they will receive messages to explain the consequences of their action. The equipment such as the hubs, switches, laptop, cables in the simulation area are interactive, students are allowed to touch the objects to find out the objects’ name, they are allowed to zoom into particular objects to have a closer look, and they could connect and disconnect the equipment on the selected network to see the consequences of their action. Students are also allowed to change the equipment on the simulation table to see the differences between the various pieces of equipment. It is anticipated that with this interaction between students and the equipment in the simulation, the efficient and safe use of the equipment in the lab will be greatly improved. The arrangement of the simulation area in SimuLab has taken into consideration more than one design principle. For instance, the design principle that draws from virtual environments and general design principles, “to design a highly interactive learning space” (principle 1) and “to design the learning space based on authentic tasks” (principle 9). These design principles not only promote the interaction between students and the virtual objects/settings but also provide an authentic learning environment for students.

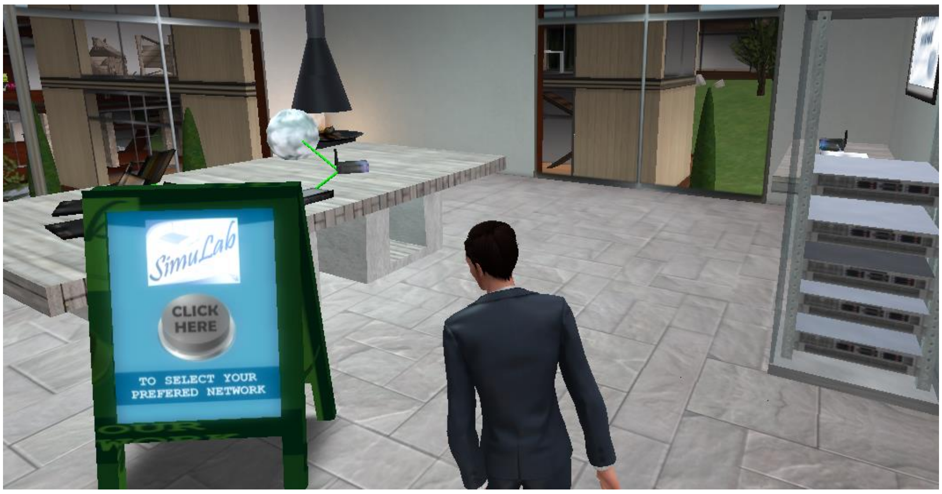


Figure 4.4. First floor view on Simulation Lab.

Figure 4.5. Interaction with networking devices on Simulation Lab.

4.2 The Questionnaires

4.2.1 Pre and Post-questionnaire.

In the first implementation, pre and post questionnaires were used. All participants completed the pre-questionnaire a week prior to the online simulation (SimuLab) being opened for participants to use. The post-questionnaire was then completed one week after the students finished using SimuLab. The pre-questionnaire comprised 29 questions: eight questions related to participants' demographic details; five questions related to prior experience in playing computer games; five questions related to prior experience of using simulation; seven questions related to prior experience of using Second Life; and, two general questions to collect participants' opinions on Second Life. The post-questionnaire included a total of 29 questions: eight questions related to participants' demographic details; 20 questions related to the 4A motivational model described in section 2.4 with five questions for each dimension of the framework, Attention, Authenticity, Achievement and Appropriateness; and, one general question asking about participant's opinions about using SimuLab. Table 4.2 shows a mapping of the questions back to the design principles and the manifestation of the principles in SimuLab. It was anticipated that this process would ensure the questionnaire was addressing the students' perception of the design success.

Table 4.2

Design principles for SimuLab, manifestation of the design principles and corresponding questionnaire questions

Design principles	**Manifestation in Design**	**Matching questions from post intervention questionnaire**
1.Use extensive interactivity	SimuLab incorporates more than 30 interactive objects that can be interrogated for their characteristics and function and can interact with each other as elements of a network	9c. The variability of instructional strategies helped keep my attention.

	design. SimuLab also incorporates Avatar interaction with the environment.	
2. Capture the learner’s attention and maintain it throughout the learner experience	SimuLab makes use of a strong visual presence through a navigable space that represents a networking laboratory and incorporates the use of a personal Avatar to represent the learner. Learner tasks were designed to encourage investigation by challenging learners to solve networking problems.	9c. The variability of instructional strategies helped keep my attention. 9d. The way the content is arranged in "SimuLab" helped keep my attention.
3. Incorporate design elements that stimulate both sensory and cognitive curiosity	Different types of multimedia elements are used throughout the building such as sound, video and visually appealing images.	9a. The content in "SimuLab" captured my interest and stimulated my curiosity. 9b. The multimedia elements used in Online Simulation motivated me and aroused my attention.
4. Incorporate attractive visual design	SimuLab incorporates visual elements that are designed to catch the user’s eye and to present a strong visual presence for all of the elements of the simulation. Colours have been used to good effect in representing signs, objects and interactive elements to ensure the environment looks and feels like a networking laboratory.	9b. The multimedia elements used in Online Simulation motivated me and aroused my attention.

5. Incorporate feedback for achievement of goals	The interactive objects and simulation setup in SimuLab provides feedback to users when accessed. Additionally an internal quiz and scoreboard incorporated achievement feedback in the second iteration.	11c. I am confident that I can make good use of the knowledge in Computer Networking 11d. Completing the online simulation gave me a satisfying feeling of accomplishment 11e. I got useful learning experience from the online simulation
6. Incorporate feedback as support for learner activities	A Facebook group, in-built tutorials and face-to-face instruction have been incorporated to introduce students to SimuLab and support use.	11a. I could control the success of learning outcomes 11b. I can establish the direction of self-learning after using online simulation.
7. Make effective use of a variety of media	A wide range of multimedia elements have been used throughout the building such as sound, video and strong colours of images support the visual appeal of the simulation.	9d. The way the content is arranged in "SimuLab" helped keep my attention.
8. Facilitate user interaction with content and other users	The arrangement of SimuLab not only promotes the interaction between students and the virtual objects/settings but also students and students. Additionally objects interact with each other as part of the process of students designing a network.	9c. The variability of instructional strategies helped keep my attention.

9. Use authentic learning settings	SimuLab incorporates an exhibition corner to exhibit network equipment like routers, switches, hub that was specially designed and modeled on the real equipment such as Linksys router and Cisco switches. Tasks are set that are authentic networking design tasks.	10a. The content of the online simulation was authentic. 10b. The online simulation used real life examples. 10c. The online simulation provided sufficient/enough real life examples.
10. Relate the learning activities to real life tasks	SimuLab is setup to allow students interaction where they can choose objects from the simulation board and interact with the equipment by just clicking on the equipment in the selected network.	12b. SimuLab used real life examples to illustrate the knowledge in computer networking 10d. The equipment in online simulation was easier to use compared with real life 10e. The activities in the online simulation would be hard to implement in real life.
11. Use content that is linked to users' needs and future goals	The content used in SimuLab allow students to choose which elements they would like to see/play with and understand from which will help them to understand the networking concept that will be required for this year 1 subject.	12a. The content in SimuLab met my learning needs and goals. 12c. It is clear to me how the content in SimuLab is related to things that I already know

12. Incorporate levels of difficulty matched to users experience and skills	The course content used in SimuLab is based on the subject "Communications and Networks" syllabus that is suitable for year 1 students as an introductory course to a computer-networking subject.	12d. I have integrated the knowledge and skills that I learned in SimuLab into studies and daily life 12e. I could relate the content that I learned in SimuLab to my study and daily life

4.2.1.1 Respondents Demographic Details.

There were 38 respondents to the pre-questionnaire. Figure 4.6 shows the majority of respondents were aged 19-20 and male, with eight female (21%) participants. The limited representation of female students in an information sciences degree is not unexpected, as they are traditionally underrepresented for information sciences degree in the Malaysia context. Thirty-two of the respondents were from Malaysia (84%). This is representative of the typical ratio of domestic and international students at the university. The majority of respondents (76%) were from three-year degree programs and the rest (24%) were from two-year Diploma programs. All participants were in a technical degree; 31 participants (82%) reported specializing in Computer Science and seven (18%) in Information Technology/Information Systems. However, the majority were early in their degree, with more than half (60.5%) having less than 1 year of study experience and the remaining participants having only 1-2 years of study experience. This is not unexpected as students invited to participate in the study were generally taking first year subjects**.**

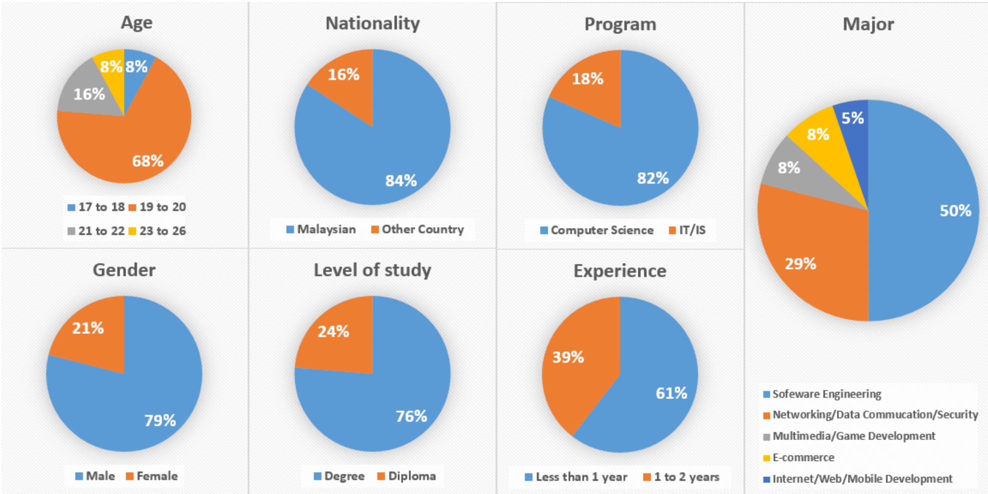


Figure 4.6. Demographic details.

4.2.1.2 Respondents Prior Experience with Technologies.

Of the respondents, 37 owned a laptop and 36 owned at least one smartphone. Only 10 participants owned a Desktop and 15 owned a tablet. Three (7.9%) had not played computer games in the past. Figure 4.7 shows the hours spent in playing computer games in a week. From this it can be assumed that the majority of respondents were familiar with computer games and would be likely to have some knowledge of Second Life, which has similar characteristics as computer games such as the social and identity features that allow communication between users and digital representation of users using avatars with attributes selections (Hull, Williams & Griffiths, 2013).

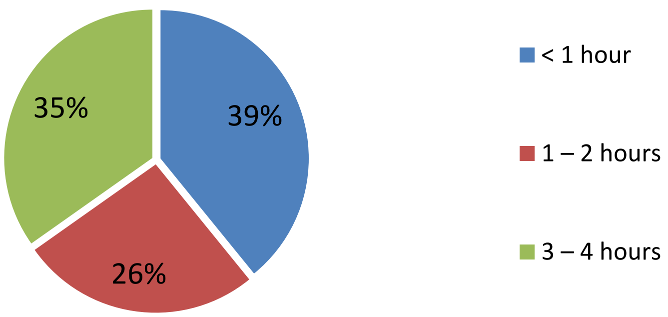


Figure 4.7. Hours spent in playing computer games.

There were five barriers to computer game play identified by participants. Thirty-five respondents (92%) perceiving barriers to computer game play (see Figure 4.8). The questions about computer game play were used here to gauge the students' views about using a similar computer context to simulation in terms of user and technical demand. Twenty-three were concerned about limited hardware or Internet bandwidth availability. This is a common concern, as hardware and Internet bandwidth requirements for gaming, particularly online games, are much higher than web browsing or email. Furthermore, 9 out of 12 students (75%) that indicated they played computer games more than 4 hours a week also reported having limited hardware or Internet bandwidth, which, on the face of it appears to be a contradiction in that the students perception of technology needs for game playing does not match with their large use patterns. It appears that they are noting that technology constraints are a barrier to use for games, but that does not appear to limit their playing. In total, more than 65% of respondents reported having this problem, which means there may be some problems when using Second Life. The second barrier to computer game play, faced by respondents, was the time spent for playing computer games might interfere with their personal time that they might choose to use for other purposes. More than 66% of the respondents that faced this problem are those play more than 3 hours game a week. Complicated functionalities and features of computer games are the next barrier in line that 10 respondents (29%) reported concern about this. Six of the respondents were concerned about the privacy issue while playing a game. Only one respondent showed concern about updating game software.

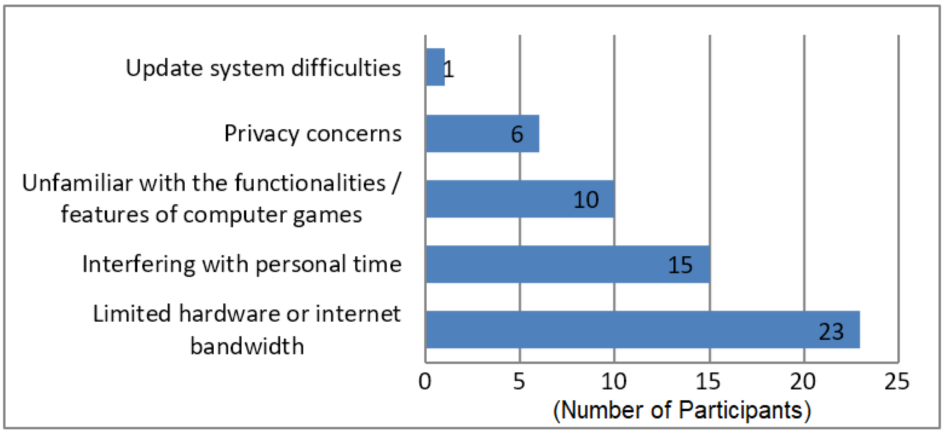


Figure 4.8. Barriers of Playing Computer Games.

All respondents reported that playing games was interesting and more than half felt computer games could be useful for academic purposes (n = 18, 51.4%). None of the participants felt games could not be used for academic purposes. These results suggest that respondents felt positive towards using games for academic purposes, so it could be expected that the respondents would also feel positive toward using Second

Life for academic purposes.

4.2.1.3 Respondents Prior Experience Using Simulations.

Of the 38 respondents, only 17 (44.7%) had used online simulation or had played online simulation games. Eleven respondents (65%) had used online simulation for less than an hour per week. Six respondents (35%) had used online simulations 1 to 2 hours per week. This shows that online simulation or online simulation use was not common among participants. Figure 4.9 shows that 11 (65%) participants believed the main barrier they faced in online simulation use was they were easily distracted and would lose focus while using it. Ten (59%) participants identified difficulties with limited hardware and Internet bandwidth. Online simulation requires higher hardware specifications and Internet bandwidth. Eight (47%) respondents were unfamiliar with the functions and features of online simulations. Therefore, the familiarity of all 38 students towards online simulation is very limited. The same number of respondents agreed that they had to spend a long time just to learn how to use the online simulation program and get familiar with the program.

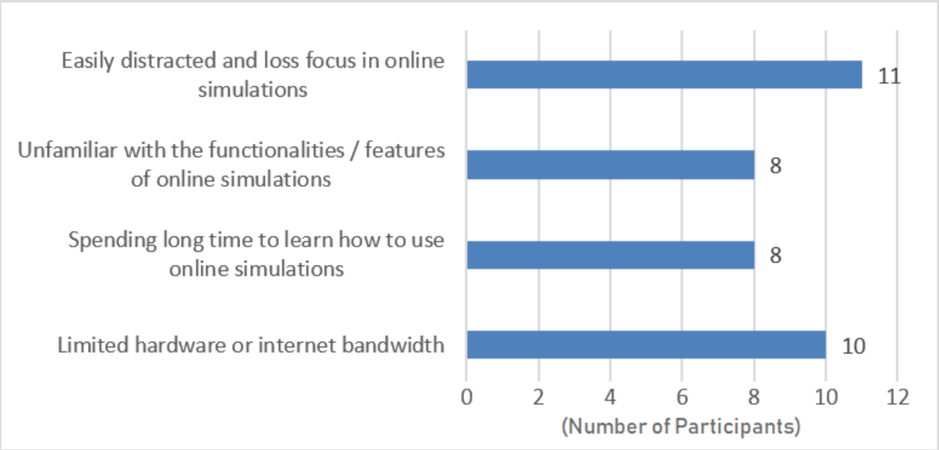


Figure 4.9. Barriers of Playing Online Simulation.

Fifteen respondents (88%) agreed that online simulations were interesting and eleven (65%) respondents believed online simulations could be used for academic purposes. Only one respondent (6%) did not agree that online simulation could be useful for academic purposes. Five (29%) respondents thought online simulation might be useful for academic purposes. Again, from the above statistics, only 1 out of 17 respondents that used online simulation prior to this study believed that online simulations were not useful for academic purposes.

4.2.1.4 Respondents Prior Experience Using Second Life.

Out of 38 respondents, only three (8%) had used Second Life previously. Two of these three had spent less than 1 hour a week with Second Life and one had spent 1 to 2 hours per week in using it. All these respondents considered themselves beginners in Second Life. All three reported rarely using Second Life for entertainment. Two did not use it as a platform to communicate/socialize/networking with friends or for collaborative work, or to share skills or experience or for seeking opinions. However, one of the respondents did use Second Life as a platform for these activities. He reported spending 1 to 2 hours a week on online simulation and playing computer games. He was the only one that faced difficulties with limited hardware and Internet bandwidth among the three. The main barrier that two of the three participants faced was they reported being easily distracted and lost focus in Second Life and also were concerned about the unfamiliar functions and features. One participant was worried about using Second Life somehow interfering with their personal time. Second Life requires higher hardware specifications and Internet bandwidth compared to other computer programs. All three respondents agreed that it could be useful to use Second Life for academic purposes. From the above statistics, it suggests that there was very little familiarity in using Second Life. When considered in light of limited experience using simulations, this suggests using simulations in Second Life would be a new experience for most of the students.

Of the respondents, 35 (92%) had never used Second Life. In fact, 24 (69%) had never heard of Second Life. Only one respondent reported they would not consider using it in the near future. The majority (67%) of respondents reported that they might give Second Life a try in future. Ten of the respondents (29%) would use Second Life if they were given a chance. This result suggests that, while students had little experience using Second Life, they would be willing to use it in the near future. *4.2.1.5 Summary for Pre-questionnaire (Set A).*

4.2.1.5 Summary for Pre-questionnaire (Set A).

The participants in this study were predominantly Malaysian, male and in their first year of study of a computer technology degree or diploma and mostly in the age bracket of seventeen to twenty-two years old. The majority of respondents were familiar with computer games and, because of the similarities between computer games and simulations; the researcher had assumed they would be likely to have some knowledge of Second Life. However, only three out of 38 participants had used Second Life previously, resulting in an investment of time by students to become effective users. Furthermore, most of the participants owned laptops and smartphones, which might not be the ideal computer hardware for Second Life compared to more powerful desktop computers where only 10 participants owned a desktop computer. According to Kluge and Riley (2008), computer hardware and Internet speed are the most crucial requirements for "connecting" to virtual worlds like Second Life. This statement also supported by "Virtual Worlds" (2019) that shows the recommendation computer specification to run 3D virtual world applications. Therefore, the student responses to these questions have shown that, in addition to having limited knowledge of Second Life it is likely engaging in the online simulated space could cause some difficulties for students if they have limitations with their personal devices, This outcomes was unexpected in that the students had claimed extensive use of computer games with similar hardware demands as Second Life. The outcome did offer some challenges for the next iteration of SimuLab, as the scheduling of the simulation did not allow changes for the first iteration. However, to address these issues, at least in some way, access to desktop computers for students without this equipment was made available and student support for initial use of SimuLab was added to the Facebook site. In summary, the participants believed that the major barriers to use of Second Life, in a learning context, were hardware specifications, distraction from the goals to be achieved and the lack of familiarity with the features of Second Life**.**

4.2.2 Post-questionnaire (Set B).

There was a total of 29 items in the second questionnaire: 8 were related to participants' demographic details; 20 were related to the A4 motivational model, 5 statements each for attention, authenticity, achievement and appropriateness and, a general question about participant's opinions on using SimuLab**.**

4.2.2.1 The Four Factors.

The motivational model questions were expected to reflect the student's experience with SimuLab, and, from these students' reflections, the research proposed to draw some conclusions about the effectiveness of implementing of the design principles for SimuLab. Table 2 shows the mean scores for the A4 factors: attention, authenticity, achievement and appropriateness. Average scores for all factors were positive (m > 3.0), reflecting general agreement on the effectiveness of the simulation implementation (SimuLab) in Second Life.

Table 4.3

Mean scores for A4 Factors (Iteration 1)

	Attention	Authenticity	Achievement	Appropriateness
Mean	3.54	3.53	3.67	3.6
N	24	24	24	24
SD	.61	.60	.55	.54

******Strongly disagree = 1, Disagree = 2, Neutral = 3, Agree = 4 and Strongly agree = 5*

4.2.2.2 Responses to Attention on Online Simulation in Second Life.

There were five statements (statement 9a to 9e) used to gauge respondents' attention while accessing SimuLab. Figure 4.10 shows the mean score for respondents' attention while accessing SimuLab. In general, mean scores for all five statements showed positive agreement (m > 3.0).

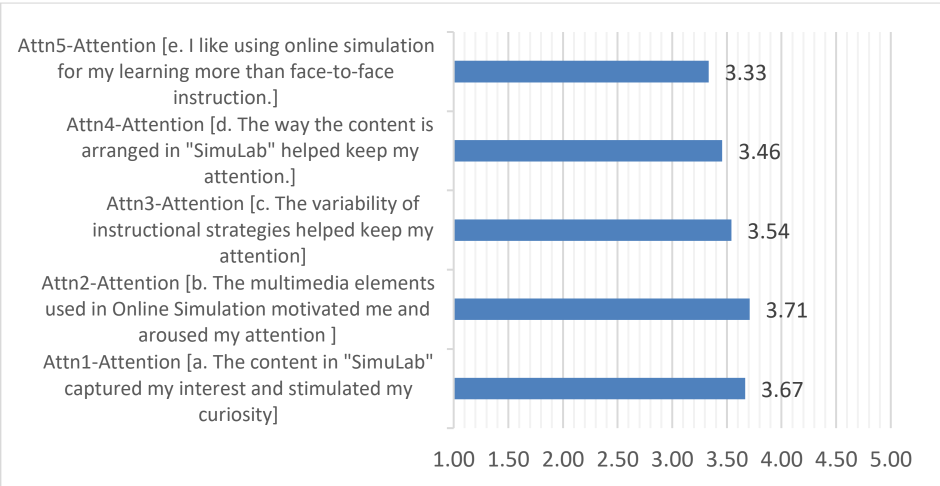


Figure 4.10. Mean scores for Attention (statements 9a to 9e).

92.5% of respondents were either positive or neutral about these five statements (negative = 7.5%; neutral = 44.2%; positive = 48.3%). Statement (9a) recorded the highest agreement among the five statements, with statement (9e) the lowest. This data suggests that the participants did not report negative feelings about SimuLab, their level of interest and their attention.

The design principles employed to specifically support Attention for this factor of the model (based on the design principles described in section 2.12.2 and the manifestation of these principles in SimuLab listed in table 4.2 were: –

- Capture the learner's attention and maintain it throughout the learner experience (Statement 9c and 9d are referring to this design principle)
- Incorporate design elements that stimulate both sensory and cognitive curiosity (Statement 9a and 9b refers to this design principle)

The use of these design principles for incorporation of the factor 'Attention' in the design of SimuLab appears to have been successful in that the students, in general, believed that the simulation captured their attention, they were positive or neutral about learning through online simulation compared to face-to-face instruction, and they stated that the structuring of the content, the content and instructional strategies helped to maintain their attention. With the highest rating, the students stated that the multimedia elements used in the simulation kept their attention. But when asked about comparing online simulation to face-to-face classroom teaching in statement (9e), only 41.7% of them agreeing with this statement.

4.2.2.3 Responses to Authenticity on Online Simulation in Second Life.

There were five statements (statement 10a to 10e) in Set-B Questionnaire that used to measure the authenticity of SimuLab. Figure 4.11 shows the mean scores for respondents' authenticity while accessing SimuLab. In general, mean scores for all 5 statements showed positive agreement ($m > 3.0$).

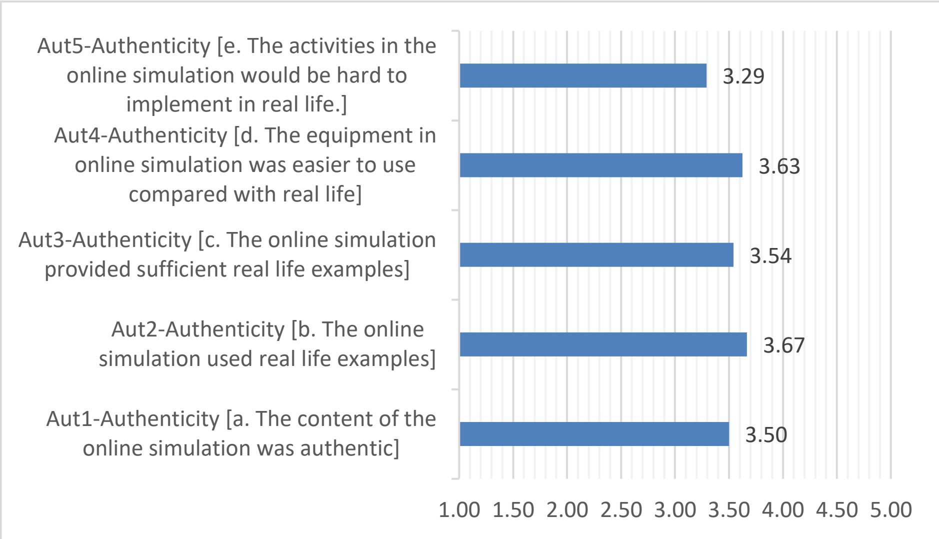


Figure 4.11. Mean scores for Authenticity (statements 10a to 10e).

91.6% of respondents were either positive or neutral about these five statements (negative = 8.4%; neutral = 38.3%; positive = 53.3%). Statement (10a) and (10b) have recorded the highest agreement among the five statements, with statement (10e) scoring the lowest. It suggests that most of these participants agreed that the construct of SimuLab, which is based on the stated design principles, is authentic; at the same time SimuLab gave them real life experiences with more relevant content.

Statement (10e) had the lowest number of agreement (37.5%), however, half of the respondents (50%) were neutral about this statement, and this is neither a strong positive nor a negative statement. Additionally, as most of the participants were new to a networking subject as well as Second Life, it is clear that they were not sure about the difficulties to teach the content in this networking subject without a tool like SimuLab and most of them have chosen to be neutral.

The design principles employed to specifically support achievement of this factor of the model (based on the design principles described in section 2.12.2 and the manifestation of these principles in SimuLab listed in table 4.2) were: –

- Use authentic learning settings (Statement 10a, 10b and 10c refers to this design principle)
- Relate the learning activities to real life tasks (Statement 10d, 10e and 11b refer to this design principle)

The use of these design principles for incorporation of the factor 'Authenticity' in the design of SimuLab appears to have been successful according to the respondents. Most of the respondents believed that the online simulation used real life examples and the content of the online simulation was authentic, they were positive or neutral about the equipment in the online simulation being easier to use compared with real life and they stated this provided sufficient real life examples for SimuLab. Most of them were neutral about whether this simulation would be hard to be implement in real life.

4.2.2.4 Responses to Achievement on Online Simulation in Second Life.

There were five statements (statement 11a to 11e) in Set-B Questionnaire that were used to measure respondents' achievement while accessing SimuLab. Figure 4.12 shows the mean score for respondents' achievement while accessing SimuLab. In general, mean scores for all five statements showed positive agreement ($m > 3.0$).

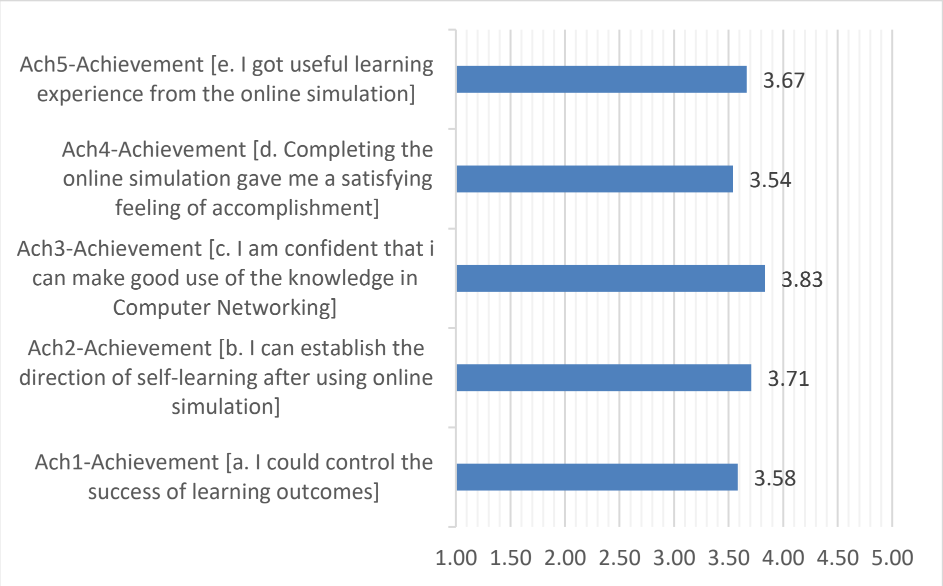


Figure 4.12. Mean scores for Achievement (statements 11a to 11e).

96.7% of respondents were either positive or neutral about these five statements (negative = 3.3%; neutral = 37.5%; positive = 59.2%). Statement (11c) and (11e) recorded the highest agreement (66.7%) among the five statements with statement (11a) and (11d) recording the lowest. It suggests that these participants were confident in using the networking knowledge learned in SimuLab and at the same time they believed the learning experience of using SimuLab was useful. These data imply that the participants were either neutral or positive about the design of SimuLab for the

‘Achievement’ factor.

The design principles used for this factor of the A4 model (based on the design principles described in section 2.12.2 and the manifestation of these principles in SimuLab listed in table 4.2) employed to support achievement of this factor of the 4A model being: -

- Incorporate feedback for achievement of goals (Statement 11c, 11d and 10e refer to this design principle)
- Incorporate feedback as support for learner activities (Statement 11a and 11b refer to this design principle)

These respondents supported this factor of the “4A motivational model” believing that the SimuLab had provided them with useful learning experiences. These data indicates that the design of “SimuLab” effectively implemented design principles drawn from the “Achievement” factor fulfilling students’ learning by providing adequate knowledge in Computer Networking.

The use of these design principles for incorporation of the factor ‘Achievement’ in the design of SimuLab appears to have been positive or neutral from the standpoint of the respondents. In general, most of them believed that they were confident that they can make good use of the knowledge in Computer Networking and established the direction of self-learning after using online simulation. Only half of the respondents believed that they could control the success of learning outcomes and felt accomplishment after completing the online simulation. Lastly, most of them agreed that they had a useful learning experience from the online simulation.

4.2.2.5 Responses to Appropriateness on Online Simulation in Second Life.

Lastly, there were five statements (statements 12a to 12e) that were used to measure appropriateness of SimuLab. Figure 4.13 shows the mean scores for respondents’ appropriateness while accessing SimuLab. In general, mean scores for all 5 statements showed positive agreement ($m > 3.0$).

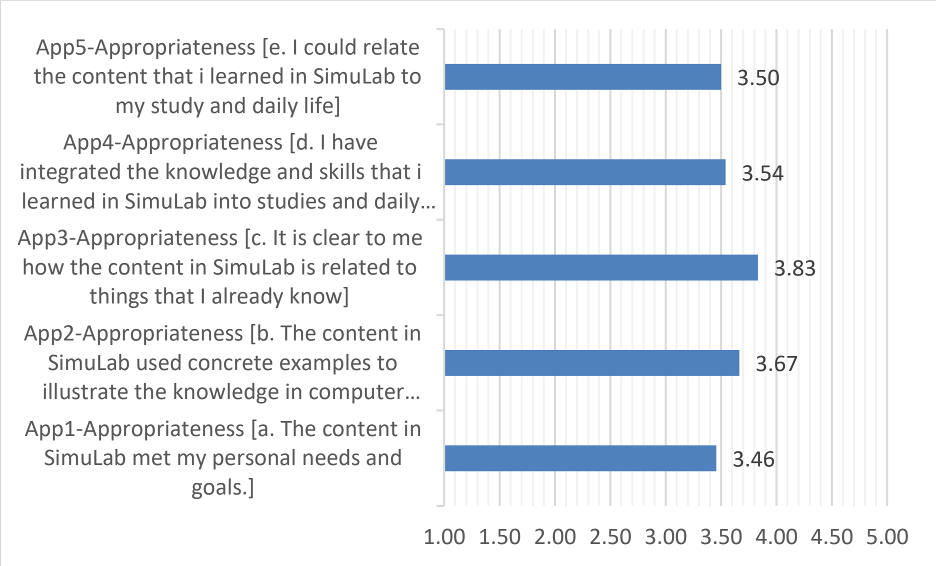


Figure 4.13. Mean scores for Appropriateness (statements 11a to 11e).

95% of respondents were either positive or neutral about these five statements (negative = 5%; neutral = 36.7%; positive = 58.3%). Statement (12c) recorded the highest agreement (75%) among the five statements. It suggests that these participants were clear that the content in SimuLab was related to their previous computer networking knowledge. Statement (12b) recorded the second highest with 66.7% of agreements. It suggests that these participants agreed that the content in SimuLab used concrete examples to illustrate the knowledge in computer networking.

The design principles used for this factor of the A4 model (based on the design principles described in section 2.12.2 and the manifestation of these principles in SimuLab listed in table 4.2) with the specific design principles employed to support appropriateness of this factor of the 4A model being: -

- Use content that is linked to users' needs and future goals (Statement 12a and 12c refer to this design principle)
- Incorporate levels of difficulty matched to users experience and skills (Statement 12d and 12e refer to this design principle)

The use of these design principles for incorporation of the 'Appropriateness' factor in the design of SimuLab appears to have been successful in that most of the respondents believed that they were clear that the content in SimuLab was related to things that they had known and their daily life and agreed that SimuLab used concrete examples. The respondents were also positive or neutral about the content in SimuLab meeting their personal goals and the knowledge and skills they learned could also be integrated into their daily life.

4.2.2.6 Summary.

In summary, the mean scores for all 20 statements were above average (more than 3.5/5) with 94% of responses either positive or neutral. The majority of participants stated that they had a good experience using SimuLab and gave either neutral or positive feedback when evaluating SimuLab. Besides, the results have shown that the users were happy with the researcher building the online simulation based on the design principles derived from the 4A's factors.

The differences in factor scores displayed in Table 2 are very small (between 0.01 and 0.14) with the factor that scored the lowest level of satisfaction being 'Authenticity'. The results indicate that the students felt either positive or neutral about the simulation even though most of them (92%) had no prior experience on using Second Life and they were unfamiliar with the features and navigation of Second Life.

4.2.3 Focus groups.

After this first implementation, the researcher invited 10 students to join a focus group discussion, however, only seven students turned up for the discussion; six of them were male students and one female student. These students were divided into two groups with 3 and 4 students in respective groups. The main reason for the researcher to conduct focus group discussion was to allow participants to propose additional ideas or features for SimuLab and to expand on their answers to the questionnaires. Table 3.2 lists the questions used with the focus groups to initiate discussion.

The data collected from focus groups was sent for transcription and after transcription, the researcher has categorized the responses according to the questions asked. With this, all responses have been categorized according to according to 4A Learning Motivational Model and the researcher was able to utilize the information collected from the focus group during development of the second iteration**.**

4.2.3.1 The "Attention" Factor.

Attention is an important component as the more the users engaged with the simulation, the greater the chances of achieving the learning outcomes of the simulation (Keller, 1987; Malone, 1981). There was one question asked and discussed in the focus groups that related to this factor. When asked about their experience in using the online simulation in Second Life, many of them had no experience in using Second Life and so carrying out tasks like walking the character, or changing the view to manipulating the objects in the simulation took time to master:

> *"It is pretty interesting, as when I enter it, I see a lot of people, a lot of movement around, when I enter the link, I was sent into a house, with a lot of videos and slides, but for me, I find is a bit difficult to move my character. I have no idea is that is my problem or others also faced the same problem." – Student 3*
>
> *"Simple, need to try to walk here and there, if you get missing, you need someone to guide you." – Student 6*

For these students, online simulation was a new way of learning and of sharing knowledge, and one student stated they were keen to use this in their learning:

> *"Online learning in this way is quite effective compare with the conventional way of learning, caused you can do it anywhere." – Student 2*

However, not all students felt the same. Some student thought that they were not a 'game person' and preferred the old traditional ways, indicating that they would prefer a more traditional approach to teaching. This supports the students' responses to statement 9e in the questionnaire where some students expressed some concern about moving to a non-traditional instructional strategy.

> *"I am not very much a game person, so it is hard for me to describe it, it is pretty difficult to move the avatar, sometimes it just lag, but it is on my opinion, the channel of medium using online simulation might not be suitable for me, I prefer the old fashion way." – Student 1*

When asked about if they found the content in SimuLab captured their interest, this question is referring to design principle 3 "Incorporate design elements that stimulate both sensory and cognitive curiosity", some students agreed that SimuLab captured their interest as they were allowed to "walk" around in the simulation and they experienced the 3D network equipment in SimuLab as well. One student claimed that he kept “playing” on the simulation part over and over again:

> *“For 1 part is yes, which is the simulation part, keep playing on that again and again.” – Student 6*

In general, most of the students had no previous experience in using online simulations in Second Life and some of them in the focus group stated that they struggled when they were using this platform for the first time. Some students spent a lot of their time in playing this simulation component. The data from focus group discussions shows that the students believed that SimuLab was designed and arranged appropriately where their attention had been captured when using SimuLab.

4.2.3.2 The “Authenticity” Factor.

Authenticity is another very important component that will keep users motivated when using the simulation. Online simulation should be designed as authentic as possible as it is important for users to “feel” the authentic setting in a simulation, which is similar to the real situation. When asked about if the online simulation in Second Life is authentic, two of the students thought that online simulation in Second Life was authentic as they were happy to see all the network equipment in 3D and they could also ‘touch’ the 3D objects in the online simulation such as routers, hubs and switches:

> *“Basically the equipment are in 3D, it looks more interesting, as if you are living in that world”. – Student 2*

The student noted the equipment could also be switched on and off which they were not normally allowed to do in an ordinary lab class, and so this was beneficial to them.

> *“More or less yes, cause from this we can touch it, in the normal lab, we cannot touch it, cannot on and off.” – Student 6*

In general, most of the students gave positive feedback for authenticity in SimuLab, even though they have concerns about their lack of experience in using online simulation in Second Life, but they stated that they found it fun to “play” while and learning new things at the same time. The questions related to “Authenticity” is referring to design principle 9 “Use authentic learning settings”.

4.2.3.3 The “Achievement” Factor.

Achievement is leading to self-confidence (Keller, 1987). Users need to have high self-confidence to be highly motivated when they are using and re-using the online simulation. When asked if they were confident to use what they learned from this lesson in the networking subject, all students responded with positive feedback in answering this question. This question is referring to design principle 5 “Incorporate feedback for achievement of goals”. One student felt that the learning in online simulation in SimuLab is more intuitive and engaging, also believing that this is a more effective way that helped in their studies:

> *“I think is a bit more intuitive, you will feel more engage with the lesson (interact), this will help me remember the notes a bit better. I think I will use it quite frequently, I think this it quite interesting, like we want it interesting and remember stuffs a lot better.” – Student 1*

Some commented that learning through online simulation is better compared to other LMS and this will benefit them in their final exam:

> *“I think we can learn better now compare to what we do now with Moodle or Blackboard.” – Student 5*

Two students felt that being anonymous and learning with others will not discriminate anyone in the online space and everyone here is equally respected and could voice their views.

> *“You can learn together with people that you do not know them, in college; we just learn with our friends, in this situation, we do not need to know the person.” – Student 3*

> *“Maybe this is also anonymous, so it is like you will not discriminate anyone here or see somebody differently, everyone will be respected for the opinion equally.” – Student 2*

When asked if they could confidently apply what they have learned in the online simulation, most of the students agreed that the online simulation in SimuLab helped in their learning, two students stated they liked the 3D models and videos in the online simulation and one student stated that they treated the online simulation as their "revision notes".

"… I would say somewhat related, it acts like a supplement together with the notes, like after we have finished studying all the notes, and we come to Second Life and have a look, refresh again, something like extra notes." – Student 2

Overall the students felt more engaged when they learnt through online simulation in Second Life compared to traditional methods using an LMS. They thought this would help them to remember their notes implying they believed they would learn more effectively. All students felt that what they had learnt from the online simulation and this new knowledge was related to their studies. Furthermore, this knowledge could be applied to their studies.

4.2.3.4 The "Appropriateness" Factor.

Appropriateness is to investigate whether the content of the simulation is appropriate or relevant to users' level and what they intend to study (Keller, 1987; Wlodowski 2003). When asked if the online simulation was presented in an appropriate way and relevant to their networking subjects, all 7 students felt that the simulation was presented in an appropriate way and relevant to their subject. Furthermore, one student commented that he could easily identify which content in SimuLab belonged to which topic:

"It is sort of appropriate, maybe the chapters there are organized properly, and you will sort of knowing which topics are on which." – Student 2

The questions asked here are referring to the design principles 12 "incorporate levels of difficulty matched to users experience and skills".

In summary, all students agreed that the online simulation was presented in an appropriate way and at the same time, the content presented in the online simulation was relevant to their subject.

4.2.3.5 Other Factors.

Apart from the 4A motivational factors, students felt that they could access the online simulation anytime, anywhere, and they could explore the simulation and also read through the slides. However, two students stated their concern about the navigation in Second Life, as most of them have not used it before. With that all students expressed a wish to have an introductory class for them to learn more about Second Life. Some students wished to have more content and models in Second Life, particularly for the simulation part. One student requested inclusion of quizzes where they can test their knowledge after they complete the simulation. This student also suggested the quizzes should come with a leader board that shows the list of highest scores as well:

> "Should add in quizzes like after we finished the simulation, this can test our knowledge, and then we can challenge our friend by putting a leader board for our scores…" – *Student 3*

When asked about other general comments about online simulation, a student from the focus group commented that he felt that online simulations are very much applicable to undergraduate students:

> *"I find it quite applicable for degree students. This is not something new but it showed us this is like something happens around us and encouraged us to try out on this. In future, try to develop something like this." – Student 1*

In summary, students wished to have more content and models in SimuLab, and one student requested the inclusion quizzes with a leader board.

4.2.3.6 Summary of Qualitative Data.

The qualitative data described above supports the quantitative findings and helps to clarify some of the detailed participant responses in the surveys. This data reinforces the previously reported survey findings in that Second Life was new to most of the students in the class and almost all students had no experience in using Second Life. However, all students in the focus group felt positive towards using the online simulation SimuLab for their study of this subject. All students agreed that the online simulation was presented in an appropriate way and the content presented in the online simulation was relevant to their subject.

Furthermore, the majority of students felt positive about their experience with the online simulation in Second Life and positive compared to traditional methods. The major difference between the two sets of data was the additional discussion about what else the students would like to see in SimuLab. This gave some clear insights for the researcher about potential redesign issues for SimuLab.

4.3 Design implications for Second Implementation

Based on the questionnaires and focus group discussion, the researcher concluded that Second Life was new to most of the students in the class, the students had no experience in using Second Life and it took them quite some time to master. Furthermore, two students from the focus group claimed that Second Life was not easy to operate, especially for students who have never or seldom played games, or used simulations, and suggested having an introductory class for students to learn to use Second Life. With this, the researcher designed an introductory session with students on using Second Life with the researcher showing the students how Second Life works including the interface and controls. Additionally, Facebook support was also extended for students to interact with and support each other.

Some of the students also thought that the online simulation should include more content. The feedback from the users encouraged the researcher to incorporate more authentic content within SimuLab where the users can spend more time. The researcher also strengthened the implementation of the design principles “use authentic settings (principle 9)” and “Incorporate levels of difficulty matched to users experience and skills (principle 12) when putting in more authentic tasks that are suitable for this group of users. The researcher implemented this intention by including an additional corner for simulation, which would cover the network topologies, the ring, the bus and the star topologies. Students were happy to see all the network equipment in 3D and to be able to ‘touch’ the 3D objects in the online simulation.

Furthermore, the researcher decided to rearrange the routers, hubs and switches at the exhibition corner to make it more accessible and add notes (in notecard format) for the items that they click on. These notes can be kept in the Second Life inventory for future revision. These suggestions were related to the design principle 1 which is “Use extensive interactivity” in the simulation lab in Second Life. It is anticipated that these additions will improve the users’ attention when dealing with online simulation.

Some students requested the inclusion of quizzes in SimuLab. They claimed that quizzes could help to test their knowledge after they had completed the simulation. Furthermore, they suggested having a leader board for the quizzes. This is referring to design principle

"Incorporate feedback for achievement of goals (principle 5)" which is related to the 4A factor "Achievement". With this, the researcher has included a quiz that consists of 20 multiple choice questions to test student's networking knowledge and after completing the quiz, students will receive the scores for the quiz and the top 10 highest scores will be listed in a leader board. This should further increase the student feeling of accomplishment after completing the online simulation (Keller, 1987; Keller, 2009; Wyss et al., 2014). These suggestions were related to the design principle 5,that draws from the 4A Motivational Model, where the level of confidence on using the online simulation can be improved through achieving the objectives in using online simulation (Keller, 1987; Keller, 2009; Wyss et al., 2014).

4.4 Redesign for Iteration 2

The online simulation laboratory (SimuLab) was redesigned in Iteration 2, with similar and additional course content to iteration 1. The course content for SimuLab in iteration 2 was modified as follow:

- Definition of computer networks.
- Peer-to-Peer Networks (P2P)
- Client/ Server Networks
- OSI Model - 7 layers
- NETWORKING HARDWARE – Hub, switches, and routers
- LAN (Local Area Network)
- MAN (Metropolitan Area Network)
- WAN (Wide Area Network)
- Network Topologies

Figure 4.14 shows the view from outside of the Simulation Lab, with the sign of SimuLab Logo and also the 2-level floor plan for SimuLab. The main reason for putting up a floor plan at the entrance is based on student feedback from iteration 1 indicating that they were not sure what was inside SimuLab. This implementation is referring to design principle "Incorporate attractive visual design (principle 4)". The new floor plan at the entrance of SimuLab will let the students know the arrangement of the virtual environment and the activities they could find in the 2-storey virtual building. The ground floor of the building is used for memory retrieval purposes where the researcher has showcased all lecture slides related to the above topics. This floor remains the same as iteration 1. Students are able to read and download the PowerPoint slides and watch the two YouTube videos.

Figure 4.14. View from outside of the SimuLab, with SimuLab Logo & floor plan.

On the first floor of the building, the researcher has redesigned the exhibition corner for iteration 2. The new setup of exhibition corner has the same equipment as iteration 1 but the equipment has been arranged in the new cabinet as shown in Figure 4.15. Beside the cabinet, there are 2 high-resolution server racks. Like iteration 1, students can click on all the equipment and zoom in to have a closer. Besides that, they will now obtain a notecard for the equipment that they click on. This new arrangement is referring to design principle "Use extensive interactivity (principle 1)" and "Capture the learner's attention and maintain it throughout the learner experience (principle 2)". Notecard is a "card" in Second Life that contains "text information" related to the equipment. Notecards can be stored in students Second Life inventory's notecards folder. Notecards that are stored in the students' inventory can always be revisited when needed for the purpose of revision. This new "notecard" concept of storing information is referring to design principle "Incorporate design elements that stimulate both sensory and cognitive curiosity (principle 3)".

Figure 4.15. Exhibition corner for iteration 2.

The simulation corner on this floor is shown in Figure 4.16. In iteration 2, students have additional simulation activities compare to iteration 1. The additional simulation activities are referring to design principle “Use extensive interactivity (principle 1)”, “Capture the learner’s attention and maintain it throughout the learner experience (principle 2)” and “Use authentic learning settings (principle 9)”. Like iteration 1, students are able to select the type of network they wish to interact with by clicking on the first simulation board. The new simulation allows students to view what topologies look like physically. There are 3 different setups for the new simulation, the bus, the ring and the star topologies. Just like iteration 1, students have to click on the second simulation board to select their preferred topology. They are able to select the type of network topology they are interested in from the pop-up menu and the network will appear on the big table beside the board. With this new setup, students can interact with the switches, cables and nodes on all topologies. The simulation shows and explains the consequences of turning on a node/switch or broken cables. On top of that, a short description on each topology is displayed on the wall when they are selected.

Figure 4.16. First floor view on Simulation Lab (with 2 sets of simulation).

There is a new corner for SimuLab in iteration 2, the quiz corner as shown in Figure 4.17, which allows students to test their networking knowledge. Students will have to complete the quiz within a given time and they will receive their scores for the quiz towards the end. The new implementation of "quiz corner" is referring to design principle "Incorporate feedback for achievement of goals (principle 5)" which is related to the 4A factors "Achievement". The quiz has 20 multiple-choice questions. 1 question will be shown at a time as in Figure 4.17 and only 1 student can attempt the quiz at a time and each student will only have 1 attempt for the quiz. To start the quiz, students have to click on the quiz machine as shown in Figure 4.18 and the quiz will start if this is the first attempt for the student. If the student has attempted the quiz before, they will receive a message not allowing them to retake the quiz. The top 10 high scores will be shown on the leader board beside the quiz machine.

Figure 4.17. Quiz corner on SimuLab first floor (with quiz question on menu screen).

Figure 4.18. The quiz machine on Simulation Lab first floor.

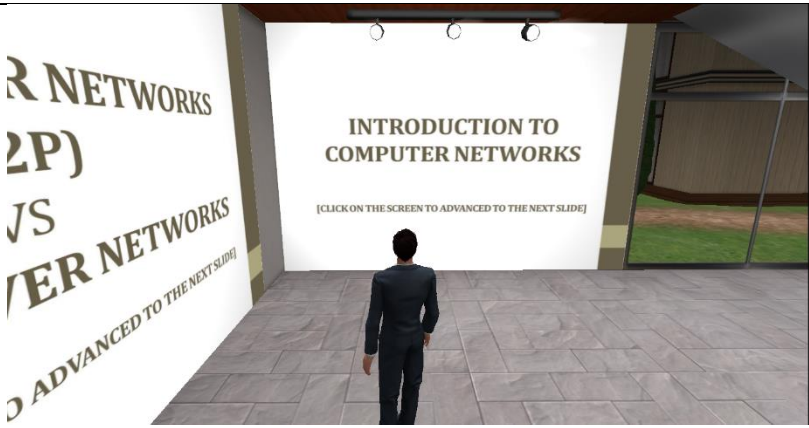
4.5 Conclusion

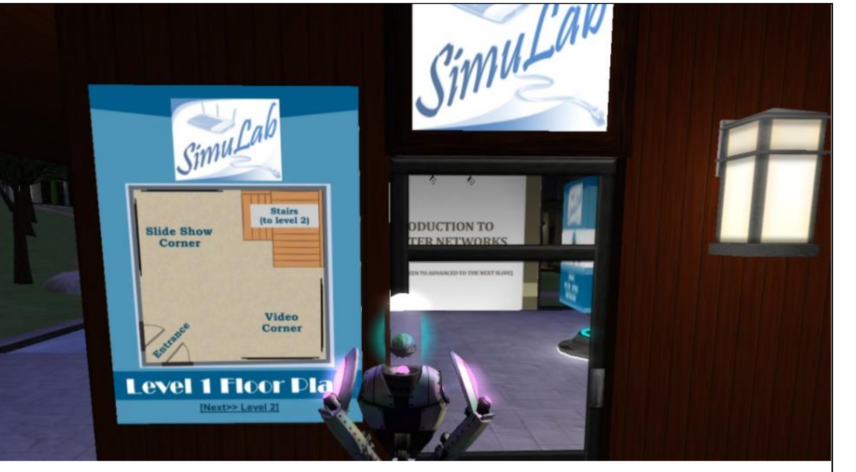
In conclusion, most students had no experience in using Second Life. However, all students in the focus groups felt positive towards using online simulations in SimuLab for their study. Furthermore, all students agreed that the online simulation was presented in an appropriate way and the content presented in the online simulation was relevant to their subject.

As for the questionnaires, most of the users believed that they had a good experience when using SimuLab and gave positive feedback when evaluating SimuLab. Most of them also believed that the content in SimuLab was related to their previous knowledge and to their daily life. The content in SimuLab used concrete examples to illustrate the knowledge in computer networking, and the students agreed that the content in SimuLab met their personal needs and goals. Furthermore, they enjoyed using online simulations for their learning more than face-to-face instruction due to the fact that the online simulation used real life examples, the equipment in online simulation was easier to use compared with real life, and the content of the online simulation was authentic and provided sufficient real life examples. Lastly, the users were confident that the knowledge in Computer Networking was useful to them. They established the direction of self-learning after using online simulation and controlled the success of learning outcome. They also felt accomplishment after completing the online simulation and agreed that they had useful learning experiences from the online simulation. The results have shown that the users were positive about their use of the online simulation based on the 4A's factors and design principles especially the 3D models that provide an authentic learning setting and the simulations that promote interactivity. These results support the argument that the design principles developed for each of the 4A factors (section 2.12.2) were appropriate and effectively implemented.

The redesign of Iteration 2 looked at this process through the lens of all of the design principles summarized in section 2.12 with an emphasis on those drawn from the 4A's Motivational Model. The redesign involved adding in extra simulations in the simulation corner and rearranging the exhibition corner for better accessibility. Section 4.7 shows the design changes between Iteration 1 and 2 with justification for each design change.

4.6 Iteration 1 vs. Iteration 2

Ground Floor				
Element	**Redesign**	**Justification**	**Design Principle**	**Screenshots**
Slides/Notes	No change	Slides in SimuLab allow students to go through the entire chapter in Second Life and also to download the slides for future readings.	3. Incorporate design elements that stimulate both sensory and cognitive curiosity 7. Make effective use of a variety of media	
Video	No change	Videos in SimuLab serve as information sharing, student can watch video in Second Life, students will be able to obtain the links for the videos and watch these videos in YouTube as well.	3. Incorporate design elements that stimulate both sensory and cognitive curiosity 7. Make effective use of a variety of media	

Floor plan	Added in for 2nd iteration	Students claimed that they get lost easily and not sure what was inside the SimuLab in first iteration. Floor plan in iteration 2 will show them the floor plan for SimuLab and have an overview on what they can see/get in this 2-storey virtual building.	3. Incorporate design elements that stimulate both sensory and cognitive curiosity 4. Incorporate attractive visual design	

First Floor				
Element	**Redesign**	**Justification**	**Design Principle**	**Screenshots**
Simulation part 1	Added in extra text for students to read while trying out the simulation.	Students not only able to try/play with the simulation, they will be able to receive take away texts explanation in the chat box. The texts are very detailed explaining on why such equipment is used in the network environment, advantages and also disadvantages of certain equipment.	1.Use extensive interactivity 8. Facilitate user interaction with content and other users 9. Use authentic learning settings 10. Relate the learning activities to real life tasks	

Simulation part 2	The whole new simulation that focuses on network topologies, Bus, Star and Ring topologies.	The new simulation allows students to view how topologies look like physically, they can play around with the switches and nodes on all topologies. The simulation will show and explain the consequences of turning on a node/switch. On top of that, a short description on each topology will be displayed on the wall.	1.Use extensive interactivity 8. Facilitate user interaction with content and other users 9. Use authentic learning settings 10. Relate the learning activities to real life tasks	

Exhibition corner	The exhibition corner has been given a new "look", putting in new cabinet to show the network equipment, i.e. switches, routers and hubs alongside server racks.	This setting allows students to have a closer view on the network equipment, at the same time; students will obtain notecard by clicking on the equipment. Notecard is a "card" in Second Life that containing "text" related to the equipment, notecard can be stored in students Second Life inventory's notecards folder. Notecards that stored in the students' inventory can always be revisited when needed.	1.Use extensive interactivity 2. Capture the learner's attention and maintain it throughout the learner experience 9. Use authentic learning settings	

Quiz Corner	The quiz corner to test student understanding on the chapter.	The quiz corner allows students to test their networking knowledge, students have to complete the quiz within given time and only 1 attempt allowed. The top 10 high scores will be shown on the leader board as well.	5. Incorporate feedback for achievement of goals	

Chapter 5

Iteration 2 Implementation and Outcomes

This chapter addresses the second iteration of the online simulation laboratory (SimuLab) in Second Life with improvements based on feedback given by students who participated in iteration 1. The chapter reports on an analysis of the collected data for Iteration 2 from the quantitative surveys (pre and post-questionnaire) and focus group data conducted with a second group of undergraduate students taking introduction to networking subjects. A comparison of the learner perception of their experience with iteration 1 students is then reported as well as a comparison of learning outcomes with student groups who studied this subject pre incorporation of the simulation**.**

5.1 Data Analysis

5.1.1 Quantitative Data.

In quantitative analysis, the data was analysed using the same method used in Iteration 1 (Section 4.3.1). Descriptive statistics are used mainly to define the collected data and they provide the overview about the samples collected (Trochim & William, 2006). Additionally, Independent sample tests were used to statistically test and compare the two different groups of data from Iteration 1 and 2.

5.1.2 The Pre-Questionnaires (Set A and Set B).

In the second iteration, similar to the first, there were two questionnaires used. All participants completed the pre-questionnaire a week prior to the opening of the online simulation. SimuLab was then opened for participants to use with a closing date listed for students one month later. The post-questionnaire was then completed one week after the online simulation was finished.

5.1.2.1 Respondents Demographic Details.

Figure 5.1 shows that the majority of respondents were aged 19-20 and there were 40 male (80%) and 10 (20%) female participants. The limited representation of female students in an information degree is expected in Malaysia as they are traditionally underrepresented. Also, there were a majority of Malaysian participants and only 14 % from other countries. This is representative of the typical ratio of international students for private institutions in this part of Malaysian. As the students invited to participate in the study were generally studying first-year subjects, all respondents in Iteration 2 were from three-year technical degree programs. The majority of the participants (78%) reported specializing in Computer Science and only 11 participants were from Information Technology/Information Systems programs. However, the majority were early in their degree, with about half of the respondents whom participated in the questionnaire having less than one year of study experience in college/university while another 22 respondents had 1-2 years of study experience in college/university.

The demographic data is very similar to Iteration 1 in terms of age, nationality, gender and program they studied (see figure 4.6 for a comparison). There were 38 respondents for the pre-questionnaire in iteration 1 and 50 respondents for iteration 2. There were 21% of female respondents in iteration 1 and 20% in iteration 2. 84% of respondents were from Malaysia in iteration 1, this ratio is very close to the nationality ratio in iteration 2 which is 86%. In iteration 1, 82% of participants came from Computer Science courses, which was very close with 78% from iteration 2 and seven (18%) in Information Technology/Information Systems. However, there was a minority of respondents with 3 to 5 years of study experience and all respondents from Iteration 2 were from a degree program unlike in Iteration 1 where 24% of respondents were from diploma programs. This is not unexpected as classes invited to participate in the study were generally first year subjects.

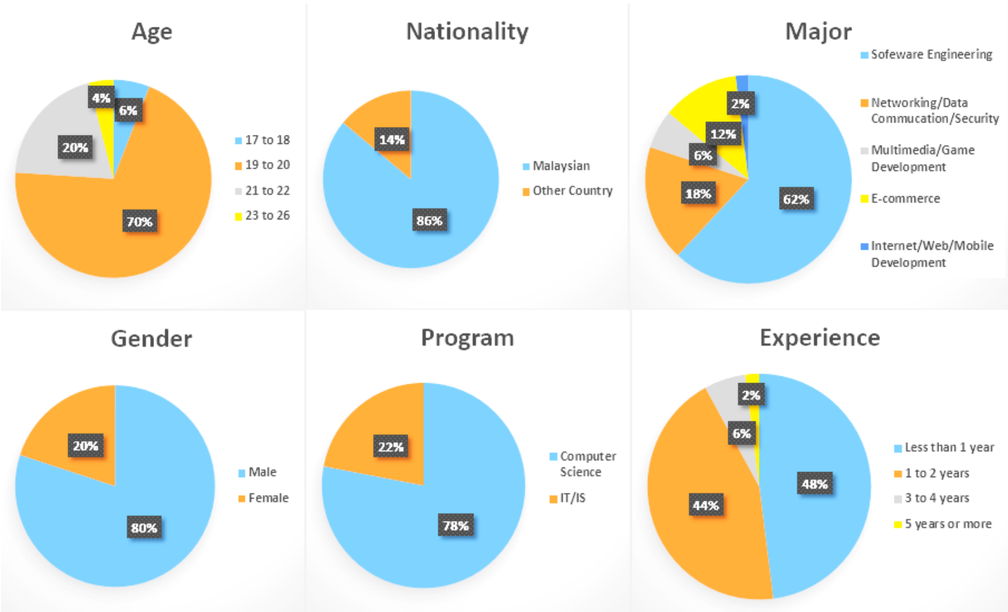


Figure 5.1. Demographic details.

5.1.2.2 Respondents Prior Experience with Technologies.

All 50 respondents owned smartphones and 49 respondents owned a laptop. Twenty-three of them owned a Desktop at home and 15 respondents owned a tablet. Figure 5.2a shows the hours that students reported they spent playing computer games in a week (see figure 5.2b for iteration 1). Almost half of the respondents played computer games for more than 4 hours a week. From the 50 respondents, only six respondents (12%) had not played computer games before and the majority of them (88%) had at least played a computer game. Unlike iteration 1, a higher percentage of respondents in iteration 2 had not played computer games before (double the number as compared to iteration 1). Before the first iteration, it was assumed that the majority of respondents would be likely to have some knowledge of Second Life, which has similar characteristics as 3D computer games although this was not the case with the first cohort and it proves to also not be the case for the respondents in the second iteration. From the significant differences in experience in using games between iteration 1 and 2 it might be assumed that iteration 2 students would be more comfortable with using complex environments like MUVEs because of their games experience. This will be taken up later in the series when reporting on barriers to use of SimuLab.

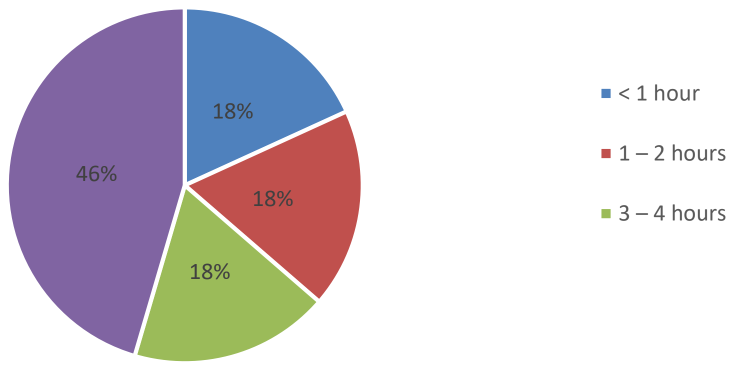


Figure 5.2a. Hours spent in playing computer games - iteration 2.

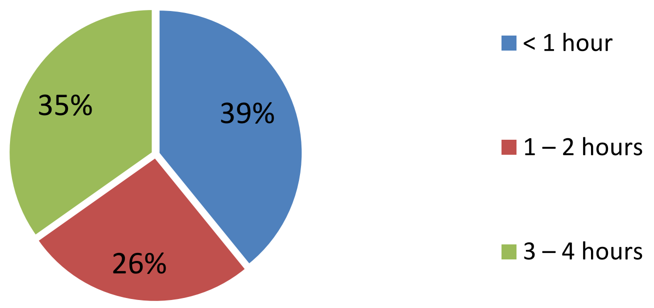


Figure 5.2b. Hours spent in playing computer games - iteration 1.

Figure 5.3 shows that 44 respondents perceived barriers to computer game play, 63.6% of respondents were concerned about the time spent for playing computer games might interfere with their personal time which they could use for other purposes. Half of the respondents that faced this problem were those playing more than three hours of games per week. Twenty-seven respondents (61.4%) were concerned about limited hardware or Internet bandwidth availability and more than 62% of the respondents that faced this problem were those play more than three hours of games per week. The students reported the reasons were that computer hardware and Internet bandwidth requirements for computer games (specifically for online games) are much higher than normal computer applications. The third barrier perceived by respondents was the complicated functionalities and features of computer games, which saw nine respondents, voice their concern about this. The complication of games is different from game to game. Online multiplayer games are usually more complicated than mobile games and offline standalone games.

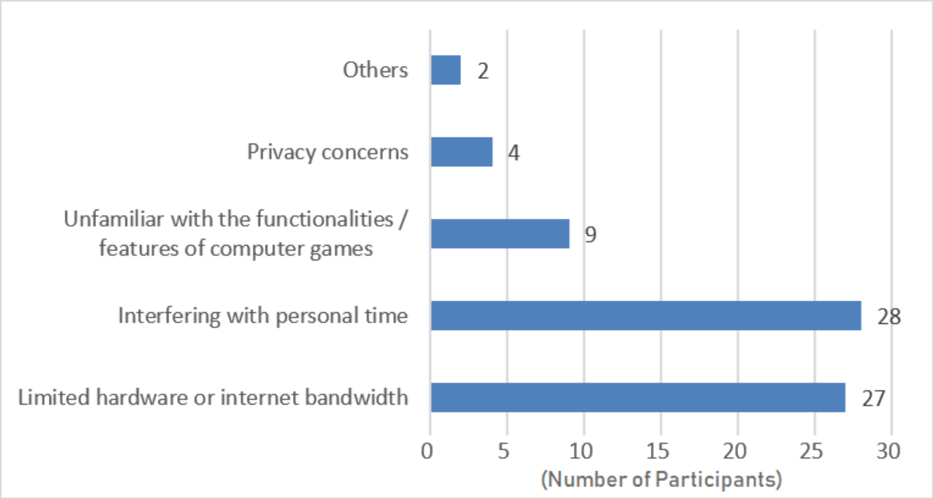


Figure 5.3. Barriers of Playing Computer Games.

Forty-two respondents (95.5%) said that playing games was interesting and believed that games can surely be used for academic purposes (*n* = 27, 61.4%) while the rest of them felt that games might be useful for academic purposes (*n* = 17, 38.6%). In comparison for iteration 1, all respondents reported that playing games was interesting (100%) and more than half felt computer games could be useful for academic purposes (*n* = 18, 51.4%). None of the participants felt games could not be used for academic purposes.

From the above statistics, it can be considered that both iteration 1 and 2 respondents felt positively towards using games for academic purposes, with almost identical results for both iterations. It could be expected that the respondents would also feel positive toward using Second Life for academic purposes.

5.1.2.3 Respondents Prior Experience of Using Simulation.

From the group of 50 respondents, only 19 respondents (38%) had used online simulations or had played online simulation games. Fifteen respondents had used/played online simulations for less than an hour per week, two respondents (10.5%) used/played for 1 to 2 hours and more than 4 hours per week respectively. This result shows that online simulations or online simulation games are not commonly used among these respondents. Figure 5.4 below shows that 11 (57.9%) participants believed the main barrier they faced while playing online simulation was the unfamiliar function and features of the online simulation. With that, the familiarity of these respondents towards online simulation was very limited. Ten participants worried that they had to spend a long time just to learn how to use the online simulation program and get familiar with the program. Eight participants faced difficulties with limited hardware and internet bandwidth, seven respondents were concerned about how easily they were distracted and lost focus in online simulations and only one respondent had other concerns than those discussed above.

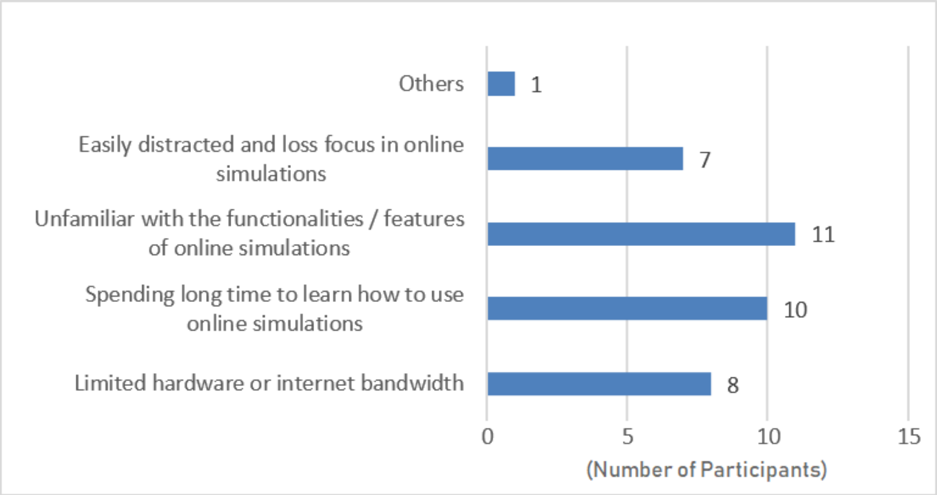


Figure 5.4. Barriers of Playing Online Simulation.

Twelve out of 19 respondents agreed that online simulation was interesting (n = 12, 63.2%) and 18 of them believed that online simulation might be useful or surely can be used for academic purposes (n = 18, 94.7%). Only one respondent (5.3%) did not agree that online simulation could be useful for academic purposes. In comparison for iteration 1, only one respondent (6%) did not agree that online simulation could be useful for academic purposes, the other 16 respondents (94%) agreed that online simulation could be useful for academic purposes. Again, from the above statistics, it could be expected that the respondents would also feel positive toward using Second Life for academic purposes.

5.1.2.4 Respondents Prior Experience in Using Second Life (SL).

Out of 50 respondents, only four (8%) of them had used Second Life prior to this project. These respondents had spent less than 1 hour a week with Second Life. Three respondents (75%) considered themselves beginner level and only one respondent considered themselves as intermediate level in using Second Life. From the four respondents that had used Second Life, all of them rarely use Second Life for entertainment. Two of them had never used Second Life as a platform to communicate/socialize /network with friends, one of them often used it for this purpose and another one rarely used Second Life as a platform to communicate/socialize or network with friends. Two respondents had also never used Second Life to share skills or experience and seek opinions; another two respondents had rarely used Second Life to do so. Lastly, only one out of three of these participants rarely used Second Life as a platform for academic purposes and also to collaborate with others.

Figure 5.5 shows that the main barrier that three out of four participants, who were previous users, faced was they were unfamiliar with the function and features in Second Life. Two participants were concerned about limited hardware and Internet bandwidth, interference with their personal time, privacy and spending a long time in learning to use Second Life. Only one participant worried that they could be easily distracted and lose focus in Second Life and also felt that they were being watched or stalked by others. All four respondents agreed that it might be useful to use Second Life for academic purposes and they might participate and contribute to the learning communities. The above statistics were very similar to Iteration 1 and it suggests that there was very little familiarity, in the sample, of Second Life as were the respondents in iteration 1. When considered in the light of limited experience using simulations, this suggests using simulations in Second Life would be a new experience for the vast majority (92%) of the students.

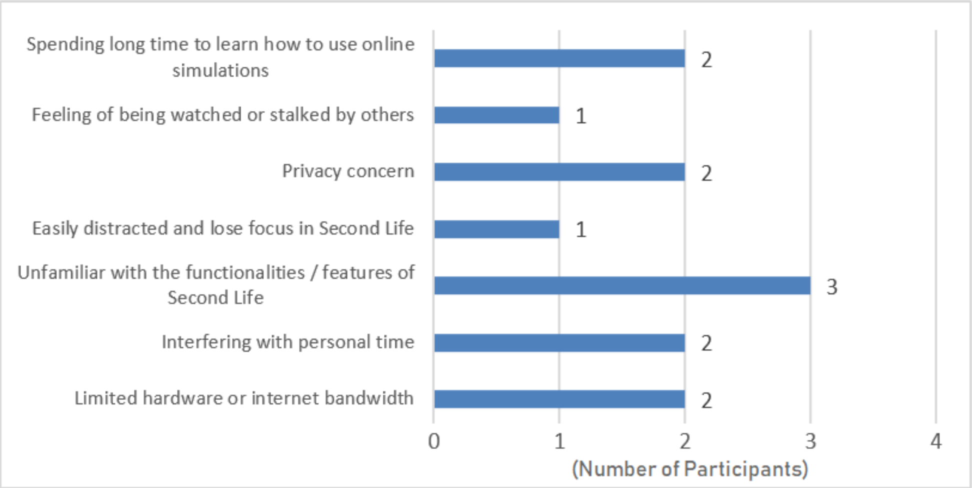


Figure 5.5. Barriers of using Second Life.

There were 46 respondents (92%) whom had never used Second Life prior to the survey. Figure 5.6 shows that 76% of these respondents had never heard of Second Life prior to the survey, six respondents (13%) claimed that they had no interest in Second Life and two respondents (5%) were not sure how to use Second Life. One respondent (2%) felt that using Second Life was a waste of their time, another respondent was concerned about the privacy when using Second Life while another respondent had other reasons for not using Second Life. In comparison for iteration 1, 35 respondents (92%) had never used Second Life, the percentage is the same in iteration 2, out of the 35 respondents, there were 24 (69%) of the respondents who had never heard of Second Life. This result suggests that, while students had little experience using Second Life.

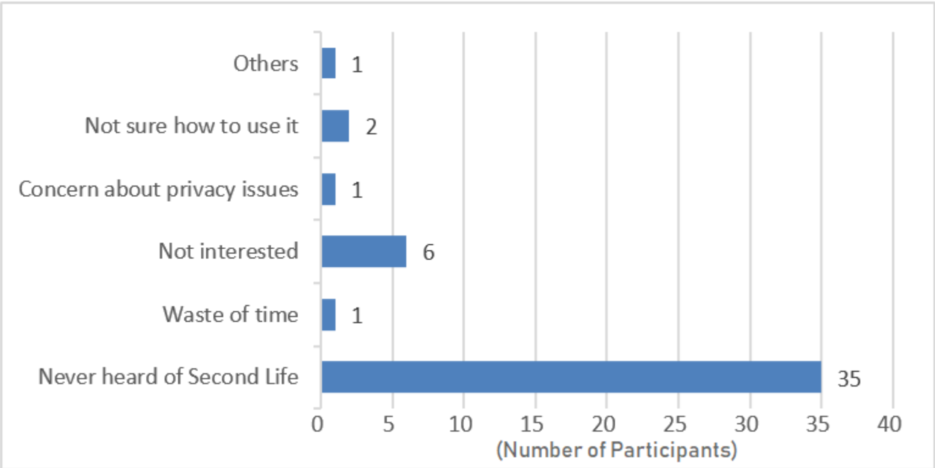


Figure 5.6. Reasons for not using Second Life.

Only two (4%) out of 46 respondents stated that they would not consider using Second Life in the near future. Close to 70% (32 respondents) said they may give Second Life a try in future and the other 12 (26%) respondents said they would surely use Second Life if given a chance. From the above statistics, the researcher can conclude that 44 (96%) respondents were keen to use Second Life if given a chance, which is very much the same as the results in iteration 1 where (97%) respondents were keen to use Second Life if given a chance. In comparison for iteration 1, only one respondent (4%) reported they would not consider using it in the near future, the rest of the respondents (96%) might or would use Second Life in future. The results from both iterations suggest that, while students had little experience using Second Life, reported they would be willing to use it for academic purposes in future and this view was consistent over the two iterations with two separate student cohorts.

5.1.2.5 Summary for the Pre-questionnaires (Set A).

Participants in this study were mostly Malaysian citizens, in their first year of study of a computer technology degree with a majority of males and mostly in the age bracket of nineteen to twenty-two years, which was almost identical to Iteration 1. While the majority of respondents were familiar with computer games, they reported limited knowledge of Second Life. Only four out of 50 participants had previously used Second Life and the amount of time they needed to invest in learning how to use Second Life. Therefore, it is not surprising that participants reported that the major barriers to use of Second Life in a learning context would be the lack of familiarity with the features of Second Life and lack of experience. Given their limited knowledge, the need to invest time to become effective users of Second Life in learning may not have been fully anticipated in the design of the first iteration of SimuLab. However the researcher did attempt to address this concern in the second iteration.

The majority of participants owned laptops and/or smartphones. These devices are not the ideal hardware for using Second Life, compared to a more powerful desktop computer. Of the 88 participants in both iteration 1 and 2, only 33 owned a desktop computer. In addition to having limited knowledge of Second Life it is likely engaging in the online simulation would have presented some difficult with the limitations of their personal devices and this is born out through their stated concerns about the limits of their own personal hardware being a barrier to use of Second Life.

In this Iteration, to support the concerns of students from iteration one about the overheads in the initial use of Second Life and to more effectively implement the second key design principle for Virtual Environments, which is to incorporate learner support for users, with an emphasis on new users. The researcher conducted additional briefing sessions for students to improve familiarity with the features of Second Life as well as guidelines for use. All students were encouraged to attend the briefing session that lasted for more than one hour before they started using Second Life to access SimuLab. During the briefing sessions, students were excited to see the Second Life interfaces and the extensive content embedded in Second Life. Many of the students were asked question related to accessing Second Life including the controls, installation and hardware requirements. After the briefing sessions, the students were urged to continue practicing in accessing the inbuilt tutorials in Second Life, an overview of the interface and key features as well as demonstrations of the interface.

Students who participated in iteration 2 still ranked highly unfamiliarity and time needed to learn how to use Second Life as barriers to use of this tool, However the second key design principle for Virtual Environments (to incorporate learner support for users) had been strengthened. Their concerns are still surprising considering that these students (born after 1990) are more likely to embrace the use of the new technologies (Waycott et al., 2010). As suggested by Margaryan et al. (2011), the 'digital natives' and engineering students use more tools in formal and informal learning and for socializing purpose. These students who participated in this research were equipped with personal computers, the Internet and other modern technologies. Furthermore, these students were studying IT and had extensive experience in using games and IT systems for all sorts of applications.

However, Bennett et al (2008) and Kennedy et al. (2008) have shown that the common assumption that modern tertiary students, or the 'Net Generation' are extremely digitally literate is not an accurate view of students entering tertiary programs and that students technology skills are diverse and significant skills in one area of technology do not necessarily translate to other technologies (Kennedy et al, 2008). The assumption that IT students are going to be highly skilled in the use of any IT technology appears to also be an issue. Studies such as those by Lim (2017) have found that Malaysian students across all discipline studies have very similar technology ownership levels and similar use of the Internet and technology tools. So the initial assumptions about the participants outlined in Chapter 2 about their technology literacy could very well have been a little optimistic. A further consideration here is that the survey did not ask the students to quantify how much the stated barriers impeded their use of Second Life, only to describe what they saw as barriers to the use of the application, so concerns about the usability and student support may not be as significant as is being argued here, but their advice about what concerned them.

In Summary, the majority of students were familiar with and users of computer games and to a lesser extent, online simulation. They saw a number of barriers to effective use of online simulations, including equipment and Internet access, but still reported extensive use of online computer games that have the same technology demands, indicating that, despite these perceived barriers to use, they are willing to accept these limitations. The majority of participants expressed a view that online simulations could be effectively used for academic purposes and despite their lack of familiarity with Second Life; they were willing to use it to support their learning. Provided their hardware was adequate and support for their use of the learning environment was in place, the students were confident in using SimuLab to support their learning in the first year networking subject.

5.1.3 Post-questionnaire (Set B).

The same questionnaire (set B) as used in Iteration 1 was used in this iteration. There were also a total of 29 questions in this questionnaire. There were 8 questions that related to the participants' demographic details, and the other 20 questions were related to the researcher's motivational model, 5 questions for each factor, attention, authenticity, achievement and appropriateness. Lastly, a general question was asked about participant's opinions on using SimuLab to end the Set B questionnaire.

5.1.3.1 The Four Factors.

As in iteration 1, the motivational model questions were expected to reflect the student's experience with SimuLab, and, from these students' reflections, the research proposed to draw some conclusions about the effectiveness of implementing of the design principles for SimuLab. Table 5.1 shows the mean scores for all four factors, attention, authenticity, achievement and appropriateness. The mean scores for all factors was positive ($m > 3.0$), reflecting general agreement on the effectiveness of the simulation implementation (SimuLab) in Second Life.

Table 5.1

Mean scores for 4A Factors (Iteration 2)

	Attention (Factor)	Authenticity (Factor)	Achievement (Factor)	Appropriateness (Factor)
Mean	3.34	3.42	3.38	3.40
N	38	38	38	38
SD	.61	.57	.67	.70

******Strongly disagree = 1, Disagree = 2, Neutral = 3, Agree = 4 and Strongly agree = 5*

5.1.3.2 Respondents Attention on Online Simulation in Second Life.

There were five statements (statement 9a to 9e) in Set-B Questionnaire that were used to measure respondents' attention while accessing SimuLab. Figure 5.7 shows the mean score for respondents' attention while accessing SimuLab. This was very similar to iteration 1 with mean scores for all five statements showed positive agreement (m > 3.0).

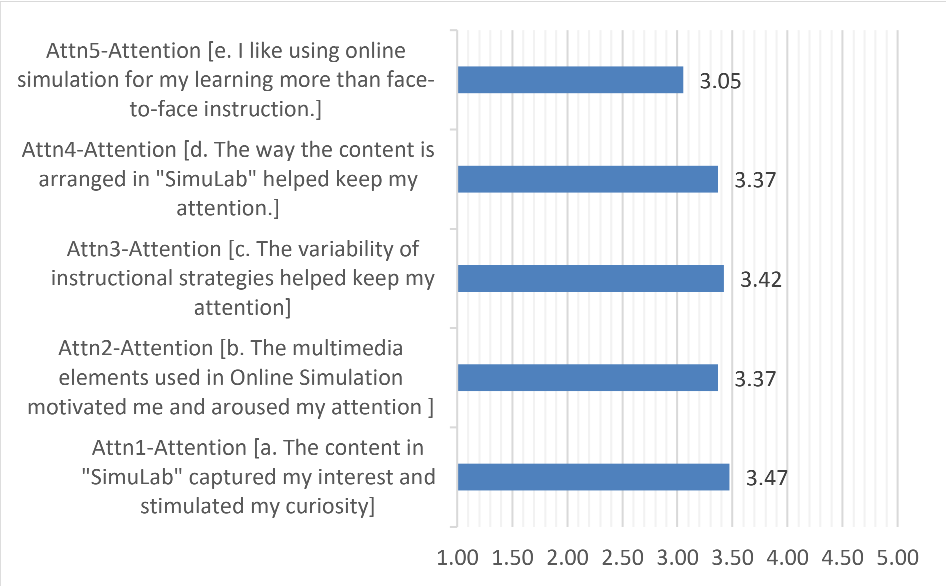


Figure 5.7. Mean scores for Attention (question 9a to 9e).

Figure 5.8 shows that 86.3% of respondents were either positive or neutral about these five statements (negative = 13.7%; neutral = 43.7%; positive = 42.6%). Statement (9a) recorded the highest agreement among the five statements, with statement (9e) the lowest. This data suggests that the participants were satisfied with the content used and content arrangement in SimuLab, the variability of instructional strategies and the use of multimedia elements that helped to keep their attention.

Similar to iteration 1, these participants did not report negative feelings about SimuLab, their level of interest or their attention.

The design principles used for this factor of the 4A model (based on the design principles described in section 2.12.2) and the manifestation of these principles in SimuLab listed in table 4.2 were: -

- Capture the learner's attention and maintain it throughout the learner experience (Statement 9c and 9d are referring to this design principle)
- Incorporate design elements that stimulate both sensory and cognitive curiosity (Statement 9a and 9b refers to this design principle)

The use of these design principles for incorporation of the factor 'Attention' in the design of SimuLab also appears to have been successful in iteration 2. Generally, most of the participants (86.8%) agreed or were neutral that the right instructional strategies were applied, which helped in keeping their attention. It appears that the students, despite giving quite positive responses for all of the other questions about 'Attention', were not entirely ready to accept that the use of simulations such as SimuLab in subjects, was more effective that face-to-face teaching. This item had the lowest number in agreement (26.3%) with more than half of the respondents (52.6%) being neutral about this statement. As most of them used Second Life for the first time, it is possible that the respondents were concerned about using the new platform and their experience was that this type of learning required more commitment to learning and investigating the content than face-to-face teaching. Alternatively, this response may indicate that they were still a bit concerned about losing the comfort of face-to-face teaching.

5.1.3.3 Respondents Authenticity on Online Simulation in Second Life.

There were five statements (statement 10a to 10e) in Set-B Questionnaire used to measure the authenticity of SimuLab in Iteration 2. Figure 5.8 shows the mean scores for the authenticity of SimuLab. In general, the mean scores for all 5 statements showed positive agreement ($m > 3.0$).

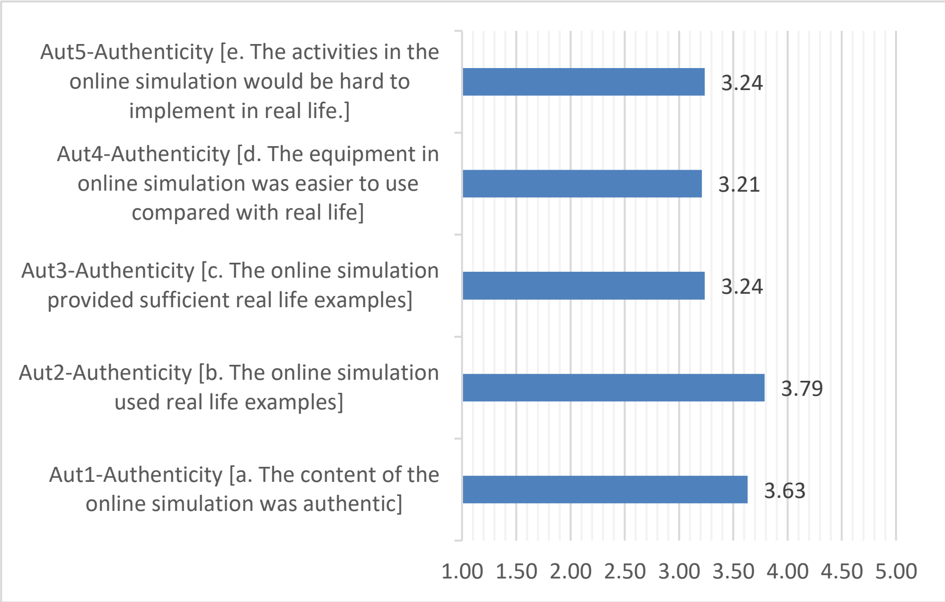


Figure 5.8. Mean scores for Authenticity (statement 10a to 10e).

89% of respondents were either positive or neutral about these five statements (negative = 11%; neutral = 43.2%; positive = 45.8%). Statement (10b) recorded the highest agreement among for five statements, with statement (10d) scoring the lowest. It suggests that most of these participants agreed that SimuLab gave students real life experiences, which gave them content that is more relevant. Statement (10b) recorded the second highest with 20 agreements. It also suggests that these participants were positive or neutral about the construction of SimuLab based on the stated design principles about authenticity. The design principles used for this factor of the 4A model (based on the design principles described in section 2.12.2 and the manifestation of these principles in SimuLab listed in table 4.2 were: -

- Use authentic learning settings (Statement 10a, 10b and 10c refers to this design principle)
- Relate the learning activities to real life tasks (Statement 10d, 10e and 11b refer to this design principle)

Most of the participants also agreed or were neutral that the researcher had applied the right instructional strategies, which developed an authentic virtual networking laboratory. Statement (10e) had the lowest number of agreement (34.2%), however, half of the respondents (50%) were neutral about this statement, and this is neither a strong positive nor a negative statement. Statements (10d) and (10c) also had lower scores than statements (10a) and (10b) with these three statements all focused on comparing simulation to real life implementation of use of networking equipment. So in reality these questions were asking the participants to compare the simulation process to use of real equipment when they had very limited use of real equipment and so the students had limited background to make judgments about the use of the simulation verse real life use.

Additionally, as most of them had not previously used Second Life and they were also new to networking subjects, it is understandable that they were not sure about how difficult it is to teach the content in this networking subject without a tool like SimuLab. Consequently, most of them have chosen to be neutral. The respondents supported this factor of the "4A motivational model" believing that the SimuLab offered them an authentic experience. Furthermore, this data again indicates that the design of SimuLab effectively implemented the design principles for this factor, that is the use of authentic settings and tasks and relating the learning activities to real life tasks offering students an authentic experience and supporting this factor of the "4A Motivational model" as a crucial design principle for this type of simulation.

5.1.3.4 Respondents Achievement on Online Simulation in Second Life.

There were five statements (statement 11a to 11e) in Set-B Questionnaire that were used to measure respondents' achievement while accessing SimuLab for Iteration 2. Figure 5.9 shows the mean scores for achievement while accessing SimuLab. In general, the mean scores for all 5 statements were positive (more than 3.0), with the lowest of 3.24 to the highest 3.53.

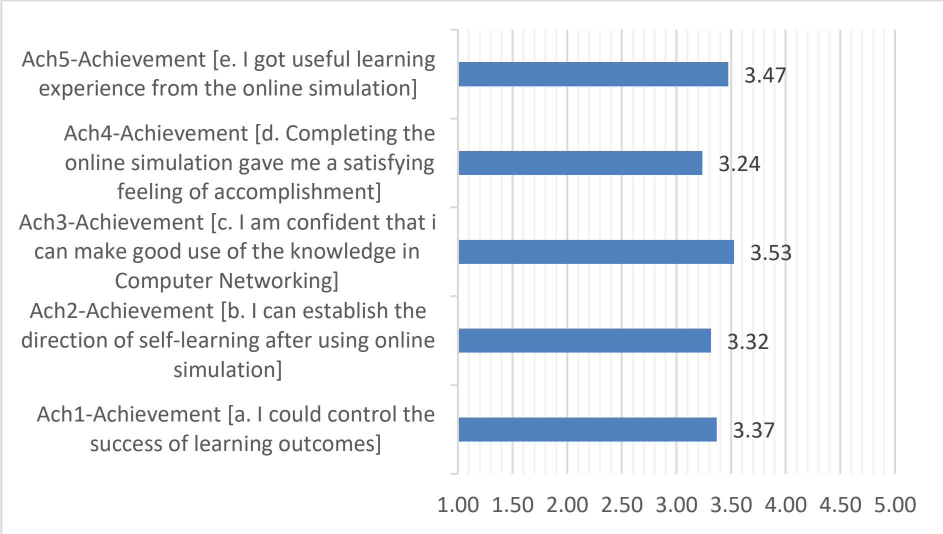


Figure 5.9. Mean scores for Achievement (statement 11a to 11e).

85.8% of respondents were either positive or neutral about these five statements (negative = 14.2%; neutral = 37.9%; positive = 47.9%). Statement (11c) has recorded the highest agreement (21) among the five statements with statement (11b) recorded the lowest. It suggests that most these participants are confident of using the networking knowledge learned in SimuLab. Also, these data suggests that the participants were either neutral or positive about the design of SimuLab for the 'Achievement' factor.

The design principles used for this factor of the 4A model (based on the design principles described in section 2.12.2 and the manifestation of these principles in SimuLab listed in table 4.2) with the specific design principles employed to support achievement of this factor of the 4A model being: -

- Incorporate feedback for achievement of goals (Statement 11c, 11d and 10e refer to this design principle)
- Incorporate feedback as support for learner activities (Statement 11a and 11b refer to this design principle)

Both statement (a) and (e) have recorded the second highest scores with 19 agreements. It suggests that most of these participants were satisfied with the control over their learning in SimuLab and also obtained useful experience when using SimuLab.

Furthermore, most of the participants also agreed or were neutral that they achieved a level of confidence after using SimuLab. As most of them used Second Life for the first time, it is possible that these respondents were still puzzled with learning using SimuLab as a new platform. Furthermore, this question asked about establishing the direction of self-learning after using SimuLab, which is a concept that was new to most of them and so the question may have been difficult for the participants to interpret.

These respondents supported or were neutral about this factor of the "4A motivational model" and most of them believed that SimuLab had boosted their confidence levels and provided them with useful learning experiences. These data indicates that the design of "SimuLab" effectively implemented design principles drawn from the "Achievement" factor fulfilling students' learning by providing adequate knowledge in Computer Networking.

5.1.3.5 Respondents Appropriateness on Online Simulation in Second Life.

Last but not least, there were five statements (statements 12a to 12e) in Set-B Questionnaire that were used to measure appropriateness of SimuLab for Iteration 2. Figure 5.10 shows the mean scores for appropriateness of SimuLab. In general, mean scores for all 5 statements showed positive agreement (*m* > 3.0).

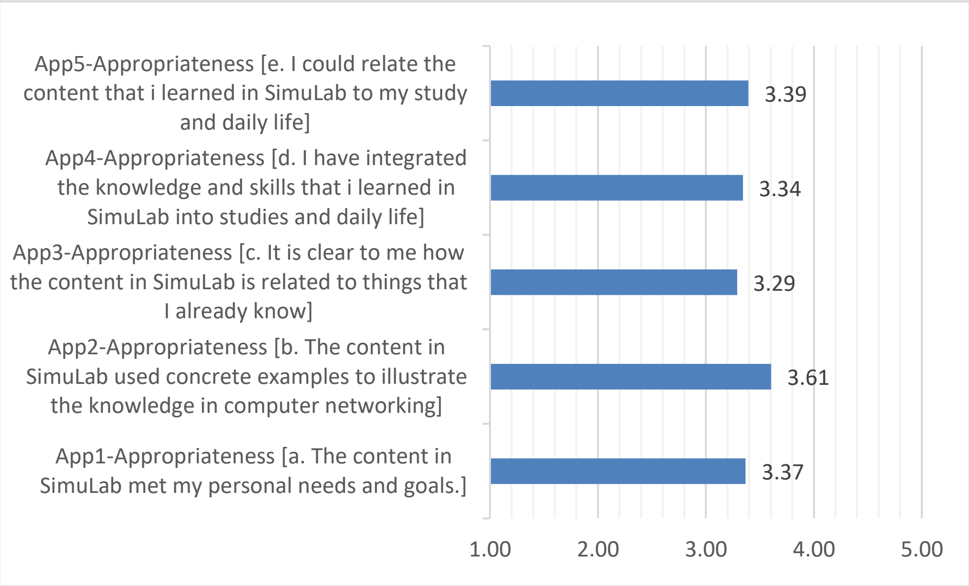


Figure 5.10. Mean scores for Appropriateness (statement 11a to 11e).

87.4% of respondents were either positive or neutral about these five statements (negative = 12.6%; neutral = 42.1%; positive = 45.3%). Statement (12b) has recorded the highest agreement (21) among the five statements. It suggests that most of these participants were satisfied with the content deployed in SimuLab, which provided them with concrete examples to illustrate the networking knowledge. Statement (12a) recorded the second highest score with 18 agreements. It also suggests that the participants were generally agreed or neutral that SimuLab met their personal goals and needs of using it.

The design principles used for this factor of the 4A model (based on the design principles described in section 2.12.2 and the manifestation of these principles in SimuLab listed in table 4.2) with the specific design principles employed to support appropriateness of this factor of the 4A model being: -

- Use content that is linked to users' needs and future goals (Statement 12a and 12c refer to this design principle)
- Incorporate levels of difficulty matched to users experience and skills (Statement 12d and 12e refer to this design principle)

Furthermore, the use of these design principles for incorporation of the 'Appropriateness' factor in the design of SimuLab appears to have been successful in that most of them also agreed or were neutral that SimuLab was developed and deployed in an appropriate way. As this question was asking to relate SimuLab to their prior knowledge in networking and this was, for almost all participants, their first encounter with this content, it should not be surprising that this was the lowest positive response as they had limited experience to make this comparison. Although, all of the questions for this factor have very similar mean scores, there is little difference in the answers.

5.1.4 Post-questionnaire (Set B) for Iteration 1 and 2.

In total 62 participants took part in the questionnaires (Set B) for Iterations 1 and 2 with 24 participants for Iteration 1 and 38 participants for Iteration 2. Figure 5.11 shows the mean scores for all four factors in Iteration 1 and 2. As for "Attention", the differences between these 2 Iterations are 0.2 (based on 5.0 scale). "Authenticity" factor recorded only 0.09 differences between Iteration 1 and 2. As for "Achievement", the differences between two iterations are 0.28 and the differences for "Appropriateness" between the two iterations recorded at 0.18. Overall, the differences in mean scores between these two iterations was less than 0.2, which is at 0.18 (3.6%).

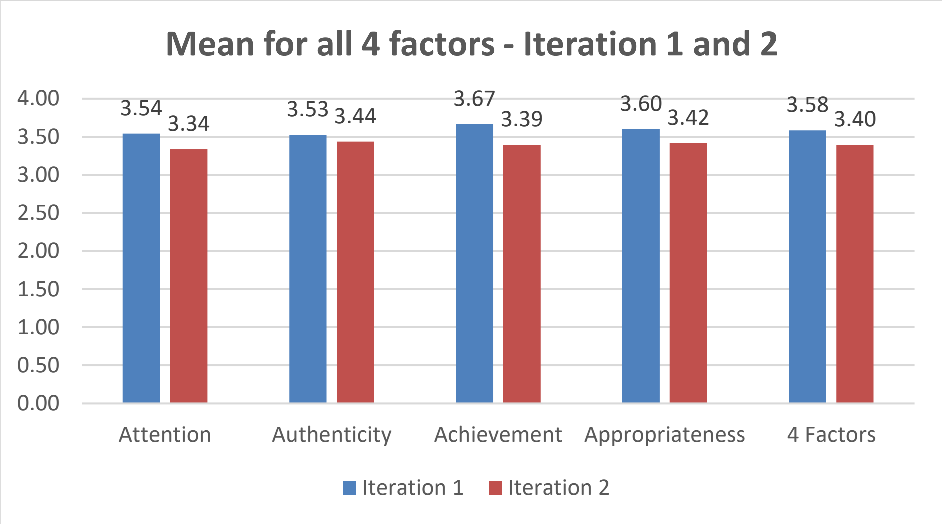


Figure 5.11. Mean scores for all 4 factors (both Iteration 1 and 2).

Despite the obvious difference in means between iteration one and two, an Independent samples test was conducted to determine if the average scores for the four factors for Iteration 1 and Iteration 2 are significantly different. Table 5.2 shows that the p-values of Levene's test for the four factors are more than 0.05 or p > 0.001. For that reason, we accept the null of Levene's test and conclude that the average for Iteration 1 and Iteration 2 for these factors has no significantly difference.

Table 5.2

Independent Sample Test – 4As Factor for Iteration 1 and 2

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper
ATT	Equal variances assumed	.01	.92	1.29	60	.20	.20	.16	-.11	.52
	Equal variances not assumed			1.29	48.93	.20	.20	.16	-.11	.52
AUT	Equal variances assumed	.32	.57	.61	60	.55	.09	.14	-.20	.38
	Equal variances not assumed			.59	44.20	.56	.09	.15	-.21	.39

ACH	Equal variances assumed	3.04	.09	1.71	60	.09	.27	.16	-.05	.59
	Equal variances not assumed			1.78	54.65	.08	.27	.15	-.04	.58
APP	Equal variances assumed	.96	.33	1.14	60	.26	.18	.16	-.14	.50
	Equal variances not assumed			1.20	55.50	.23	.18	.15	-.12	.49

One interpretation of this slight consistent difference between iteration 1 and 2 could be that iteration 2 had more content and simulated elements embedded, compared with iteration 1, and in response to the iteration 1 focus group discussion, more student support for using SimuLab was embedded in the simulation and consequently, students were more skilled at using the simulation.

An Independent samples test was conducted to determine if the mean scores for all 20 statements in the Set B questionnaires for Iteration 1 and Iteration 2 were significantly different. The *p*-values of Levene's test for 19 of these statements are more than 0.05 or $p > 0.001$. For that reason, we accept the null of Levene's test and conclude that the average for Iteration 1 and Iteration 2 for these 19 statements has no significantly difference. This table is shown in Appendix 1.

However, statement 12 c (It is clear to me how the content in SimuLab is related to things that I already know) recorded a *p*-value of 0.006 with $t(60) = 2.911$, that is the mean scores for this statement in Iteration 1 (3.83) and Iteration 2 (3.29) are significantly different. This is shown in Table 5.3 As explained earlier; this question was asking to relate SimuLab to their prior knowledge in networking. It is not clear why the participants in iteration two responded so differently to iteration one participants, especially considering iteration 2 contained more content and the design was modified to try to improve the implementation of the design principles. A number of possible explanations could be considered. The lecturer may not have linked their previous knowledge to this new topic as well has he had for the previous iteration. For the first iteration, this was the first time the Faculty had used a MUVE for a subject and so there was a lot of excitement and planning about its implementation. For the second iteration, this was not the case and so the academic teaching the subject may have been less specific about the relationship of the content to the previous content. Also the sequencing of subject content on networking could have been slightly different for a number of students in this cohort, there could have been a smaller number of students who came through a course with networking subjects included compared to cohort 1. This data is not available and so it can only be supposition. It is anticipated that the qualitative data may shed some light on these differences.

Table 5.3

Independent Samples Test – Iteration 1 and 2 for statement 12c

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig.	Mean Difference	Std. Error Difference	Lower	Upper
12. Appropriateness [c. It is clear to me how the content in SimuLab is related to things that I already know]	Equal variances assumed	2.91	.09	2.83	60	.006	.52	.18	.15	.88
	Equal variances not assumed			3.04	58.66	.004	.518	.17	.18	.86

It is also worth highlighting in this discussion that the other 19 questions showed no significant difference between iteration 1 and 2, even after the design changes described in section 4.6 and argued for from the student responses after the implementation of iteration 1. The participants cannot be compared as they are entirely different cohorts with different expectation, but similar backgrounds. What can be considered is that both groups of participants were positive about the use of the simulation as a way of developing knowledge about this topic due to increased motivation. However, in an anecdotal sense, one would expect the second group of students, who made use of an improved tool, would be more positive than the first, but the statistical comparison shows there was not significant difference. There is no data available to test hypotheses about why the second group was not more positive, but a number of ideas can be proposed.

Some potential views could be that the second group of participants had a higher expectation of SimuLab because they had heard about the tool from their seniors, and this may have raised their expectation. This group of participants may have higher expectation of SimuLab after the introduction session with the researcher as the researcher showed some screenshots and explained some of the features in SimuLab. Furthermore, the lecturer could have discussed SimuLab with them after the introduction session. Another idea is that the second group of participants were more used to use of high quality games and simulations, and so again their expectations about the quality of SimuLab were higher than the first group. Besides, this outcome might also be due to a majority of the participants (62%) that participated in iteration 2 had never used online simulations or had played online simulation games, therefore, they might have different expectations of SimuLab and its level of difficulty in use. Again, during focus group and questionnaires in iteration 2, many participants pointed out that they faced delays when they were using SimuLab and some of them faced difficulties in using SimuLab with limited hardware and internet bandwidth. The delay issue in SimuLab in Second Life can be one of the main reason that the participants had unpleasant experience using SimuLab with or without the improvements. Of course, these ideas are supposition as there isn't any data to investigate further, and methodologically the comparison of two different cohorts has no statistical validity.

At first glance, this appears to be disappointing because of the changes made to SimuLab based on the feedback from the first iteration, but on further consideration, the participants in the second iteration had no knowledge of the first iteration and, both group of participants were encountering SimuLab for the first time. In this case these participants could not make the comparisons with the implementation that the researcher could and from a methodological standpoint there is no basis to make a comparison because of the difference in cohort. Nevertheless, the mean scores difference between the students responses for the 4A factors for the two iterations is less than 0.2, indicating that participants in both iterations were in very close agreement with each other indicating they were positive and supportive of the online simulation.

5.1.5 Focus Groups.

As in iteration 1, the data collected from focus groups in iteration 2 was sent for transcription. After transcription, the researcher has categorized the responses according to questions. With this, all responses have been categorized accordingly.

The focus group discussion for iteration 2 was conducted after the second implementation of SimuLab. The participating students were selected from the group of students who had completed the simulation and questionnaires set A and B. The main reason for the researcher to conduct focus group discussions was to allow participants to give additional feedback about their experience with SimuLab for a first year networking subject. The researcher invited 15 students to join in focus group discussions and all students turned up for the discussion. Fourteen of them were male students and one was a female student. These students were divided into three groups of 5 students. Student 1 to 5 in group 1, student 6 to 10 in group 2 and student 11 to 15 in group 3.

5.1.5.1 The "Attention" Factor.

Attention is important components in the design of SimuLab as the more the users spend time on the simulation, the greater the chances of achieving the learning outcomes of the simulation (Keller, 2009; Malone and Lepper, 1987). As with the first iteration, there was one question asked and discussed in the focus groups, which related to this factor (see table 3.2). . When asked about whether the content in the online simulation captured their interest (this question is referring to design principle 3 "Incorporate design elements that stimulate both sensory and cognitive curiosity"); some of them were very interested in the 3D models of routers and switches. Some of them liked to interact with the simulation and one student felt that the slides in SimuLab were helpful:

> *"Graphical representation of model, because in normal teaching only explain using text but this simulation allows us to visualize the actual process and how it related to the concepts." – Student 12*

Some of them stated that the environment and network equipment models captured their interest, they spent a lot of their time in “playing” the simulation components in SimuLab and one student praised that the online simulation was more interesting compared with diagrams and text from textbook and the settings are authentic.

> *“It is like something is physical that we can see, such as topology, in normal class, only in diagram or text form, it is not interesting but in SimuLab, we can see something just like in real life.” – Student 11*

One student thought that the online simulation in Second Life was well managed and it had lots of information and the objects in Second Life were mostly interactive:

> *“I think everything is well managed, instructions can lead you to everywhere, the SimuLab has a lot of interaction items, and a lot of information, and it makes learning more interactive.” – Student 11*

Different students faced different difficulties when using Second Life. For some students, this was the first time they had experienced networking equipment like routers or switches and they reported that they had never tried this type of equipment in real life:

> *“….using the simulation was fun as it has the interaction attributes but it was lag in my computer. The models were like real and I still have not seen that in real life but in simulation, I was able to see the model in 360 view and zoom in as well, I was informed about these equipment.” – Student 7*

In general, almost all of the students had no previous experience in using online simulations in Second Life and the setup was very new for them. Generally, most students experienced the networking equipment like routers or switches in the simulation environment for the first time and they liked the simulation and 3D network equipment models. They spent a lot of their time in interacting with the simulation components in SimuLab because they believed that the online simulation was more interesting compared with diagrams and text from textbook and the settings are authentic. This response supports the participants’ responses in questionnaires and reinforces the acceptance and value of the simulation is supporting students learning.

5.1.5.2 The "Authenticity" Factor.

Authenticity is another very important component of SimuLab design that was intended to keep users motivated when using the simulation. Online simulation should be designed close to reality and be as authentic as possible (Wang and Burton, 2013) as users will tend to look for the authentic setting that is similar to the real situation. When asked about if the online simulation in Second Life is authentic, some of them thought the 3D models were authentic and another student thought that SimuLab looked like a Museum of networking equipment. This question is related to "Authenticity" factor and is referring to design principle 9 "Use authentic learning settings". One student suggested including every topic from the subject in the online simulation:

> *"It is good if you can make every topics in this subject (CSIT127) the same as the LAN/WAN simulation." – Student 4*

Another student suggested using VR headsets for SimuLab to improve the immersiveness for the online simulation:

> *"It does look like real life and realistic but you need a powerful graphic for that, if we can have VR headset for SimuLab, we will be able to immerse in the simulation." – Student 7*

In general, the majority of students gave positive feedback towards SimuLab and commented that they believed the 3D models and simulation appeared authentic. They stated that they had very little experience in using online simulation in Second Life, but they still found it fun to "play" with and hoped that the researcher could include all topics in their networking subject in the simulation.

5.1.5.3 The "Achievement" Factor.

Achievement will lead to self-confidence, users need to be equipped with high self-confidence for them to be highly motivated when using and re-using the simulation (Malone & Lepper, 1987). The questions asked are referring to design principle 5 "Incorporate feedback for achievement of goals". When asked if they were confident to use what they learned from this lesson in the networking subject, 9 out of the 15 students agreed that what they learned from the online simulation and that it actually helped them in this subject. Furthermore, one student mentioned that the videos in the online simulation helped him to visualize how the actual process of the packets travel through the internet, which gave them more confidence when it comes to understanding of the concept:

> *"Yes, this will help in my subject, the topics here is also in my networking subjects like WAN, LAN and etc…" – Student 1*

When asked if they could confidently apply what they had learned in the online simulation, most of the students felt that they could now confidently apply what they had learnt from the online simulation and this new knowledge in real life was related to their studies. One student thought that the topology topic could now be easily understood after seeing how it was arranged on the simulation table. One student thought that the simulation helped him to understand about the topics and gain more knowledge. In general the majority of the students felt that learning through online simulation in Second Life was more interesting and also helped them in understanding the subject matter better compared to traditional methods and what they had learned from the online simulation was relevant to their studies and could be applied to their studies.

5.1.5.4 The "Appropriateness" Factor.

As for Appropriateness, this component looks into whether the contents of simulations are appropriate or relevant to users' level and what they intend to study. The question asked is referring to the design principles 12 "incorporate levels of difficulty matched to users experience and skills". When asked if the online simulation was presented in an appropriate way, most students (14 out of 15 students) felt that the simulation was presented in an appropriate way and organized properly. Only one student thought otherwise. Furthermore, all students felt that the simulation was related to their networking subject CSIT127. Overall, most students believed that the online simulation was presented in an appropriate way and they also felt that the content presented in the online simulation was relevant to their subject.

5.1.5.5 Other Factors.

Apart from the "4A motivational factors", students felt that they could access the online simulation anytime, anywhere, and they could explore the simulation to gain more information. They saw this as a positive aspect of the simulation:

> *"Ya, I think it has to do with exploring and learning, in SimuLab, most students are supposed to explore the space, new information will pop up and they are supposed to read and gather information while exploring and interacting with others." – Student 11*

When asked about their experience in using the online simulation in Second Life, many of them said that this was something very new for them and most of them had no experience in using Second Life with these responses matching their responses to the questionnaire:

> *"My first impression on Second Life is quite confusing, I am not sure where to go but slowly I managed to visit more places including the SimuLab." – Student 13*

When asked about the most important things they learned in the online simulation, students described the different experiences they had when using the online simulation. Three students claimed the simulation was useful for their learning and the equipment in SimuLab was easy to interact with:

> *"I believed that some stuff in the simulation is easier to understand compare to normal class as it can be interacted. That's the key component in this simulation and also the visual understanding compare to slides only in normal face to face class." – Student 8*

When asked about other general comments about the online simulation, three students felt that SimuLab was good and something new for them, they were willing to try something new that benefits them.

Finally, the researcher concluded that most of the students in the class had none or very little experience in using Second Life and so they required some time to master it. However, students in the focus groups provided positive feedback towards using SimuLab for their study and some felt that the online simulation was useful and helpful during preparation for their final exam. Many of them mentioned that visual representation of equipment in the simulation was so much better than text and diagrams in textbooks.

5.1.5.6 Outcomes of the Focus Groups for Iteration 1 and 2.

Based on the focus group discussion for iteration 1 and 2, the researcher concluded that Second Life was new to most of the students in both iterations, most of the students had no experience in using Second Life and it took them quite some time to navigate through it. The researcher had conducted an introductory class for students about Second Life to demonstrate the interface and navigation, however, the overheads of time spent on learning how to use Second Life were considered by students to still be high. Students in both iterations commented that they faced problems in efficiently using Second Life due to their low hardware specifications. As shown in Questionnaire (Set A) responses, only 46% of the respondents owned a desktop computer at home, most of the respondents own either smartphones or laptops which might not be the ideal computer hardware for using Second Life compared to a more powerful desktop computer. This issue might be resolved in future if laptops have the same or more processing power than desktop PCs.

Furthermore, students in both iterations thought that the online simulation should include more simulation content even after the researcher had added in an additional table that covered the network topologies, the ring, the bus and the star topologies in iteration 2. Some students in both iterations also thought that simulations helped them to gain more knowledge and understand about the topics more easily. An overwhelming majority of students from both iterations felt that the simulation was presented in an appropriate way and organized effectively.

Students in both iterations were pleased to see all the network equipment in 3D. In addition, they liked that they could also ‘touch’ the 3D objects in the online simulation. Based on this response from the iteration 1 cohort, the researcher rearranged the routers, hubs and switches at the exhibition corner to make it more accessible and added a feature so that students could then receive notes for the items that they click on in notecard format, which could be kept in the Second Life inventory for future revision.

Some students requested the inclusion of quizzes in SimuLab in Iteration 1.

They claimed that quizzes could help to test their knowledge after they have completed the simulation. Furthermore, they suggested having a leader board for the quizzes. In Iteration 2, the researcher included a quiz that consists of 20 multiple choice questions in SimuLab to test student's networking knowledge and after completing the quiz, students received scores for the quiz and the top 10 highest scores were listed on a leader board.

5.1.6 Learning Outcomes.

In both Iterations, the subject lecturer Mr. Shanmuga conducted a quiz a few weeks after the students had completed the online simulation. The quiz covered chapter 1 and 2 of the subject with the following topics: -

- Types of networks
- Networking Hardware
- Network Topologies
- OSI Model

A comparison of this quiz with student groups from pre and post use of the online simulation was carried out to try to get some sense of the effectiveness of the simulation in improving the learning outcomes of the subject. Because the measure does not make use of a control vs. experimental group and were administered to different cohorts of students over time, the comparison makes use of descriptive statistics and the result can be considered as an indicator of trends rather than a definitive measure. Quiz results from 2013 to 2015 (pre-simulation student results) were compared to the mean for quiz in 2016 (Iteration 1) and 2017 (Iteration 2). Table 5.4 shows the mean for the 3 samples, year 2013 – 2015 with total of 119 participants, year 2016 (Iteration 1) with 47 participants and 58 participants for year 2017 (Iteration 2). The mean for year 2013 – 2015 is the lowest among the 3 samples. This shows that the average quiz marks for year 2013 to 2015 is 31.45 over 50. The average mark increased to 33.02 after implementation of Iteration 1 in 2016, an increase of 4.99% compare to year 2013-2015. After the implementation of Iteration 2 in 2017, the average marks for year 2017 increased to 38.19 over 50, which is a 21% increase from year 2013-2015.

Table 5.4

Mean for Quiz in 2013-2015, 2016 and 2017

	N	Mean	Std. Deviation	Std. Error Mean
Quiz_2013_2015	119	31.45	9.03	.83
Quiz_2016	47	33.02	6.85	.99
Quiz_2017	58	38.19	5.59	.73

An independent sample t-test for this data was conducted to find out if the average marks for quiz in 2013-2015, 2016 and 2017 are significantly different. Table 5.5 shows the independent samples t-test for data collected for year 2013 to 2015 and 2016 (Iteration 1), the mean difference of 1.566 over 50 marks is not statistically significant: $t(164) = -1.076$, $p \approx 0.28$ ($P>0.05$).

Table 5.5

Samples t-test 2013-2015 vs. 2016

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Quiz_ Marks	Equal variances assumed	1.57	.213	-1.08	164	.28	-1.57	1.46	-4.46	1.31
	Equal variances not assumed			-1.21	110.51	.23	-1.57	1.3	-4.14	1.00

Table 5.6 shows the independent samples t-test for data collected for year 2016 (Iteration 1) and 2017 (Iteration 2), the mean difference of 2.228 over 50 marks. There was a significant difference in mean between year 2016 and 2017 (t_{103} = -4.259, p < .001). The average marks for year 2017 was 2.228 marks higher compare to year 2016.

Table 5.6

Independent Samples t-test 2016 vs. 2017

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Quiz_ Marks	Equal variances assumed	2.23	.14	-4.26	103	.00	-5.17	1.21	-7.58	-2.76
	Equal variances not assumed			-4.17	88.25	.00	-5.17	1.24	-7.63	-2.71

Table 5.7 shows the independent samples t-test for data collected for year 2013 to 2015 and 2017 (Iteration 2), the mean difference of 7.276 over 50 marks. There was a significant difference in mean between the mean for 2013-2015 and year 2017 ($t_{165.201}$ = -6.094, p < .001). The average marks for year 2017 is 7.276 marks higher compare to year 2013-2015.

Table 5.7

Independent Samples t-test 2013-2015 vs 2017

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Quiz_ Marks	Equal variances assumed	7.28	.008	-5.21	175	.00	-6.74	1.29	-9.29	-4.19
	Equal variances not assumed			-6.1	165.20	.00	-6.74	1.11	-8.92	-4.56

With this, the mean difference between year 2013 – 2015 and 2016 is more than 1.5 marks greater and the mean difference between year 2013 to 2015 and 2017 are more than 6 marks greater indicating that the participants may have benefited from the online simulation and indirectly improved their knowledge in this subjects for this section of the subject. The major difference between iteration 1 and 2 implementation, beside strengthening of some elements of the design, was that it contained significantly more content and more simulations and this could be the reason why students appeared to be more successful. However, again the comparison is between different cohorts of students and even though the results for all cohorts do suggest improvements in learning outcomes, more research needs to be done for this outcome to be conclusive. This will be taken up in the final chapter.

5.2 Conclusion

In conclusion, as in Iteration 1, most students had none or very little experience in using

Second Life but these students have provided overwhelming positive feedback towards using the online simulation SimuLab for their study. Furthermore, many of them mentioned that visual representation of equipment in the simulation was so much better than text and diagrams in textbooks. Lastly, most students in Iteration 2 believed that the online simulation was presented in an appropriate way and the content presented in the online simulation was relevant to their subject.

As for the questionnaires, most of the respondents in general believed that they had a good experience when using SimuLab and gave positive feedback when evaluating SimuLab with the responses across both iterations being remarkably similar. The respondents in general believed that the simulation captured their attention, the structuring of the content, the content and instructional strategies helped to maintain their attention, and with the highest rating, the students stated that the multimedia elements used in the simulation both motivated them and aroused their attention. As for authenticity, the respondents in general believed that the online simulation used real life examples, the content of the online simulation was authentic and provided sufficient real life examples. Furthermore, the respondents in general also believed that they were confident that they could make good use of the knowledge in the Computer Networking subject and established the direction of self-learning after using the online simulation. They also believed that they were successful with learning outcomes and felt accomplishment after completing the online simulation.

The data collected from the questionnaires shows that the design of SimuLab effectively implemented the vast majority of the design principles drawn from the design principles based on 4A Motivational Model with the factors attention, authenticity, achievement and most of appropriateness successfully implemented and integrated into SimuLab. These factors managed to capture students' attention and offered students an authentic experience. Furthermore, these factors fulfilled students' learning needs by providing adequate knowledge in Computer Networking and providing appropriate content in SimuLab. In summary, the respondents supported the factors of the 4A Motivational Model as crucial underpinning of the design principles for this type of simulation.

One component of Appropriateness appears not to have been as well implemented as the other factors of the 4A Motivational model with the participants believing that the linking of students' previous knowledge to the new content was not as well implemented as other design elements of the model. This as especially so for the participants in the second iteration. This issue will be taken up in the final chapter.

Last but not least, from the results of the independent t-test to find out if the average marks for the quiz in 2013-2015 (pre-simulation teaching) compared to 2016 and 2017 (use of simulation in teaching) were significantly different, there were indications that it was possible that the participants benefited from the online simulation and indirectly improved their knowledge in this subject. The average results (2017 – iteration 2) for this section of the subject were 13.5% higher compared with students who studied the subject in previous years (2013-2015). This supports the student's belief, as expressed in the questionnaires, that SimuLab supported their learning and understanding of the difficult and complex nature of this subject.

Chapter 6

Discussion and Conclusion

6.1 Background

This study had its origin in a curriculum issue; the difficulty of teaching networking subjects in an undergraduate computer science program. The difficulty is centered on the complexity of the content, the motivation of students to engage fully with this content, the high cost of setting up a real laboratory containing all of the equipment needed to illustrate the subject content and the danger of damage to expensive equipment where inexperienced students make genuine mistakes in design when setting up network systems (Chan, 2015, Li et al., 2008, Gil et al., 2011).

Chang (2004) has argued that "…the principles underlying Computer Networking are intrinsically very profound and complex" (p.209) and student difficulty with the subject has also been noted by Shao and Maher (2012) who has argued "many students including computer science students find difficulty in understanding the abstraction of protocols and the complexity of concepts in networking" (p. 92).

The researcher proposed that one way to address these issues is to use a MUVE simulation for the students to develop skills and knowledge in a virtual environment and that this environment would not only increase the motivation of students in studying this content, but would also have better outcomes for students' knowledge and skills in the computer network subject. Within this context, a set of design principles was developed based on well-supported principles and the A4 motivational model proposed. The principles were applied to a virtual environment developed in the simulation tool Second Life and this simulated environment was implemented through two iterations, to develop the students' knowledge and skills and to test the theoretical motivational model for such contexts and as the basis for a design framework for MUVEs.

Each iteration was implemented within a specific networking subject offered in an undergraduate program and modified based on the first iteration using a design-based research approach, ensuring the design principles developed around the A4 motivation model were a central focus. Protocols were developed for collecting data on the student profiles and outcomes from the student experience. This chapter discusses the outcomes of this study by addressing the research questions, reviewing the findings of the study reported in chapters 4 and 5 and proposing a design framework for educational MUVEs.

6.2 Research Questions

The research questions developed at the early stage of this research are as follow:

i. What is the relationship of components of motivation to students' experience in an online simulation?

ii. What are students' perceptions of design elements embodying motivational components in an online simulation?

iii. Can a well-designed MUVE improve learning outcomes for information science students studying complex and abstract concepts such as computer networking?

Each of these questions will be discussed in the following section.

6.2.1 Research Question 1: What is the relationship of components of motivation to students' experience in an online simulation?

The first research question sought to look at the relationship between components of motivation and student perception of the online simulation. The online simulation (SimuLab) was developed based on design principles drawn from the 4A model, the virtual environments literature, and the general design principles for technology supported learning settings. The design principles derived from the 4A's learning motivational model consists of four main factors of motivation: Attention, Authenticity, Achievement and Appropriateness.

Figure 6.1 shows mean scores of students' perceptions for the 4A factors in iteration 1, iteration 2 and the average from the questionnaires administered after each iteration. The mean scores for all factors in both iterations and their average were positive ($m > 3.0$), reflecting general agreement on the effectiveness of the simulation implementation SimuLab. With the positive mean scores in all components of motivation, this also shows the positive experience the participants had in using SimuLab.

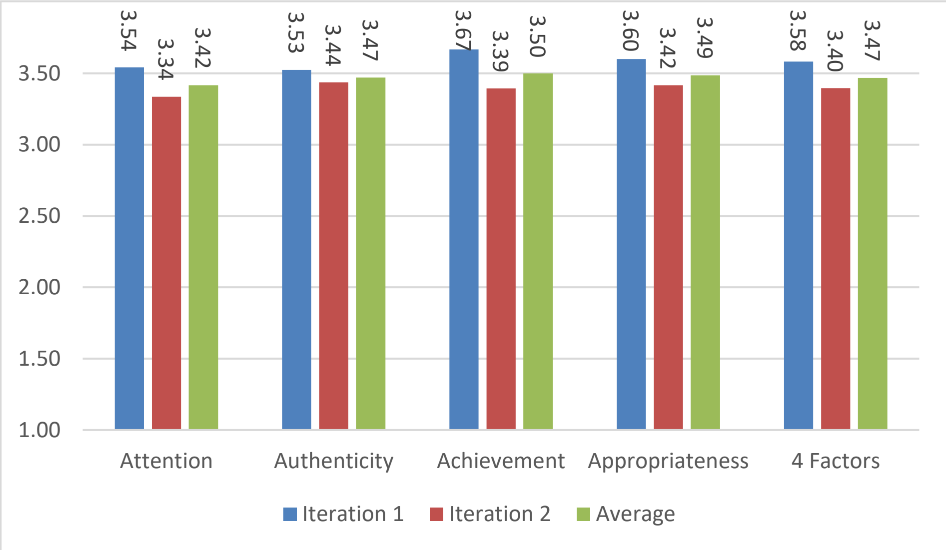


Figure 6.1. Mean scores for 4A factors (Iteration 1, 2 and average of both Iterations).

There were 62 participants who took part in the questionnaires (Iterations 1 - 24 participants and Iteration 2 - 38 participants). The differences between these two Iterations are 0.2 (based on 5.0 scale) for “Attention” factor, As for “Authenticity” factor; there were only 0.09 differences between two iterations. “Achievement” factor recorded the differences of 0.28 between the two iterations and the differences for “Appropriateness” recorded at 0.18 between the two iterations. In average of all four factors, the differences in mean scores between these two iterations was at 0.18.

When considering the individual factor, “Authenticity”, this factor recorded the lowest mean scores among the four factors in iteration 1; “Achievement” recorded the highest at 3.67. However, in iteration 2, “Authenticity” factor recorded the highest mean scores among the four factors at 3.44. This could be due to the fact that iteration 2 had more simulated content and elements embedded as compared with iteration 1 based on the feedback from the first iteration.

“Achievement” factor recorded the highest mean scores in iteration 1 and also the average mean scores for both iterations. With the use of these design principles for incorporation of the factor ‘Achievement’ in the design of SimuLab appears to have been neutral or positive based on respondents’ responses. Most of the respondents believed that SimuLab had boosted their confidence levels, they were confident that they can make good use of the knowledge in Computer Networking and established the direction of self-learning after using online simulation.

Furthermore, from the possible 1240 responses, there were 1113 (89.8%) responses either positive or neutral about statements that were related to components of motivation. Questionnaire results suggest that students felt positively about motivational components of the A4 learning motivational model. Furthermore, student focus group responses also indicated heightened motivation and interest in the subject content, when learning through SimuLab.

As for focus group for iteration 1 and 2, the researcher found that Second Life was new to most of the students in both iterations. With lack of experience in Second Life, students in both iterations were still positive towards simulations helping them to gain more knowledge and understanding about the computer network topics. Also, the majority of students from both iterations felt that the simulation was presented in an appropriately way and organized effectively. Furthermore, students in both iterations were very satisfied to see all the 3D network equipment and they could virtually 'interact' the 3D objects in the online simulation.

In summary, from both the questionnaire data and the focus group data, the students reported being quite positive about each of the 4A model motivational components and also were positive about their experiences when learning through SimuLab as well as expressing a belief that SimuLab helped them to develop knowledge and skills in networking design.

6.2.2 Research Question 2: What are students' Perceptions of Design Elements Embodying Motivational Components in an online simulation?

This research question sought to understand the students' perceptions of the design elements of the simulation that were designed to support student motivation within the simulation SimuLab. Figure 6.2 shows five related statements that support this research question collected from questionnaire data showing total student responses for both iterations. The first statement (1a. The content in "SimuLab" such as the information used video, slides and online simulation captured my interest) recorded a mean score (*M* = 3.55) from 62 respondents, 95.2% of respondents were either positive or neutral about this statement. This statement addresses design principles two, seven and eight (Table 4.2), that is "Capture the learner's attention and maintain it throughout the learner experience", "Make effective use of a variety of media" and "Facilitate user interaction with content and other users". So, from the student responses, their overwhelming perception is that these design principles were implemented in a way that supported their effective use of SimuLab to develop knowledge and skills in computer network.

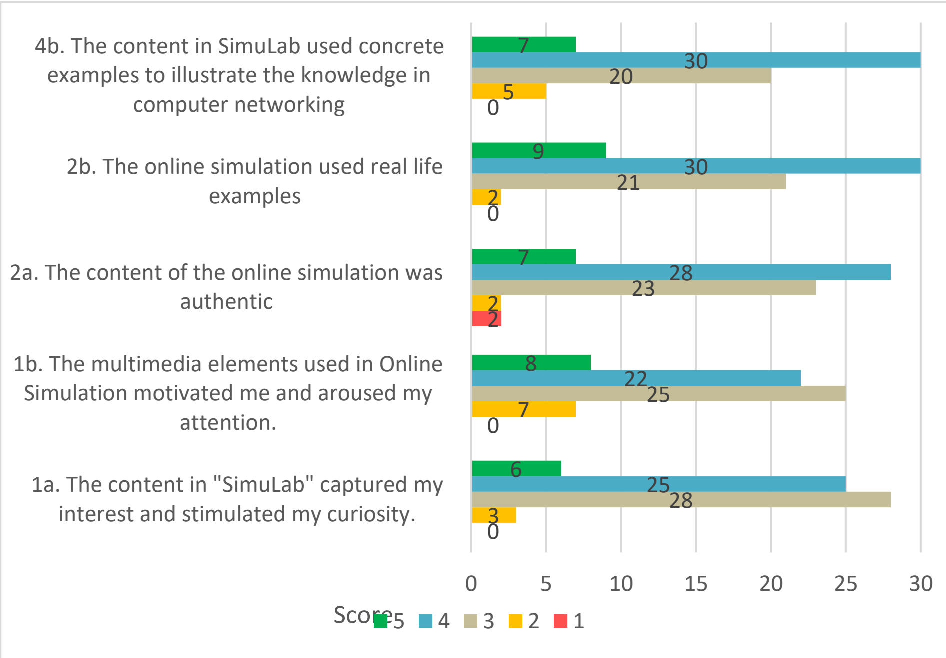


Figure 6.2. Statement to answer Research Question 2.

The second statement in figure 6.2 (1b. The multimedia elements used in Online Simulation motivated me and aroused my attention) recorded the mean score of 3.50. This statement addresses design principles three and four (Table 4.2), that is "Incorporate design elements that stimulate both sensory and cognitive curiosity" and "Incorporate attractive visual design". From the above responses, the students had quite positive perception in these design principles implemented in SimuLab.

The third statement in figure 6.2 (2a. The content of the online simulation was authentic) recorded a mean score of 3.58. This statement recorded that 93.5% of respondents were either positive or neutral about this statement. The next statement in figure 6.2 (2b. The online simulation used real life examples) recorded the highest mean score (M = 3.74) among the 5 statements. The figure also shows 96.8% of respondents were either positive or neutral about this statement. Both 2a and 2b statements refer to design principles nine (Table 4.2), which is "Use authentic learning settings". From the responses to these statements, most of the students felt positive about the authentic settings such as network simulations and videos and slides of networking equipment implemented in SimuLab. Furthermore, most of the students believed that the elements used in SimuLab like 3D objects, graphics and videos were interesting and motivated them to want to learn more about the topic.

The last statement (4b. The content in SimuLab used concrete examples to illustrate the knowledge in computer networking) recorded a mean score (mean) of 3.63. Figure 6.2 shows 91.9% of respondents were either positive or neutral about this statement. This statement addresses design principles ten (Table 4.2), which is "Relate the learning activities to real life tasks". Hence, from the student responses, most of them had quite a positive perception of the implementation of this design principle in developing SimuLab with appropriate examples such as the 3D model and the simulations in SimuLab. In general, for Research Question 2, there were 93.2% of respondents either positive or neutral about these statements. These five statements also recorded a mean of 3.6. So, the data shows that the students perceived that the design elements of SimuLab that have been listed against the questionnaire statements in table 4.2, supported the motivational components of the "4A Motivational Model".

Further evidence that students perceived the design elements of SimuLab supported the motivational components of the "4A Motivational Model" can be drawn from the comments given in the focus groups. Some of them commented that they were very interested in the 3D models of routers and switches; referring to design principle nine "Use authentic learning settings". Under the same design principle, some students commented that the environment and network equipment models captured their interest and one student praised that the online simulation was more interesting compared with diagrams and text from textbook and the settings are authentic. Also, students thought the 3D models were authentic and other students thought that SimuLab looked like a Museum of networking equipment. Furthermore, some students commented that they liked to interact with the simulation, which is referring to design principle one "Use extensive interactivity" and eight "Facilitate user interaction with content and other users". This should not be unexpected, considering the design elements which are related to authenticity and interaction, both were drawn from a set of design principles that have partially been drawn from the model in the first place, but it does support the veracity of the implementation of the design principles and the value of the motivational model as a construct for both design and implementation of the simulation.

In summary, from both the questionnaire data and the focus group data the students perceptions of the design elements embodying motivational components in SimuLab, across both iteration 1 and 2, was extremely positive with all design principles used to support motivational design well supported by students.

6.2.3 Research Question 3: Can a well-designed MUVE improve learning outcomes for information science students studying complex and abstract concepts such as computer networking?

This research question sought to understand if a well-designed MUVE, using the adopted design principles for this study, could be used to improve learning outcomes for computer networking subjects. Figure 6.3 shows seven related statements about student attainment and learning outcomes, gathered from both iterations. The first statement (3a. I could control the success of learning outcomes) recorded a mean score (M = 3.45), 90.3% of respondents were either positive or neutral about this statement. As for the second statement (3b. I can establish the direction of self-learning after using online simulation), this statement recorded a mean score of 3.47 and 88.7% of students were either positive or neutral about this statement. These two statements address design principles six (Table 4.2), which is "Incorporate feedback as support for learner activities". From the student responses, they were quite positive about the implementation of the design principles in SimuLab and implementation of SimuLab helped them to learn the networking topics, as this is quite a new subject for most of them.

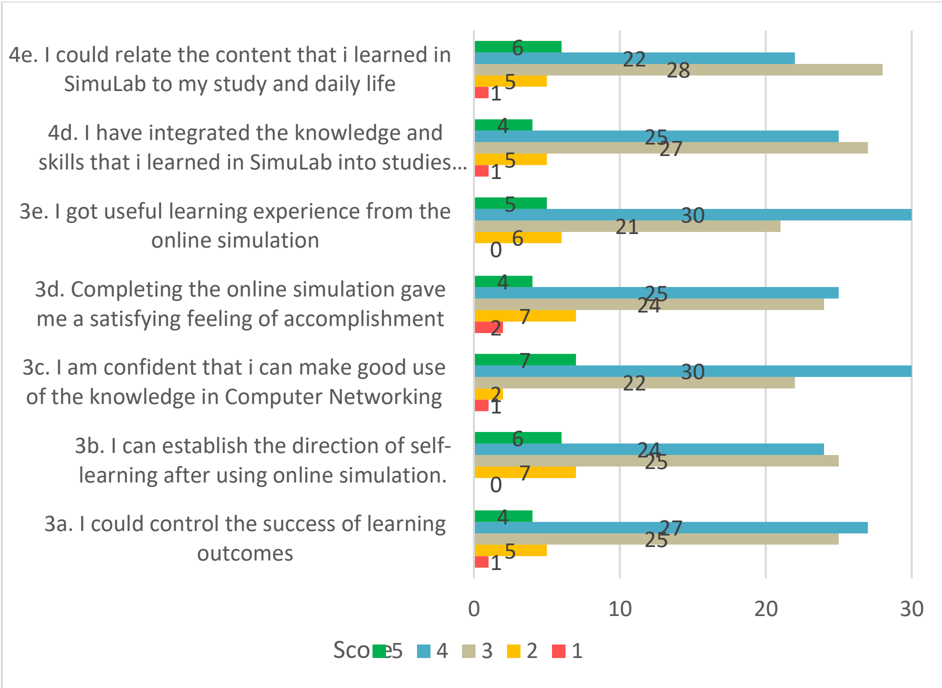


Figure 6.3. Statement to answer Research Question 3.

The next statement (3c. I am confident that I can make good use of the knowledge in Computer Networking) recorded the highest mean score (M = 3.65) among these seven statements. Figure 6.3 shows that 95.2% of respondents were either positive or neutral about this statement. As for statement 3d (3d. Completing the online simulation gave me satisfying feeling of accomplishment) recorded a mean score of 3.35 and 85.5% of respondents were either positive or neutral about this statement. As for statement 3e (3e. I got useful learning experience from the online simulation), this statement recorded the mean score of 3.55 and 90.3% of respondents were either positive or neutral about this statement. These three statements address design principles five (Table 4.2), which is “Incorporate feedback for achievement of goals”. From the student responses, they were quite positive about the implementation of SimuLab based on this design principle, not only did they perceive that they gained networking knowledge from SimuLab, that presented the content in a different way to traditional classroom methods, the majority of them had positive learning experiences from using SimuLab. As this is the first time for most of them, even with very limited knowledge of using Second Life, they were still having quite positive feelings of accomplishment after using SimuLab.

As for statement 4d (4d. I have integrated the knowledge and skills that I learned in SimuLab into studies and daily life), this statement has a mean score of 3.42 and the last statement (4e. I could relate the content that I learned in SimuLab to my study and daily life) recorded the mean scores of 3.34. Figure 6.3 shows that 90.3% of respondents either positive or neutral about these two statement. These two statements also address the same design principle twelve (Table 4.2), which is “Incorporate levels of difficulty matched to users experience and skills”. From the student responses, they were quite positive about the content in SimuLab that they thought was suitable for them which is based on the year 1 networking subject. Most of them believed that they could relate the knowledge they gained from SimuLab to their study and activities in daily life, this can be further supported by the students during focus group as most of them felt that the simulation was presented in an appropriate way and relevant to their subject.

For Research Question 3, there were 90.1% of respondents either positive or neutral about these statements. These five statements also recorded a mean of 3.47. The data shows that majority of students perceived that the design principles (design principles five, six and twelve) were successfully implemented in SimuLab and they were quite positive about achieving the objectives of using SimuLab. Additionally, the students’ comments given in focus groups showed that 60% of them agreed that what they learned from the online simulation actually helped them in this subject in development of their knowledge and skills. Furthermore, most of the students felt that they could now confidently apply this new knowledge that they had learnt from the online simulation in real life was related.

This perception of achievement is supported by the outcomes of the quiz after the completion of use of SimuLab. The results of an independent t-test show that the average marks for a quiz on the content of SimuLab in 2013-2015 (pre-simulation teaching) were lower as compared to 2016 and 2017 (use of simulation in teaching). The average results (2017 – iteration 2) for this section of the subject were 13.5% higher compared with students who studied the subject in previous years (2013-2015) without access to SimuLab. This shows that students using SimuLab did better than previously years without access to SimuLab. This indicates that the participants may have benefited from the online simulation and indirectly improved their knowledge in this subject. This also supports the student's belief, as expressed in the questionnaires and focus groups, that SimuLab supported their learning and understanding of the difficult and complex nature of this subject.

The answers to the previous research question indicates that the students believed that SimuLab was well designed in that it effectively incorporated well developed design principles and their responses to this research question indicated that they believed that the use of SimuLab improved their learning outcomes. Additionally, the quiz results indicated that the students' knowledge and skills were higher than for students who did not have access to SimuLab. This aspect of the study however must be viewed carefully as the quiz results reported are from different cohorts of students over time and students who attempted iteration 2 of Simulab had a much fuller version of the MUVE to support their study of this subject than students who attempted iteration 1 of the MUVE.

Again, as mentioned in Chapter 5, the above data (quiz results) are not experimental data. The data does show that the students using SimuLab did better than previously years, with the students using iteration 2 with expanded content and interactivity doing the best of all student cohorts. This does suggest improvement in learning outcomes when using SimuLab. Further research is needed to support any claims of better outcomes.

6.3 Findings of the Study

Findings from both Iteration 1 and 2 show that most students had none or very little experience in using Second Life but they have provided positive feedback towards using the online simulation in SimuLab for their study. Furthermore, many of them mentioned that visual representation of equipment in the simulation was so much better than text and diagrams in textbooks. Also, most of the respondents believed that the online simulation was presented in an appropriate way and the content presented in the online simulation was relevant to their subject and they believed they had a good experience when using SimuLab.

El Tantawi et al. (2013) have conducted a similar study to allow students to undergo a virtual orientation session and access reading materials and practice clinical procedures. El

Tantawi et al. (2013) have reported that all students in this study agreed that their educational experience in Second Life was fun and useful. No doubt that this was a better result but there were only 16 students from a dental school involved in this research, so the sample size was quite small.

As for the questionnaires, the data shows that students believed that the design of SimuLab effectively implemented design principles drawn from the "4A Motivational Model" with the four factors, attention, authenticity, achievement and appropriateness successfully implemented and integrated into the MUVE. These factors managed to capture students' attention and offered students an authentic experience. Furthermore, these factors fulfilled students' learning needs by providing adequate knowledge in Computer Networking and providing appropriate content in SimuLab. In summary, the respondents supported the factors of the "4A Motivational model" as crucial design principles for this type of simulation.

Broom et al. (2009) conducted a study in University of Glamorgan to allow groups of nursing students to use online simulation before clinical placements. In this study, 87% of students perceived that computer simulation to be a suitable tool to assist nursing students gaining new skills before placement (Broom et al., 2009). Furthermore, all nursing students that took part in the survey agreed that this simulation had helped them in applying knowledge to practical contexts (Broom et al., 2009). It is difficult to make a direct comparison of the outcomes of this study and Broom's study as a different scale for student responses was used and different questions were asked, but there is scope for a limited comparison. For this study five statements in the questionnaire for both iterations sought students views about if they had learned new skills and knowledge from the online simulation (SimuLab) and this data is comparable to Broom's question in that the data addresses the question of whether the students believed they had gained new skills and helped them to apply knowledge. The results of both questionnaires show 51% of the 62 students agreed on these statements and 40% of them were neutral, only nine percent of them did not agree to these five statements. These results are more positive than Broom's findings (Broom et al., 2009) as only 9% of students indicated that the online simulation was not a suitable tool to teach the networking, compared with Broom's study where 13% of participants were of the view that the tool was not suitable to teach nursing content. One significant difference in the studies was the use of a less authentic setting in

Broom's environment that is the use of cartoon characters that could have influenced the findings.

Deale (2013) conducted a study in the United States in Second Life to train hospitality students to showcase the hotel rooms, site visits, and case studies for projects. In this study, 78.6% of the students believed that Second Life was effective as a virtual classroom space for an online class. Deale (2013) has argued that students benefited from obtaining experiences online by "visiting" the scenarios virtually, dealing with different scenarios which are difficult to setup and by developing skills in practical sessions. Again, the results from the five statements from the questionnaires from this study were better compared to Deale (2013), 91% of the respondents in both iteration 1 and 2 agreed or were neutral that the online simulation was a suitable tool to teach the networking subject.

As for the learning outcomes in both iterations, the researcher can conclude that students from iteration 1 and 2 have benefited from SimuLab and this has helped these students to not only gain more knowledge under networking subjects, this also help them to gain better result in quiz. The average mark between 2016 and 2017 were significantly different and the average marks for 2017 is more than five marks (10%) as compared to 2016. The average marks between year 2013 – 2015 and 2017 were more than six marks (12%) that was significantly different. The major difference between iteration 1 and 2 implementation were more than strengthening some elements of the design, SimuLab in iteration 2 contained more 3D content and simulations, this could be the reason why students appeared to be more successful. This study then is supported by the literature reported here in that similar studies, using Second Life as a simulated learning environment, have all shown positive participant responses to the use of simulation to support either complex learning needs or avoid costly setting up of equipment or unethical use of patient data to develop skills and knowledge.

6.4 A Design Framework for the use of MUVEs in Educational Contexts

The design of MUVEs to support skill and knowledge development has not been well explicated (Rogers, 2011). This study attempted to develop a design framework for this context, through evidence based design principles and a theoretical framework to support the motivation of users to develop their skills and knowledge in either complex content that is difficult to teach in lecture or setup in the laboratory. To test the framework the researcher applied three layers of design principles in the design of the online simulation SimuLab. The first layer was based on design principles for Virtual Environments with a strong set of underlying assumptions, the second layer was based on design principles drawn from the 4A Motivational Mode and lastly, the third set of design principles are drawn from the broader perspective of technology supported learning settings.

6.4.1 Design Principles for Virtual Environments.

The researcher developed the online simulation, SimuLab, in Second Life based on the well-established design principles for virtual environments. The main key design principle is interactivity. Interactivity commonly takes the form of social interaction between users and interaction between users and objects in Virtual Environments. The students supported the claim that interactivity was well implemented in SimuLab through their responses in focus groups agreeing that they spent a lot of their time in interacting with the simulation components in SimuLab.

The researcher also incorporated learner support for users, which is the second design principle for virtual environments. Second Life has learner support incorporated into it as one of the main features. Users were trained on the basic skills in using Second Life after they have created new avatar. In order for the researcher to more effectively implement the second key design principle for Virtual Environments, the researcher conducted a series of briefing sessions for students to improve familiarity with the features of Second Life.

The next design principle for Virtual Environments is to support different type of media in the Virtual Environment Platform. Second Life is able to support different media and allow the content creator to development their creative ideas in alternative media. Students in both iterations were happy to see all the network equipment in 3D as they could interact with the 3D objects in the online simulation and they also felt that the videos and slides in SimuLab were helpful.

The last design principle for Virtual Environments is the use of avatars, digital representations of users in the virtual world is another. Second Life allowed user to choose their own avatar before they “enter” the Second Life’s world. Second Life also allowed users to customize their avatar based on individual preferences.

6.4.2 Design Principles based on 4As Motivational Model.

There are four design principles that have been drawn from the "4A Motivational Model", attention, authenticity, achievement and appropriateness. The model has been explicated and argued for extensively in sections 2.12.2. The model is based on the argument that motivation is a key driver for student learning and effective implementation of design principles derived from the model will result in close engagement of students and consequently stronger support for learner construction of their own knowledge (Ryan & Deci, 2000). The four pillars of the model, attention, authenticity, achievement and appropriateness can be used both as a key component of the framework for design of MUVEs, and the basis of the tools to measure the success of the model in its application to design.

The most significant design principle is incorporating of interactivity in "SimuLab". In "SimuLab", users are allowed to interact between each other, they are allowed to interact with any objects in the simulation lab and users are able to zoom in/out an object in Second Life, manipulate the status of the object and many more. All of these features allow close interaction between users and the content of the virtual environment. With the existence of this level of interactivity in the online simulation, the users' noted their high level of engagement with the content. Students in Iteration 2 gave credit to interactivity in the online simulation and noted that they found many interactive objects in the online simulation, which allowed them to learn in an interactive way. Other students found that the simulation was fun as it had many interactive attributes that contributed to the fun of using the simulation.

The researcher incorporated learner support for using the Second Life platform through Facebook as well as the in-built tutorials and face-to-face instruction to introduce students to the simulation. The researcher created two Facebook groups, one for each iteration that was used to support users for any Second Life related issues. This allowed users to ask any questions related to Second Life and SimuLab in the group. With that, the level of confidence on using the MUVE platform was improved as students noted they achieved their objectives and this led them to feeling proud of themselves after using online simulation in Second Life. Furthermore, in the 2^{nd}

implementation, the researcher incorporated quiz corner where students were allowed to test their networking knowledge after completing the simulations. A leader board display in the simulation lab displayed the top 10 high scores. Students in focus groups suggested quiz corner and the leader board for Iteration 1.

The third design principle drawn from the 4A Motivational Model was to offer authentic learning activities in the online simulation. The setting of "SimuLab" mirrored a networking lab where the students find most of the network equipment exhibited and used in the network settings. Furthermore, students were allowed to select different type of network settings from the menu in SimuLab. After that, they were allowed to interact with the network equipment such as changing the status each of the equipment to figure out the consequences of their actions, these were the typical practical tasks in the networking laboratory. Besides, students were to observe the status of the network settings after their interaction with the network equipment. For example, they were able to observe different outcomes when they performed the same action on the same network equipment in different network setting or on different network topologies. With this, students can easily understand the characteristics of each network settings or network topologies. Some of these actions are prohibited in the ordinary networking lab as they may cause damage to equipment or network, but simulation allows students to make these decisions without disastrous consequences and they can understand the consequences by observation. Students in focus groups thought that the online simulation in Second Life was authentic in that they could see the network equipment in 3D, which looked like the real object. One student praised that the interaction in online simulation was more interesting compared with only diagrams and text from textbook. Furthermore, they could also interact with these 3D objects in the online simulation.

Lastly, the content used in the online simulation followed the year 1 networking subject syllabus (chapter 1 and 2) from the University of Wollongong, and the online simulation was targeted for year one students from both computer science and information technology programs. The lecturer for this subject has confirmed that the content and topics used in the simulation lab were relevant to their studies and suitable for users' level of study. 21 out of 22 students who participated in focus group for both iterations agreed that the online simulation was presented in an appropriate way and they also felt that the content presented in the online simulation was relevant to their subject.

6.4.3 General Design Principles for Technology Supported Learning Settings.

As for general design principles, the researcher developed "SimuLab" using different media as a key feature when designing 3D virtual worlds (Gül et al., 2007). Gül et al. (2007) have argued that designing in 3D word requires different media, from using text, 2D images, 3D models, video and etc. The students were very interested in the 3D models of routers and switches when accessing SimuLab. They stated that they liked to interact with the simulation and felt that the slides in SimuLab were helpful.

The second general design principle is authentic learning which the researcher had in mind when SimuLab was developed. SimuLab had incorporated authentic tasks and real-life problems, which allowed students to experience the authentic settings. The students then confirmed this through focus groups where the majority of students gave positive feedback towards SimuLab and commented that they believed the 3D models and simulation appeared authentic.

Lastly, the researcher has incorporated interactivity to SimuLab. Most of the items in SimuLab are highly interacted, which will help to increase the student's attention span when using the 3D virtual world. The researcher had in mind to meet the users' requirements and have the right level of feedback when developing SimuLab. This principle is the same as a design principle for Virtual Environments, as reported in with general design principles, the students agreed during the focus group discussion that they spent a lot of their time in interacting with the simulation components in SimuLab and they believed that the online simulation was more interesting compared with diagrams and text from textbook.

6.4.4 Summary of Design Principles Development and Implications for the Design Framework.

The design principles used to develop the first iteration of SimuLab have been extensively described in chapter 2 and can be summarized as: -

- Use extensive interactivity
- Capture the learner's attention and maintain it throughout the learner experience
- Incorporate design elements that stimulate both sensory and cognitive curiosity
- Incorporate attractive visual design
- Facilitate learning support and achievement feedback
- Make effective use of a variety of media
- Facilitate user interaction with content and other users
- Use authentic learning settings, activities and real-life problems to solve
- Relate the learning activities to real life tasks
- Use content that is linked to users' needs and future goals
- Incorporate levels of difficulty matched to users experience and skills.

Additionally, feedback from this initial implementation indicated that students reported deficiencies in feedback for both user support and achievement. This was addressed in iteration 2 through incorporation of a quiz for self-assessment of their knowledge and tutorials, both internal to the simulation and face-to-face before use of the simulation. In this case, no new principles were added, but the design strengthened to address the deficiency. Following analysis of the data from the second iteration, the researcher proposed to include another design principle which was to "incorporate onboard assessment" in the online simulation such as a multiple-choice quiz for participants to complete the full cycle of online simulation after they have done with the practice. The onboard assessment can also allow participants to self-knowledge-check on how much they have achieved based on the learning outcomes of the online simulation. The onboard assessment can come with the leader board to show the top scorers for the onboard assessment, the leader board will further motivate the participants to practice well before attempting the quiz to make sure they are the top scorer. Then a further design principle of

- Onboard assessment

  has been added to the design principles of the framework.

6.5 Limitations of the Study and Future Research

This study is limited in that it has been implemented as an initial investigation of the use of a simulation, in the form of a MUVE, to improve the learning experience and outcomes from students studying the challenging body of knowledge of computer network in information sciences degrees. As such, it is limited in the number of participants accessible to the study and thus the scope, as well as the potential for any analysis beyond descriptive statistics. Moreover, data on engagement of the students has been limited by limitations of the tool used in the ability to collect student time on task and interaction. Additionally, the use of a 5 point Likert scale may have limited the range of responses that students were able to offer and a broader scale, such as a 7 point scale may have helped students to differentiate in responding to questions where they may have not felt neutral, but the 5 point scale did not give them to opportunity to do so.

The use of the A4 model is also a limitation in that the model is a construct that has been argued specifically for this study and has not been previously used as a framing for this type of investigation. This brings with it some limitations in the lack of access to previous studies and also a lack of validation of the model.

Additionally, the time-on-task data is not available for this research. The author placed a trigger at the entrance of SimuLab building that welcome all the visitors. At the same time, it was used as the visitor counter that collect data on how many visitors that have entered the building through the main entrance. However, this trigger can only gather the data when the visitor enter from the main entrance. For instance, after the visitor enter the building, if the visitor log off inside the building and log in again later, it will not gather any information of the visitor in their subsequence visits as the visitor will be placed in the exact location where they log off earlier.

However, the analysis does show some important trends in the use of such environments and some potential for success as well as a way ahead for further research. Additionally, the 4A model appears to have been an effective guide to developing aspects of the design principles and an effective mechanism to evaluate the outcomes of the study. This model has not been used in this way before and so further investigation of the effectiveness of the model in supporting design needs to be examined through a validation process. This would need to be carried out through broader use of the model. The outcomes of the study offer an opportunity to develop an experimental study incorporating control and experimental groups through access to a much larger number of participants by implementing a larger study on the home campus with up to one hundred students. Such a study could incorporate a cross over experimental research design with the full subject implemented in Second Life with the experimental group and control group changing modes at mid-session ensuring equity in the study as well as a mechanism to test hypotheses. Additionally, the use of the model by multiple designers implementing the subject at multiple locations would be an opportunity to investigate designer use and understanding of the model and validation within an experimental context.

Lastly, Second Life supports interaction between users and also users and objects. The setup in this study also allowed users to interact with both users and objects, but interaction with other users was not compulsory for them and this type of interaction is hard to be tracked in Second Life. In other words, social interaction was ready in SimuLab but was not required. Also, SimuLab was mainly focused on the simulation process which the interaction between users and objects are crucial and was embedded in the simulation. Furthermore, SimuLab is open at all hours and the simulation are ready for the participants at any time. However, it was not compulsory for them to "meet" up with others and interact with each other while working on simulation.

6.6 Final Recommendations

The proposed simulation could offer a safe practical space to solve problems with complex networking equipment use and develop work ready graduates from the information science program. Outcomes are promising in addressing the problem of the difficulty of teaching this complex subject. The design principles adopted appear to have been instrumental in the positive outcomes for this teaching intervention. It is clear that there is room for further developing the design principles to look more closely at how the implementation of principles can be illustrated and verified and to add specifications about activity design. Additionally, assumptions about learner skills in using such learning settings need to be considered carefully in that MUVEs are very complex environments requiring a significant investment of time by learners to develop the navigation skills and protocol knowledge to effectively use the tools for successful and efficient learning, emphasizing the importance of well developed design principles and associated activity design. It is recommended that the University of Wollongong support the implementation of an experimental study to increase understanding of potential outcomes of this type of curriculum tool. It is also recommended that the University take up this teaching intervention across all of the campuses and sites where this subject is offered because of the student perception of success in the study of network content and skills.

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Appendices

Appendix 1

1. Independent Samples Test

Table showing the, an Independent samples test showing the difference in the average scores for 19 of the 20 statements in the Set B questionnaire for Iteration 1 and Iteration 2 are not significant, while for question 12c, there is a significant difference.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
							Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig.			Lower	Upper
9. Attention [a. The content in "SimuLab" captured my interest and stimulated my curiosity]	Equal variances assumed	.982	.326	1.001	60	.321	.193	.193	-.193	.579
	Equal variances not assumed			.962	42.852	.341	.193	.201	-.211	.597
9. Attention [b. The multimedia elements used in Online Simulation motivated me and aroused my attention.]	Equal variances assumed	1.171	.284	1.613	60	.112	.366	.227	-.088	.820
	Equal variances not assumed			1.556	43.325	.127	.366	.235	-.108	.841
9. Attention [c. The variability of instructional strategies helped keep my attention]	Equal variances assumed	.563	.456	.587	60	.559	.121	.205	-.290	.531
	Equal variances not assumed			.606	53.918	.547	.121	.199	-.279	.520
9. Attention [d. The way the content is arranged in SimuLab helped keep my attention.]	Equal variances assumed	1.811	.183	.282	60	.779	.064	.226	-.388	.515
	Equal variances not assumed			.299	57.746	.766	.064	.213	-.362	.489
9. Attention [e. I like using online simulation for my learning more than face-to-face instruction.]	Equal variances assumed	.593	.444	1.213	60	.230	.281	.231	-.182	.743
	Equal variances not assumed			1.223	50.344	.227	.281	.229	-.180	.742
10. Authenticity [a. The content of the online simulation was authentic]	Equal variances assumed	.775	.382	-.456	60	.650	-.105	.231	-.567	.357
	Equal variances not assumed			-.430	40.093	.669	-.105	.245	-.600	.389

10. Authenticity [b. The online simulation used real life examples]	Equal variances assumed	.225	.637	-.629	60	.532	-.123	.195	-.513	.268
	Equal variances not assumed			-.644	52.720	.523	-.123	.191	-.506	.260
10. Authenticity [c. The online simulation provided sufficient real life examples]	Equal variances assumed	.072	.790	1.492	60	.141	.305	.204	-.104	.713
	Equal variances not assumed			1.537	53.655	.130	.305	.198	-.093	.703
10. Authenticity [d. The equipment in online simulation was easier to use compared with real life]	Equal variances assumed	.000	1.000	1.505	60	.137	.362	.240	-.119	.843
	Equal variances not assumed			1.534	52.030	.131	.362	.236	-.112	.835
10. Authenticity [e. The activities in the online simulation would be hard to implement in real life.]	Equal variances assumed	.064	.801	.011	60	.991	.002	.204	-.406	.411
	Equal variances not assumed			.011	51.499	.991	.002	.201	-.401	.406
11. Achievement [a. I could control the success of learning outcomes]	Equal variances assumed	1.888	.175	.948	60	.347	.189	.199	-.209	.586
	Equal variances not assumed			.999	56.750	.322	.189	.189	-.190	.567
11. Achievement [b. I can establish the direction of self-learning after using online simulation]	Equal variances assumed	3.870	.054	1.863	60	.067	.393	.211	-.029	.814
	Equal variances not assumed			2.021	59.445	.048	.393	.194	.004	.781
11. Achievement [c. I am confident that I can make good use of the knowledge in Computer Networking]	Equal variances assumed	1.190	.280	1.503	60	.138	.307	.204	-.101	.716
	Equal variances not assumed			1.562	54.919	.124	.307	.197	-.087	.701
11. Achievement [d. Completing the online simulation gave me a satisfying feeling of accomplishment]	Equal variances assumed	1.464	.231	1.257	60	.214	.279	.222	-.165	.722
	Equal variances not assumed			1.328	57.113	.189	.279	.210	-.141	.698
11. Achievement [e. I got useful learning experience from the online simulation]	Equal variances assumed	.346	.558	.945	60	.348	.193	.204	-.216	.601
	Equal variances not assumed			.907	42.611	.369	.193	.213	-.236	.622
12. Appropriateness [a. The content in SimuLab met my personal needs and goals.]	Equal variances assumed	.642	.426	.375	60	.709	.090	.240	-.390	.570
	Equal variances not assumed			.380	51.410	.705	.090	.236	-.385	.564
12. Appropriateness [b. The content in	Equal variances assumed	.634	.429	.294	60	.770	.061	.209	-.356	.479

SimuLab used concrete examples to illustrate the knowledge in computer networking]	Equal variances not assumed			.300	51.914	.766	.061	.205	-.350	.473
12. Appropriateness [c. It is clear to me how the content in SimuLab is related to things that I already know]	Equal variances assumed	2.911	.093	2.829	60	.006	.518	.183	.152	.884
	Equal variances not assumed			3.035	58.660	.004	.518	.171	.176	.859
12. Appropriateness [d. I have integrated the knowledge and skills that I learned in SimuLab into studies and daily life]	Equal variances assumed	1.232	.271	.872	60	.386	.173	.199	-.224	.570
	Equal variances not assumed			.917	56.453	.363	.173	.189	-.205	.552
12. Appropriateness [e. I could relate the content that I learned in SimuLab to my study and daily life]	Equal variances assumed	.973	.328	.374	60	.709	.079	.211	-.343	.501
	Equal variances not assumed			.389	55.086	.699	.079	.203	-.327	.485

Appendix 2

2. Focus Group Transcript – Iteration 1

Question 1: In your own words, could you describe this online simulation in Second Life? Or can you share some of your experiences in using this online simulation?

Student 3: It is pretty interesting, as when I enter it, I see a lot of people, a lot of movement around, when I enter the link, I was sent into a house, with a lot of videos and slides, but for me, I find is a bit difficult to move my character. I have no idea is that is my problem or others also faced the same problem.

Student 1: I am not very much a game person, so it is hard for me to describe it, it is pretty difficult to move the avatar, sometimes it just lag, but it is on my opinion, the channel of medium using online simulation might not be suitable for me, I prefer the old fashion way.

Student 2: Online learning in this way is quite effective compare with the conventional way of learning, caused you can do it anywhere.

Student 6: Simple, need to try to walk here and there, if you get missing, you need someone to guide you. Maybe need some games, if we put game inside, we will spend more time inside.

Student 7: I think need more content, it just 2 floors, it can complete like 10 mins.

Question 2: What was the most important thing you learned in this online simulation?

Student 5: I have different type of experience, is a different form of learning, what I going through is SL is better than Blackboard, not like the same thing the lecturer uploaded to blackboard.

Student 1: It is very different it seems, I think if we are to use this, we need a class just to introduce the system to students. Especially those who have never play 3D game before. People just like me, as I am not much a gamer, so for me that's a bit difficult.

Student 3: Not everyone is tech savvy, not everybody would understand what is going on. Specially for girls as most of them do not play game.

Student 6: Don't get lost.

Question 3: Do you feel you will use what you learned from this lesson in the networking subject? If yes, how? If no, why not?

Student 1: I think is a bit more intuitive, you will feel more engage with the lesson (interact), this will help me remember the notes a bit better,

Student 3: You can learn together with people that you do not know them, in college; we just learn with our friends, in this situation, we do not need to know the person.

Student 2: maybe this is also anonymous, so it is like you will not discriminate anyone here or see somebody differently, everyone will be respected for the opinion equally.

Student 1: Ya, I think I will use it quite frequently; I think this it quite interesting, like we want it interesting and remember stuffs a lot better.

Student 5: I think we can learn better now compare to what we do now with Moodle or Blackboard.

Student 7: Yes, can use it in exam.

Student 6: Some of the video is related to our quiz.

Question 4: Did you find the content in SimuLab captured your interest? Why or why not?

Student 5: Okay, at first when I went inside the room, I saw a box there and when I click on it, it popped-up a video, like why suddenly got noise as for me, I work simultaneously, I will use Alt-Tab when I work on my things, I heard some noise from the lab, then I go back and check about it and found that's the noise from a video. I thought this will link me to YouTube.

Student 4: I think for me is a no, I think is very very hard to understand what is going on, I think the setting, when I click on the setting, I want to tweak, and then my computer is overheated and I cannot really do that, it is very hard to find the video settings.

Student 1: I think is the same for me, as I said I am not a game person, so I wasn't so good on that, so I think the introduction class on how to use this system will help.

Student 2: 3D stuffs like modem, routers all around, projector, the animation and we walk around.

Student 6: For 1 part is yes, which is the simulation part, keep playing on that again and again.

Question 5: Did you find the online simulation in SimuLab authentic or not? Why?

Student 2: Basically the equipment are in 3D, it looks more interesting, as if you are living in that world.

Student 3: Actually you can make a game session, like a leaderboard, like make it more interesting, make learning more competitive.

Student 6: More or less yes, cause from this we can touch it, in the normal lab, we cannot touch it, cannot on and off.

Question 6: Do you feel you can confidently apply what you have learned in the online simulation? Why or why not?

Student 2: Yes, I would not say 100%, I would say somewhat related, it acts like a supplement together with the notes, like after we have finished studying all the notes, and we come to SL and have a look, refresh again, something like extra notes.

Student 7: I think so. The model of hub and switch and servers.

Student 6: The video part, and the simulation part are quite useful.

Question 7: Do you feel the online simulation was presented in an appropriate way? Why or why not? Was it relevant to ISIT105? Why or why not?

Student 2: It is sort of appropriate, maybe the chapters there are organized properly, and you will sort of knowing which topics are on which.

Student 7: Yes.

Student 6: Yes, it is related.

Comments:

All students felt that the simulation was presented in an appropriate way and organized properly. One student noted they could easily identify which part belongs to which topic.

Question 8: What benefits do you perceived with this online simulation?

Student 2: is like a 2nd experience, I think no one has try before among my friend, this is my first time trying SL, not many has tried before.

Student 3, 5 : This is my first time as well.

Student 6: Play whenever you can. You can just experience it and you can just look through the slides.

Question 9: What concerns do you have regarding the use of this online simulation?

Student 1: Maybe if we use alone, we might think that this is everything already, traditional notes will also be needed.

Student 7: Stuck in the wall.

Student 6: Missing in the simulation, suddenly go through the wall, suddenly flying.

Question 10: What additional support do you wish you had in the online simulation and from whom?

Student 1: Yes, the introduction class.

Student 2: Make (force) everyone use it, then we can talk with friends here. You can start this like a community.

Student 7: Hard to find the place at the beginning.

Student 6: Not really difficult to use. I need help to find the place, especially when I missing. Then I am not sure who to ask. Missing in the same area.

Question 11: What improvement or changes do you hope to see in this online simulation?

Student 2: The fluidity of the movement in the game, like make it more fluid when you move, when you interact with the program, make it smoother.

Student 1: I think now more students are gamers, so they will have very high expectation on graphic and stuff.

Student 4: The optimization of the game.

Student 3: Should add in quizzes like after we finished the simulation, this can test our knowledge, and then we can challenge our friend by putting a leaderboard for our scores. Makes you want to be better than them. You will work harder and spend more time.

Student 7: More content in SL, more simulation and more models.

Question 12: Do you have any additional comments or questions about this research study?

Student 1: I find it quite applicable for degree students. This is not something new but it showed us this is like something happens around us and encouraged us to try out on this. In future, try to develop something like this.

Appendix 3

3. Focus Group Transcript – Iteration 2

Question 1: In your own words, could you describe this online simulation in Second Life? Or can you share some of your experiences in using this online simulation?

Student 1: When I first enter Second Life, it is quite lag in the afternoon, not sure what problem was it, but it was fine when I enter after 12 midnight.

Student 2: Doesn't perform as good as mainstream game, at least should be on par with game, it takes a lot of my laptop performance.

Student 3: I tried this before, no different from my first try (SL), same control.

Student 4: I need a new account for Second Life, I am under age, I need to be 18 to create account. I cannot look around the virtual lab without that, I thought I can look around.

Student 5: When the first time I enter SimuLab, it is very exciting and this is something new, but kind of disappoint me was when I went to the virtual lab, it was quite lag, my internet was okay. When enter to SimuLab, when I played the video on the ground floor, I waited for few minutes to load and the video started to play only when I went off. When I were on the first floor, I wasn't know the location of the quiz, no other problem other than that. I wasn't know how many marks I have for the quiz, I can only see that quite some time after I clicked on the answer, I am not sure is my computer problem or internet problem.

Student 7: At first, the online simulation looks like prominent to me but later I found out that it is quite buggy, maybe my computer is not powerful enough, using the simulation was quite lag and not smooth for me. I managed to go in and it was kind of eye catching, but using it is quite lag. Using the simulation was fun as it has the interaction attributes but it was lag in my computer. The models were like real and I still have not seen that in real life but in simulation, I was able to see the model in 360 view and zoom in as well, I was informed about these equipment.

Student 10: The models (Switches & Routers) on the table were not detailed as in the exhibition area. The real one will have more ports.

Student 11: I think everything is well managed, instructions can lead you to everywhere, the SimuLab has a lot of interaction items, and a lot of information, and it makes learning more interactive.

Student 12: First Impression is quite lag, the computer with lower specs takes longer time to render the graphics.

Student 13: My first impression on Second Life is quite confusing, I am not sure where to go but slowly I managed to visit more places including the SimuLab.

Student 14: Some of the map view function that will lead to confusion.

Student 15: In the aspect of control, is quite annoying, using both mouse and keyboard to control and sometimes you will stuck inside the wall.

Question 2: What was the most important thing you learned in this online simulation?

Student 2: Learning to adapt with new control for Second Life.

Student 3: Simulation is very useful for us, the rest are the same.

Student 4: For me, the best thing is when you can interact with the topology in the simulation.

Student 5: This is very useful for people like me who will stay up at night and when you need help, you may ask my lecturer some question (if he stays online), it will be much easier.

Student 8: I believed that some stuff in the simulation is easier to understand compare to normal class as it can be interacted. That's the key component in this simulation and also the visual understanding compare to slides only in normal face to face class.

Student 11: I watched the video and I understand how packets travels through the routers and switches and arrived at the recipients, previously I did not know how the entire process works. The videos help a lot.

Student 12: I also learn the physical appearance of routers/switches, previously I don't have any idea how these look like. Although it is not the exact size, but you will at least know how the equipment look like.

Student 13 and 14: agreed with student 11 and 12.

Question 3: Do you feel you will use what you learned from this lesson in the networking subject? If yes, how? If no, why not?

Student 1: Yes, this will help in my subject, the topics here is also in my networking subjects like WAN, LAN and etc. I have downloaded the slides also.

Student 2: I studied about this before.

Student 3: The models at the second floor will help us to remember.

Student 4: For me, the best thing is when you can interact with the topology in the simulation.

Student 6: Yes

Student 7: Ya

Student 8: Yes, things like OSI layer, Topologies.

Student 9: Ya

Student 10: Ya

Student 11: The videos help me to visualize how the actual process of the packets travel through the internet.

Student 14: More details on equipment in the SimuLab

Question 4: Did you find the content in SimuLab captured your interest? Why or why not?

Student 2: I think is a little bit too much, watching video in a game is laggy.

Student 7: Yes, the environment.

Student 9: The slides are helpful.

Student 10: The switches, the model there quite interesting.

Student 11: It is like something is physical that we can see, such as topology, in normal class, only in diagram or text form, it is not interesting but in SimuLab, we can see something just like in real life.

Student 12: Graphical representation of model, because in normal teaching only explain using text but this simulation allows us to visualize the actual process and how it related to the concepts.

Student 13: I feel like pictures, videos in SimuLab attracted my attention the most.

Question 5: Did you find the online simulation in SimuLab authentic or not? Why?

Student 4: It is good if you can make every topics in this subject (CSIT127) the same as the LAN/WAN simulation.

Student 7: It does look like real life and realistic but you need a powerful graphic for that, if we can have VR headset for simulab, we will be able to immerse in the simulation.

Student 10: Some models look like real life equipment

Student 11: Ya, I do, it looks like Museum, everything on the wall, structure with information on it.

Student 12: Even though is not exactly the same size of real life, but it is sufficient for learning.

Question 6: Do you feel you can confidently apply what you have learned in the online simulation? Why or why not?

Student 1: Something new.

Student 2: Not very confident for me.

Student 4: I am really interested in the second floor but I cannot do much about it.

Student 6: Yes.

Student 7: Something that is visual, you can see it from the simulation that will help us to understand more and gain information.

Student 8: Yes.

Student 9: Yes.

Student 10: You can understand Topologies easily by seeing how it was arranged on the table with the laptops and switches.

Student 11: In my studies yes.

Student 14: Yes

Student 15: Yes as student.

Question 7: Do you feel the online simulation was presented in an appropriate way? Why or why not?

Student 1: Ya

Student 2: Ya

Student 3: Ya

Student 4: Ya

Student 5: Ya

Student 6: I don’t think is easy to understand Second Life. You need to ask someone on how to use.

Student 8: It is only when we start to use, after that is okay.

Student 9: Yes

Student 10: Yes

Question 8: Was it relevant to your subject CSIT127? Why or why not?

Student 1 to 15: All say yes

Question 9: What benefits do you perceived with this online simulation?

Student 1: Can do it at home.

Student 3 & 4: Learn something new

Student 5: Learn something new anytime, anywhere.

Student 10: More networking information.

Student 11: Ya, I think it has to do with exploring and learning, in SimuLab, most students are supposed to explore the space, new information will pop up and they are supposed to read and gather information while exploring and interacting with others.

Student 14: The background sound is quite annoying.

Question 10: What concerns do you have regarding the use of this online simulation?

Student 2: Computer hardware. Will be laggy when there is more people.

Student 7 & Student 10: Lag, need high specification.

Student 11: for students that never expose to game or simulation will find it hard to go around and explore the new environment.

Student 12: because Second Life is not make for this purpose, some of the features in SL are not suitable for simulation.

Student 13: Agreed with Student 11.

Question 11: What additional support do you wish you had in the online simulation and from whom?

Student 5: Many students can do the quiz together.

Nothing specific for student 6 to student 15.

Question 12: What improvement or changes do you hope to see in this online simulation?

Student 2: Just the quiz.

Student 7: When I was using the slides, it doesn't use too much of processor power, but this simulation will take more power, it is kind of making the computer slow and not convenience. (Lower the hardware requirements and network), can add VR head set.

Student 12: To have timer for the quiz.

Student 13: Maybe not just the house, more places for us to explore. Quiz can be multiple person to do at the same time.

Question 13: Do you have any additional comments or questions about this research study?

Student 3: I expected SL to be like that.

Student 4: I prefer first person view, but if I am in the first person view, I won't be able to see anything.

Student 11: Some students do not know what SimuLab is all about. Should have more information on that.

Student 13: I feel like this is good.

Student 14: Good and something new for us.

Appendix 4

4. Questionnaire – Set A

QUESTIONNAIRE SET A (Prior to the Online Simulation)

Title: Investigating the Design and Implementation of Educational Multi User Virtual Environments in Second Life applied to Information Sciences.

The research aims to investigate how design components of online simulations in Multi User Virtual Environments (MUVEs) may impact on students' learning motivation in higher education. This study will involve the development of a set of educational MUVEs design principles, implementation of a design example with authentic tasks and then testing the design within classroom settings using a design based research paradigm and finally the development of a design framework based on these research outcomes.

Section A: Demographic Details

1. How old are you? *
   - o 17 – 18
   - o 19 – 20
   - o 21 – 22
   - o 23 – 24
   - o 25 – 26
   - o Above 26
   - o

2. Please specify your gender. *
   - o Male
   - o Female

3. Please specify your nationality. *
   - o Malaysian
   - o Other:

4. What level of Computer Science / Information Technology / Computing Programme are you currently studying in your Institution? *
   - o Diploma
   - o Degree

5. What specialization are you studying? *
   - o Computing / Computer Science
   - o Information Technology / Information Systems

6. What major are you specialized in? *
   - o Networking / Data Communications / Security
   - o Business Intelligence
   - o Software Engineering
   - o Artificial Intelligence / Knowledge Management
   - o Internet / Web / Mobile Development
   - o Multimedia / Game Development
   - o E-Commerce / E-Business
   - o Other:

7. How long have you been studying in your university / college? *
   - o < 1 year
   - o 1-2 years
   - o 3-4 years
   - o 5 years and above

8. Which of the following technology devices do you own or use? *

(You can select more than one)

- o Smartphone
- o Desktop
- o Laptop / Netbook
- o Digital Tablet

Section B: Prior Experience - Computer Games

9. Have you played computer games before? *

- o Yes - continue question 10.
- o No (will proceed to Question 14)

Section B: Computer Games

10. How many hours a week do you play computer games? *

- o < 1 hour
- o 1 – 2 hours
- o 3 – 4 hours
- o More than 4 hours

11. What are the barriers or problems that you have encountered in playing computer games? *
(You can select more than one)
Check all that apply.

- o Privacy concerns
- o Interfering with personal time
- o Limited hardware or internet bandwidth
- o Unfamiliar with the functionalities / features of computer games
- o Other:

12. Do you find playing games interesting? *

- o Yes
- o No

13. Do you think it can be useful to use computer games for academic purposes? *

- o Yes
- o No
- o Maybe

Section C: Prior Experience - Online Simulations

14. Have you used online simulations before? (For example training simulation for vehicle or equipment) *

- o Yes - continue question 15.
- o No (proceed to Question 19)

Section C: Online Simulations

15. How many hours a week do you use online simulations? *

- o < 1 hour
- o 1 – 2 hours
- o 3 - 4 years
- o More than 4 hours

16. What are the barriers or problems that you have encountered in using online simulations? *
(You can select more than one)
Check all that apply.

- o Limited hardware or internet bandwidth
- o Unfamiliar with the functionalities / features of online simulations
- o Spending long time to learn how to use online simulations
- o Easily distracted and loss focus in online simulations
- o Other:

17. Do you find using online simulations interesting? *

- o Yes

- No

18. Do you think it can be useful to use online simulations for academic purposes? *
    - Yes
    - No
    - Maybe

Section D: Prior Experience - Second Life

19. Have you used Second Life before? *
    - Yes - continue question 20.
    - No (will proceed to Question 26) Skip to question 26.

Section D: Second Life

20. How many hours a week do you use Second Life? *
    - < 1 hour
    - 1 – 2 hours
    - 3 – 4 hours
    - More than 4 hours

21. What is your level of expertise in using Second Life? *
    - Beginner
    - Intermediate
    - Advanced

22. Please tick on the frequency of use for Second Life: - *

Mark only one per row.

	1 – Do not use	2 – Rarely Use	3 – Often Use	4 – Use all the time
For entertainment (i.e. watch video, concert and etc)				
To communicate / socialize / networking with friends (i.e. meeting, gathering and etc.)				
To share my skill / experience / knowledge (i.e. cooking skill, design artworks and etc)				
For academic purposes (i.e. to learn new skill)				
For collaboration (i.e. to work together in group project)				
To seeking advice (i.e. get someone advice about something)				

23. What are the barriers or problems that you have encountered in using Second Life? *
(You can select more than one) Check all that apply.
    - Privacy concerns
    - Interfering with personal time
    - Easily distracted and loss focus in Second Life
    - Feeling of being watched or stalked by others
    - Limited hardware or internet bandwidth
    - Unfamiliar with the functionalities / features of Second Life
    - Spending long time to learn how to use online simulations
    - Other:

24. Do you think it can be useful to use Second Life for academic purposes? *
    - Yes
    - No
    - Maybe

25. If Second Life is to be used for academic purposes, will you actively participate and contribute to the learning communities? *

- Yes
- No
- Maybe

Question 26 and 27 to be answered by those who chose 'No' for Question 19

26. What are your reasons for not using Second Life? *

- Never heard of Second Life
- Not interested
- Do not have the technologies to support the use of social media
- Concern about privacy issues
- Restricted by parents / guardians
- Not sure how to use it
- Waste of time
- Other:

27. Will you be considering using Second Life in the near future *

- Yes
- No
- Maybe

Section E: General Comments

28. Would you like to make any comments or give any advice about the use of Second Life for academic purpose?

____

____

29. If you have had good experiences in the using Second Life in your studies, would you allow me to contact you to discuss further? If yes, kindly please include your email.

____

____

Appendix 5

5. Questionnaire – Set B

QUESTIONNAIRES (After Online Simulation)

Title: Investigating the Design and Implementation of Educational Multi User Virtual Environments in Second Life applied to Information Sciences.

The research aims to investigate how design components of online simulations in Multi User Virtual Environments (MUVEs) may impact on students' learning motivation in higher education. This study will involve the development of a set of educational MUVEs design principles, implementation of a design example with authentic tasks and then testing the design within classroom settings using a design based research paradigm and finally the development of a design framework based on these research outcomes.

Section A: Demographic Details

1. How old are you? *
   - o 17 – 18
   - o 19 – 20
   - o 21 – 22
   - o 23 – 24
   - o 25 – 26
   - o Above 26

2. Please specify your gender. *
   - o Male
   - o Female

3. Please specify your nationality. *
   - o Malaysian
   - o Other:

4. What level of Computer Science / Information Technology / Computing Programme are you currently studying in your Institution? *
   - o Diploma
   - o Degree

5. What specialization are you studying? *
   - o Computing / Computer Science
   - o Information Technology / Information Systems

6. What major are you specialized in? *
   - o Networking / Data Communications / Security
   - o Business Intelligence
   - o Software Engineering
   - o Artificial Intelligence / Knowledge Management
   - o Internet / Web / Mobile Development
   - o Multimedia / Game Development
   - o E-Commerce / E-Business
   - o Other:

7. How long have you been studying in your university / college? *
   - o < 1 year
   - o 1-2 years
   - o 3-4 years
   - o 5 years and above

8. Which of the following technology devices do you own or use? *
(You can select more than one) Check all that apply.
   - o Smartphone

- Desktop
- Laptop / Netbook
- Digital Tablet
- Other:

Section B: Online Simulation in Second Life
Which of the following statements about Online Simulation in Second Life are you agreeable with: -

9. Attention *
Mark only one oval per row.

	(1) - Strongly disagree	(2) - Disagree	(3) - Neutral	(4) - Agree	(5) - Strongly agree
a. The content in "SimuLab" captured my interest and stimulated my curiosity.					
b. The multimedia elements used in Online Simulation motivated me and aroused my attention.					
c. The variability of instructional strategies helped keep my attention.					
d. The way the content is arranged in "SimuLab" helped keep my attention.					
e. I like using online simulation for my learning more than face-to-face instruction.					

10. Authenticity *
Mark only one oval per row.

	(1) - Strongly disagree	(2) - Disagree	(3) - Neutral	(4) - Agree	(5) - Strongly agree
a. The content of the online simulation was authentic.					
b. The online simulation used real life examples.					
c. The online simulation provided sufficient/enough real life examples.					
d. The equipment in online simulation was easier to use compared with real life.					
e. The activities in the online simulation would be hard to implement in real life.					

11. Achievement *
Mark only one oval per row.

	(1) - Strongly disagree	(2) - Disagree	(3) - Neutral	(4) - Agree	(5) - Strongly agree
I could control the success					

of learning outcomes.					
I can establish the direction of self-learning after using online simulation.					
I am confident that i can make good use of the knowledge in Computer Networking.					
Completing the online simulation gave me a satisfying feeling of accomplishment.					
I got useful learning experience from the online simulation.					

12. Appropriateness *
Mark only one oval per row.

	(1) - Strongly disagree	(2) - Disagree	(3) - Neutral	(4) - Agree	(5) - Strongly agree
The content in SimuLab met my personal needs and goals.					
The content in SimuLab used concrete examples to illustrate the knowledge in computer networking.					
It is clear to me how the content in SimuLab is related to things that I already know.					
I have integrated the knowledge and skills that i learned in SimuLab into studies and daily life.					
I could relate the content that i learned in SimuLab to my study and daily life.					

Section C: General Comments
24. Would you like to make any comments or give any advice about the use of Second Life for academic purpose?