UNIVERSITY OF SOUTHAMPTON

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School of Electronics and Computer Science

A Conceptual Framework for Serious Games and its Validation

by

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ABSTRACT

FACULTY OF ENGINEERING, SCIENCES AND MATHEMATICS

SCHOOL OF ELECTRONICS AND COMPUTER SCIENCE

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A CONCEPTUAL FRAMEWORK FOR SERIOUS GAMES AND ITS VALIDATION

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This research introduces a conceptual framework for the design of serious games and uses the Technology Acceptance Model (TAM) for its validation. An initial study identified 12 attributes of educational serious games that can be used to support effective learning. These attributes are used in the conceptual framework to support learning and pedagogy in combination with the games. The Serious-Games-TAM was used to confirm that serious games, based on the proposed framework, would both be accepted by the learner and be useful for learning. Validation involved the collection and analysis of data from learners using a specially developed serious game that introduced international students to public transport in Southampton. After completing the game, participants completed a short questionnaire and the data was analysed using structural equation modelling (SEM). The results identified the attributes and combinations of attributes that led the learners to accept and to use the serious game for learning. These findings significantly contribute to helping game designers and educational practitioners design serious games for effective learning.

Contents

List of Figures

List of Tables

Declaration of Authorship

I, Amri Yusoff, declare that the thesis entitled "A conceptual framework for serious games and its validation" and work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- parts of this work have been published as :

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Signed:

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Note on formatting

Guidance from *The Chicago Manual of Style* (15th ed) (2003) was taken on the use of commas and semicolons in run-in lists (section 6.126). In brief, all elements of a list are separated by commas, and where one or more elements are clauses, by semicolons.

Abbreviations

AMOS	Analysis of Moment Structures
SEM	Structural Equation Modelling
TAM	Technology Acceptance Model

Symbols

A	Attitude
BI	Behavioural intention to use
EOU	Perceived ease of use
LC	Learner control
R	Reward
S	Subjective norm
SL	Situated and authentic learning
TS	Transfer of learnt skills
U	Perceived usefulness
β	A path representing a causal relationship (regression coefficient) between dependent variables
e	Dependent variable errors
γ	A path representing a causal relationship (regression coefficient) from independent variable to dependent variable
φ	A path represented by an arched two-headed arrow representing the covariation between one independent variable and another independent variable

Chapter 1

Introduction

Learners have been accustomed to traditional methods of learning such as acquiring new knowledge and training through customary classroom activities. Shadbolt (2008) noted that, in the near future, learning will utilise game technologies as part of the learning experience. For example, utilising examples of real equipment and simulating real experience from inside a game will provide an optimal, meaningful, and engaging learning experience. One current problem with traditional teaching is that the ratio of learners to teachers is prone to increase in times of financial prudence. As a result, learners may get fewer contact hours and may be given less guidance on how to progress in their studies. Therefore, many researchers and educationists are focusing on developing improved and more effective teaching methods to solve these problems, such as using games for learning.

One of the reasons for using games is that they are known to be fun and entertaining and, when mixed with learning material, could attract learners to play and to remain engaged until the learning objectives have been achieved.

A further reason is that current learners of school and university age have grown up in a digital environment complete with computers and mobile phones. They play more games on computers, or on games devices, compared with previous generations. It may be argued that the delivery and organisation of teaching material needs to be changed to accommodate these learners and meet their expectations (Reeves, 2008). Providing these learners with suitable games could be one of the ways of meeting these needs, together with the support of traditional teaching in the classroom.

Many companies, researchers, and educationists are developing serious games for learning (Iuppa & Borst, 2007). For example, the U.S. Army uses serious games for tactical and strategic training that allow trainees to participate in simulated real-world battles. In the

game called ALTSIM (Advanced Leadership Training Simulation), the trainee is presented with a virtual environment of a tactical command centre (Iuppa & Borst, 2007). With the use of realistic characters and events, participants are trained to give a correct response, based on decisions made using information from the virtual environment.

However, due to unclear standards and guidelines, it is difficult to claim that these games really meet the learner's requirements or expectations. There are also games being developed for educational purposes, including teaching English as second language, which are too easy for their level or just too difficult (Verdugo & Belmonte, 2007). It could be that most of the games available for learning have not benefitted from expert input (Verdugo & Belmonte, 2007).

To address the apparent problems associated with serious games, this research will consider serious games from two viewpoints. The first is to define a framework for serious games, based on learning theory that will result in effective learning, allowing a formal definition of a serious game to be developed. To demonstate the framework we develop a specific game for our work aimed at teaching overseas students to use Southampton's bus services.

Secondly, we apply the Technology Acceptance Model (TAM) to our framework for validation, this allows game developers to understand and have confidence in the framework , so that the serious game developed is acceptable to the learner .

1.1 Research Objectives

This research focuses on introducing a conceptual framework for the design of serious games and uses the Technology Acceptance Model (TAM) for its validation. The attributes of serious games are identified and used within the framework for supporting effective learning. Based upon the framework, a specially developed game introduced international students to public transport in Southampton, and data from participants analysed in evaluating the framework and the use of the TAM.

The objectives of this research are to:

- Identify serious games attributes that support effective learning.
- Develop a serious games conceptual framework that would aid game designers and educationists.

- Demonstrate an implementation of the framework by designing an actual serious game for experiment and evaluation.

- Validate the attributes and combination of these attributes that contribute to learner acceptance of the use of serious games.

While learning theories have been applied to traditional learning, their application to serious games is still new. The attributes derived from a review of learning theories would be named *educational serious games attributes* and the first research question is to identify these serious games attributes. The strategy for answering this question is to review educational and learning theories and select those that are appropriate for serious games. The initial research question can be defined as:

RQ1: What are the relevant educational attributes that would support learning in serious games?

The proposed conceptual framework would result from a combination of actual game model, serious game theory, and educational learning theory, where the latter is represented by educational serious games attributes. The structure of this proposed framework is the *conceptual framework for serious games*. The second research question is to define this conceptual framework and this is answered by reviewing all the current game models and articles on the theoretical models of serious games. The second research question can be defined as:

RQ2: What is a common framework that can be used as conceptual guidance in designing serious games?

After defining a conceptual framework for serious games, a method is required to determine how this framework can be tested on players learning with serious games. The testing method used involved building a prototype serious game based on the conceptual framework, and then using this game in experiments for testing learner behaviours and outcomes. Together with the Technology Acceptance Model, these experiments would lead to further understanding of learner behaviour towards serious games. The third research question can be defined as:

RQ3: How can the selected attributes, in the proposed serious games conceptual model, be tested so that the best configuration will result in predicting learner intention to use serious games?

The results after conducting the experiment would yield certain findings. The analysis of the experiment results, and the scope of the recommendations based on experienced gained

by conducting the research, can be offered as useful guidance for serious game designers and educational practitioners. Therefore, these recommendations can be use to define and explore the fourth research question, which can be defined as:

RQ4: What recommendations can be offered to serious game designers and educational practitioners who intend to use serious games for effective learning?

1.2 Thesis Structure

This thesis is organised into nine chapters.

Chapter 2 provides the detailed explanation of a definition of serious games from three different perspectives. The perspectives considered are educational, psychology and computer science. This provides a formal definition of a serious game that is used in this thesis.

Chapter 3 begins with exploring and reviewing some of the educational and learning theories and identifies twelve serious games attributes that support learning and engagement. The game attributes are then presented based on critical thinking resulting from the literature review on behaviourist, cognitive, constructivist, and psychological perspectives. The prospect of having attributes within the serious game that could lead to better learner engagement, and cause the learner to be drawn deeply into the game, is highlighted.

Chapter 4 expands the attributes defined previously into forming part of a proposed conceptual framework for serious games. Major components of the proposed framework, which includes games attributes, learning outcomes, games activities and game achievement, are described.

Chapter 5 presents an introduction to the Technology Acceptance Model, which is used for predicting learner acceptance of serious games. A research question has been formulated to identify the serious games attributes which are related to the learner's intention to use serious games for learning. The answer to this research question will contribute toward helping the game designer or educational practitioner to construct serious games that are accepted by the learner. A proposed TAM model for serious games is presented, for testing a set of hypotheses with the serious game called *Unilink Bus Game*. This game was developed for enabling international students to use the University bus service.

Chapter 6 presents the research methodology used for addressing the research questions. This chapter also shows how the creation of *Unilink Bus Game* is based on the conceptual

framework, with help from the evaluation of other well-accepted serious games. An outline of how the research was conducted is given, from generating the questionnaires, through the pilot test, to analysis of the data. The chapter ends by explaining the selection of the target audience, the locations and the survey schedule.

Chapter 7 shows the results gained from the survey, following a number of participants learning the bus system by playing *Unilink Bus Game*. The analysis is performed using AMOS[1] by testing the relationship of Structural Equation Modelling (SEM) based on the TAM model of serious games. This chapter ends with how this data relates to the hypotheses and research question, and justification of the results of the experiment.

Chapter 8 discusses the results. Their interpretation and the significant findings are reviewed here. This chapter discusses how these findings address the research question. This chapter identifies some shortcomings of the experiments and their remedies.

Chapter 9 concluded the thesis and summarises how the research method used have met the research objectives. The chapter identifies the significant contributions that have arisen from this research related to serious games attributes in predicting learner acceptance. It also discusses the weaknesses and limitations of the study, and suggests further research.

[1] A structural equation modelling program to test the relationship; developed by SPSS

Chapter 2

A Proposed Definition for Serious Games

It is clear from the literature review that the term “serious games” is ill-defined, and depends to a large extent on the user’s perspective. In order to resolve the problem statement discussed in Chapter 1, a clear definition of serious games is required. To assist with the development of a serious game, this chapter will consider it from three different perspectives: education, psychology and computer science. The rationale behind this is that:

- The Educational perspective will provide the latest theory of pedagogy for implementing serious games.
- The Psychology perspective will help to guide the serious games in making the learner feel more motivated.
- The Computer Science perspective will be the tools and affordances for a technology of serious games to be put to effective use.

This study will allow the serious game to be defined and situated in the context, based on these three perspectives. The resulting definition will enable a focus on the scope that of this research. This will later help define the concept framework of serious games, which will be used as a guide for the design of serious games.

2.1 An Overview of the Educational, Psychology and Computer Science Domains

2.1.1 *Educational perspectives*

The theories of learning and pedagogy have been proved successful in the traditional teacher-learner relationship in the classroom. Effective learning is measured by how well the learner understands or performs according to what has been taught. The key to successful teaching is to choose the correct method, and apply it the learner when studying. This is important because a successful pedagogy design placed upon the learner would bring about effective learning. This pedagogy can be sought from the learning theories of behaviourism, cognitivism and constructivism.

2.1.1.1 Behaviourism

The behaviourist theory is based on theory of reinforcement by stimuli and response, which can be applied to the interactive process in a game such as matching to the correct answer (Paraskeva, Mysirlaki, & Papagianni, 2010). This is a view that learning is based upon experience and this includes the theory of classical conditioning (Pavlov, 1927), law of effect (Thorndike, 1914) and operant conditioning (Skinner, 1993). Skinner states that learning is internalised through operant conditioning, a process of response-stimulus, where a result occurs as a consequence of actions, and that it is the environment surrounding the learners that influences them and supports their learning.

2.1.1.2 Cognitivism

Cognitive theory deals with how learning is processed inside the mind and how the individual processes the information inside the brain. Piaget's stage theory (Piaget, 1954) shows how the mind develops through certain stages. Piaget identifies four development stages: sensorimotor, preoperation, concrete operation, and formal operation.

- The sensorimotor is the first stage, and occurs from birth to 2 years old. Here the child is learning through its senses what is happening from its surroundings, and developing its coordination.
- In the preoperation stage, the child is at preschool (3 to 7 years old). In this stage, the child is capable of using symbols to represent objects. For example, the child can understand the word *car*, even though the real car (object) is not present.

- The stage of concrete operation is from 8 to 11 years old. This is the stage where a child can think logically and reversibly. For example, they can add the numbers 3 and 2 to produce 5, and can think in reverse: 5 minus 3 is 2 to get back the original number.
- The stage of formal operation occurs in 12 years olds and above. At this stage, the child is capable of solving a complex problem or analysing a problem.

Each stage must be completed before proceeding to the next stage, and this is not automatic. For example, the sensorimotor stage must be completed and experienced because it is a prerequisite for learning to be developed before going to the next stage. This theory suggests that learners need to construct their learning through activity and exploration.

2.1.1.3 Constructivism

The constructivist theory shows how learning is built, not just from the learner's own experience, but also from their social interaction (Bruner, 1966). The studies undertaken by Papastergiou (2009; 2010) and Karagiorgi & Symeou (2005) looked into ways of applying pedagogy theories to educational technology. They highlighted some of the areas that need to be emphasised as follows.

- Allowing the learner to obtain knowledge by his own actions, and letting the learner independently choose his topic of study, thus allowing him to self-interpret the content.
- Allowing the learner to acquire new skills based on his own experience of learning and by doing so, taking time to do it until he is happy to accept it.
- Allowing the learner to collaborate and negotiate in acquiring new knowledge when working with peers or within a community of social practice. Situated learning (Lave & Wenger, 1991) is the concept where the learner becomes involved with the community of practice and becomes more engaged and active in learning within this community, then becoming an expert in this field. Suchman (1987) takes this concept of situated learning further and uses it in the framework of human-computer interaction, while Moreno & Mayer (2007) describe how the learner creates and builds this learning experience into knowledge.

Once learners are able to build up their learning they could acquire a sense of self-efficacy. Self-efficacy is a person's belief that he is capable of performing any given task, and high confidence and high motivation will lead him to greater achievement. Bandura (1989)

stated that an individual can construct this self-efficacy based on mastery in their skill, supported by self experience and from observing others.

Other educational areas that are essential to learning are content delivery and learner feedback. The content delivery can follow the methods laid out by Gagné (1970) which involve a hierarchy of teaching steps in order to support mastery.

2.1.2 *Psychology perspectives*

If the educational perspectives define what is effective learning, then the psychology perspective can contribute some motivational factors for successful learning. If learning deals with observable behaviours, the psychology factors are what are emotionally experienced while learning. Psychological theory seeks to better understand human thought and behaviour, and provide a better understanding of how students learn (Poulou, 2005). This deals with positive and negative emotions. Positive emotions for learning are enthusiasm, focus, engagement, enjoyment, persistence, trying hard, challenge, curiosity, fantasy, competition, cooperation and recognition (Malone, 1980; Preston & Morrison, 2009). Negative emotions for learning are anxiety, feeling exposed, fear of challenge, fear of failing, feeling inferior, fear of something new, which may lead to trying to avoid learning.

These are the emotions that the learner needs to handle while learning. Dealing with the negative emotions and encouraging positive values thus contribute to successful learning.

Hejdenberg (2005) stated that in the current world, there are so many options, it is difficult to make a sound judgement of what is right or wrong. It is difficult to measure how well we are doing something right. Therefore, we always try to compare ourselves against other people and by doing so, obtain some pleasure and satisfaction from it. This is where the use of the games comes in because, by playing games, learners are free to explore and experience these feelings in the game world when competing with each other.

2.1.3 *Computer Science perspectives*

Computer science and technology has played an important role in shaping the current state of the education system. Much work has been conducted by researchers (Salomon, Perkins, & Globerson, 1991; Squire, 2005) for improving and enhancing education technology in this field. The focus here is on the use of computer technology and the methods afforded by the computer field, and how they support teaching and learning. The use of computer

technology for learning provides an opportunity for: interaction, learning by doing and experimenting, problem solving, hypothesis testing, building up skills, and challenging, creative thinking and decision-making, overlearning, adaptation to learner ability, collective and collaborative learning and social networking.

Based on Laurillard's (1989) learning activities on electronic teaching media, the experience of technology-supported learning can be classified into several categories.

1. *Attending or apprehending*. This learning experience can be offered through printed word, YouTube, video streaming and DVD. Williams, French, & Brown (2009) used DVD as an alternative method to train nurses in practical clinical experience. Although the study conducted showed some improvement in the nurses' experience, they felt that more realism and more interactive learning could bring further improvement in their studies. They strongly believed that teaching using DVD could not be a replacement for one-to-one traditional teaching. This method can be offered as a supporting teaching method to the current traditional teaching.

2. *Investigating or exploring.* This learning experience can be offered by library search, CD, DVD, and web searching tools. The technology offers some interactivity but it is still limited by the learner's navigation and browsing strategy. However, multimedia can be offered in number of combinations such as text, still images, animation video and audio. Another advantage is that it can be stationary or portable, because it can be used with a laptop or mobile phone, which leads to the concept of *ubiquitous computing*, that is the use of the computer and the application can be everywhere. Norhayati & Siew (2004) have showed that this method of using multimedia can be effective in impacting the morale of the learner.

3. *Discussing or debating.* This learning experience can be offered by online conference, Skype, chat messages and SMS text. The technology offers some facilities in the form of real-time live, as well as asynchronous, communication for the learner. This can be done by a group or on an individual basis.

4. *Experimenting or practising*. This learning experience can be offered through PC laboratory work, on-site field experiments and computer simulation. The technology offers greater interactivity to the learner, because they can make some changes with this type of learning. In other words, the teaching can be adapted to the learner's needs. A minor drawback with simulations, compared to traditional teaching, is the added cost, time to develop, and the effort taken to complete the

simulation environment (Akl et al., 2010; Begg, 2008). Simulation can range from simple PC-based experiments to teach and test basic science subjects such as maths or physics, to the use of a high fidelity mannequin simulator (Okuda et al., 2009). The main advantage of simulation is that the learner can formulate hypotheses in the simulation environment and can modify or test these hypotheses by changing some parameters inside the simulation. Simulation allows these changes to be achieved dynamically, and is able to provide – to some extent – complex scenarios that are difficult for humans to handle. The simulation can be in the form of problem-based learning or the investigation of some model that is not visible to human eyes. Simulation can be used to create awareness and to give the learner a rapidly generated model, for example providing a clue to what is affecting sea life over a span of time on an artificial reef (Stone, White, Guest, & Francis, 2009). Because a high-risk environment can be simulated for learning purposes, simulation does not put the learner or others at risk (Hunecker, 2009; Wechselberger, 2009). Learners are free to explore using a trial and error approach without risk or high cost. Sound and graphics can simulate an environment so the learner feels close to the real life situation. In hospitals the bedside practice of medical students and residents usually stresses the patients. A solution to this uneasiness is to replace live bedside training with a simulated environment, providing the same opportunity for students to practice and experiment in a virtual environment. This new direction will help focus clinicians on first caring for the patient's well-being and feelings through patient safety and the quality of interaction.

5. *Articulating or expressing.* This learning experience can be offered through computer games, interactive animation and high fidelity simulation. These technologies allow the learner to be more productive, i.e. to make the learner produce something during the learning. The employment of rich features in computer games and high fidelity simulations makes the learner more engaged with the learning and more immersed in the situation. Atkinson & Willis (2009) show that the popular highly graphic video game, *Grand Theft Auto*, can be used to illustrate how the learner can have a learning experience in an urban environment. However, the most important point identified by Aldrich (2004) in achieving effective learning inside this highly graphical content environment, is how to handle *reflection* carefully. This is where the learner reflects on the learning

objective and how their learning has taken place within this highly engaging environment.

Although high fidelity simulation and computer games offer immersive and engaging environments, sometimes they fail to deliver successful learning. Studies done by Swatz et al. (2010) and Egenfeldt-Nielsen (2004) show that highly interactive computer games do not necessarily guarantee successful learning. This is because, when the students were fully immersed in the game, they sometime ignored certain aspects of the play (or certain learning activities), skipped the feedback, and failed to interact with the game directions. In addition, students who had no prior knowledge of the game strategy, sometimes dived straight into the game, without a good strategy, resulting in them losing heavily, becoming frustrated, remaining ignorant of what went wrong, unsure how to play or learn, finally this leads them giving up on the whole game.

The reviews of simulation and entertainment games by Narayanasamy et al. (2006) and Susi et al. (2007) have shown that these media are highly entertaining and fun. However, another game genre – called serious games – offers a somewhat more subtle objective than entertainment, and this form is more focused on important elements of learning (learning objective). The primary purpose of a serious game is to develop learner skills and knowledge.

2.2 Mapping Serious Games from Different Perspectives

This section proposes how serious games can be defined by considering three perspectives; Educational, Psychology and Computer Science.

2.2.1 *Serious games informed by educational perspectives*

The educational perspectives suggest that the learner constructs their own knowledge and their understanding is generated from negotiation within their community or peers. While peer-to-peer learning is how a learner acquires from others how to navigate a game world, mastery of knowledge has to come from their learning experience as well as from collaboration with their peers (Langer, 2009; Sauvé, 2009). Learning is not necessarily restricted to the classroom or tied to a curriculum. Instead, the learner may be seen as a producer, a contributor to their knowledge, and autonomous in their learning (Kafai & Fields, 2009; Steinkuehler & Squire, 2009). The development of knowledge by the learner can be achieved from self and active exploration within the game (Conati & Manske,

2009). Looking for clues to the game's obstacles, and searching for answers within the game, is a way in which this might work. To gain mastery in certain skills within a game requires doing two things. One is to be able to solve certain problems within the game and this normally requires some work by the learner to undertake some critical thinking within the game. Second, is the ability to transfer a previously learnt skill when progressing to the next level, i.e. reuse of the previous skill to gain a new skill. Skill advancement is progressive while playing the game, and mirrors the mastery of some skills from experiences in the real world.

Self-efficacy is reflected by player behaviour. This self-efficacy can be measured by the amount of time spent within the game. The longer time spent by the learner playing the game usually means that the learner is doing well and further boosts their confidence. Offering help and support (or *scaffolding*) within the game, reinforced with learning feedback, will increase the learner's self-efficacy (Yates, 2005). To be sure that the learners can cope by themselves or be able to apply the learning skill on their own, the serious game must know when to apply and when to remove this scaffolding before the responsibility is shifted to the learners.

The instructional content delivery can be done by carefully design of the game activity. Learners can be informed of their progress by adequate feedback during this activity. If the educational perspectives require that the learner takes his time to learn based on the development of better performance then the serious game can cater to this by adjusting the learning activity according to the learner achievement.

Problems will arise from trying to adapt the educational perspectives based on a single method. For example, if the learner is allowed to chart his own learning, how does he know how to learn and to plan his own activity? If learning is based on the learner's own natural experience, how can standards be set in order to assess whether meaningful learning has taken place? How can the learner be confident that the knowledge gained is the correct knowledge that he is supposed to have learned and not the 'wrong' knowledge and skill? Addressing these questions requires a multi-method approach.

2.2.2 *Serious games informed by psychology perspectives*

Serious games in the virtual world do give us some rewarding pleasure when comparing our play against others or computer opponents. This gives some satisfaction and confidence because, in games, rules are known and the objective is clear.

In order to maintain positive emotions such as enthusiasm, being in focus, engagement, enjoyment, persistence, trying hard, challenge, curiosity, fantasy, competition, cooperation and recognition, the learner needs to be fully immersed within the game world.

If the learner is highly motivated within the game, he thinks that he can achieve something and be more confident with learning. This positive attitude can suppress the negative emotions and this makes the learning easier and more successful.

A good game is able to establish an intrinsic motivation for the learner. Intrinsic motivation makes it possible for the learner to have fun because they choose to, and they willingly spend a significant amount of time playing, and this is done freely on their own (Kickmeier-Rust & Albert, 2009; Wechselberger, 2009).

The concept of "flow" by Csikszentmihalyi (1990) shows how important it is for the learner to stay within the game by "being in the zone". Staying engaged within the game shows how effective the serious game can be when used for learning. This can be done by directing a suitably appropriate challenge to the learner's skill in order to avoid boredom. The study undertaken by Bakopoulos & Tsekeridou (2009) shows that enjoyment will increase the playing time and this will result in knowledge retention.

Mediocre or poor students usually do poorly at school due to lack of concentration on the lesson because of boredom and their lack of attentiveness (Virvou, Katsionis, & Manos, 2005). However, incorporating the concept of "flow" within the serious game would help to attract this type of student to remain engaged with the lesson throughout and would benefit them in learning.

Studies show that a game can also be perceived positively or negatively depending on gender (Dondlinger, 2007; Hayes & King, 2009; Mitchell & Savill-Smith, 2004; Paraskeva, et al., 2010; Steinkuehler & King, 2009). These studies show that games can indirectly influence the behaviour of boys and girls differently, and the serious game designer should consider these characteristics so that the learning process can be accepted by all.

In applying the theory of diffusion of innovation (E. M. Rogers, 2003) to the adoption of computer games by teachers, Kebritchi (2010) shows that a teacher would be more likely to adopt the game if it is perceived to give them a relative advantage (for example, females like narrative in a game or male prefers action). Therefore, the serious game designer should try to accommodate the learner styles and preferences when designing the game for education.

2.2.3 *Serious games informed by computer science perspectives*

The concept of serious games was first explored during 2002 by the US military through their use of game technology for military training (Iuppa & Borst, 2007). It is apparent from the current literature that there is no single acceptable definition for serious games. One view is that the use of the word *serious* refers to the considerable pedagogic element embedded within these games (Zyda, 2005), while an opposing view is that *serious* reflects the purpose of these games (Michael & Chen, 2006). A number of authors have suggested that serious games are an application of gaming technology used to solve problems that are too expensive or too critical to conduct in real life, for example in education, healthcare, sales and marketing (Rejeski, 2007; Susi, et al., 2007). It can be concluded that one of the most important things about serious games is that they are defined by educational objectives, and not by entertainment. Sawyer (2008), in "Ten Myths about Serious Games", noted that learning through serious games may not be as much fun as normal games. But serious games are developed where the main purpose is to learn, and fun may be part of it; without the fun, the learner still can learn and achieve the purpose of playing it. One reported advantage of serious games is the simulation of real-life situations such as an environment (user support desk), a system (a production line), and a role-play scenario (sales meeting). This allows a learner to experience something that is too costly, too risky, or ethically unacceptable in the real world (PIXELearning, 2008). For example, the serious game could encompass how a paramedic team responds to a major incident, such as an explosion in the middle of a crowded city. Training with serious games can eliminate the elaborate and expensive setting, not to mention the high risk involved of learning in a real situation.

By using serious games to support learning, their rich gaming features can be exploited in order to keep learners engaged with the learning while having enjoyment as well. For example, Gee (2007a) identified that serious games will

- encourage active rather than passive learning
- encourage the learner to take risks, thus allowing the learner to make mistakes without being embarrassed
- allow for mutual collaboration (networking) in order to solve a problem
- encourage intrinsic learning because, compared to traditional methods, games are more engaging and more interesting

- not bore the learner with lots of practice; the use of humour, fun, and challenge will make the learning experience more memorable
- let the learner learn together with sound, interaction, images and text, not just words.

2.3 Serious Games Definition

There has been considerable debate on the correct definition of "serious game". Serious Games Jam[2] is the online forum that holds a series of regular discussions about serious games matters, and most of the participants are serious games designers, educational practitioners and game developers. The topic of most importance in discussions continues to be an interest in the definition of serious games. Participants stress that fun is not a consideration for serious games, but that the most important is achieving the goals of learning, while the game elements, such as satisfaction, motivation, relevancy and engagement, should be qualities of serious games rather than fun. This argument is also supported by Westera et al. (2008); Rooney et al. (2009) stated that fun is not the main motive for the use of serious games. Kiili (2005) stressed that fun should not be a factor in designing serious games but, in order to achieve a meaningful and engaging learning experience, serious games need to integrate with the educational theories of game design.

In this work, a serious game is defined as

> "a learning tool that incorporates game technology for the purpose of achieving learning objectives rather than pure entertainment."

This approach is employed because learners are more motivated not only because of game engagement features but also because these are integrated with some pedagogic elements. Such elements would need to be introduced within the serious game in order to meet the objectives or goals of the learning. In this context, a serious game would not be the same as a pure game, which is solely for the purpose of entertainment. Instead, games features are used as a vehicle to achieve the learning outcomes. Although a serious game can be like a simulation game, that mirrors the real world in a virtual world, it may not be designed for fun but is still not boring. This is because the emphasis is on engaging learners, motivating them, showing them the relevance, and later inspiring them with the intention of using the

[2] Serious games jam is an online discussion and collaborative space to discuss serious games matters (seriousgamesjam.com/)

serious game for learning (Narayanasamy, et al., 2006). Johnston & Whitehead (2009) classified simulations as a subset of serious games and both serious games and simulations are not intended primarily for fun but for learning purposes.

2.3.1 *The scope of serious game definition*

This research breaks new ground in defining the scope of the serious games. The general definition of serious games has been stated above, but the scope of this definition will cover the three main perspectives (educational, psychology and computer science) and the result is that this scope enables some of the problems discussed in Chapter 1 to be addressed.

Section 2.2.1 identified three problems that will arise from trying to adapt educational perspectives based on a single method. How does the learner know how to learn and to plan his own activity? How can standards be set to assess whether meaningful learning has taken place? How can the learner be confident that he gains the knowledge that he is supposed to?

- The first problem is addressed by defining the learner capability within the serious game framework. This defines what capability the learner wants to achieve by playing this game.
- The issue of standards of assessment, game achievement and feedback, addressed in the framework, will act as a quality control for the serious game learning standards.
- The third problem is addressed by defining the instructional content within the framework as the subject matter that the learner is supposed to learn, and this is associated with the learning objectives or intended learning outcomes.
- Lastly, the serious game activity should incorporate some of the educational attributes that are based on the pedagogy theories that result in successful learning.

The current generation is growing up through the digital era, called *digital natives*, and are competing for a better life in the future. They are always looking for innovative technology and creativity. No country can sustain itself or survive if it just wants to remain as a commodity supplier or consumer (Nodoushan, 2009). The country needs to become innovative and productive. Today, we are facing issues of decreasing student quality (Tao, Cheng, & Sun, 2009) and existing programmes will not be able to cope with preparing

students to face future uncertainties (Ben-Zvi, 2010). If their education hinders them becoming innovative, then it will be difficult to apply what they learn in the future.

- The serious games proposed here allow for student self-innovation and creativity. There should be feedback that is able to guide the learning activity within the game, thus continuing to challenge the thinking of the learners. The learning outcomes are not just tailored to the learner capability, but also able to increase their skill and capability with more challenging self-adjusted game learning activity.
- From the psychology and computer science perspectives, we need to find out how acceptable and willing the user is to employ serious games for learning. The user behaviour and gender preferences can be identified with the Technology Acceptance Model (TAM). The TAM by Davis (1989) has been used in information technology to predict the acceptance by users of new technology. By applying the TAM to serious games, we can obtain some explanations of how some external variables are capable of influencing learner behaviour in using serious games.

2.4 Examples of Serious Games

A number of games and simulations have been used during this research in order to find some serious game examples that would confirm the above definition. The selected games used here are based on PC games downloaded from the web. Of all the games that have been studied, four are acceptable serious games intended for learning and close to the definition of serious games described above. These serious games will be used, or referred to, in this thesis. The examples of serious games within this definition are *EnerCities*, *Chest Pain Simulator*, *Darfur is Dying* and *Climate Challenge*.

The *EnerCities*[3] project is co-funded by the European Commission programme Intelligent Energy Europe. It has been developed for creating awareness among youngsters of how

[3] The *EnerCities* project from http://www.enercities.eu/project/

energy can be used more efficiently and intelligently, and to influence their behaviour and attitudes toward energy conservation. This serious game is selected because it shows that games can be highly entertaining but also engaging, see Figure 2-1.

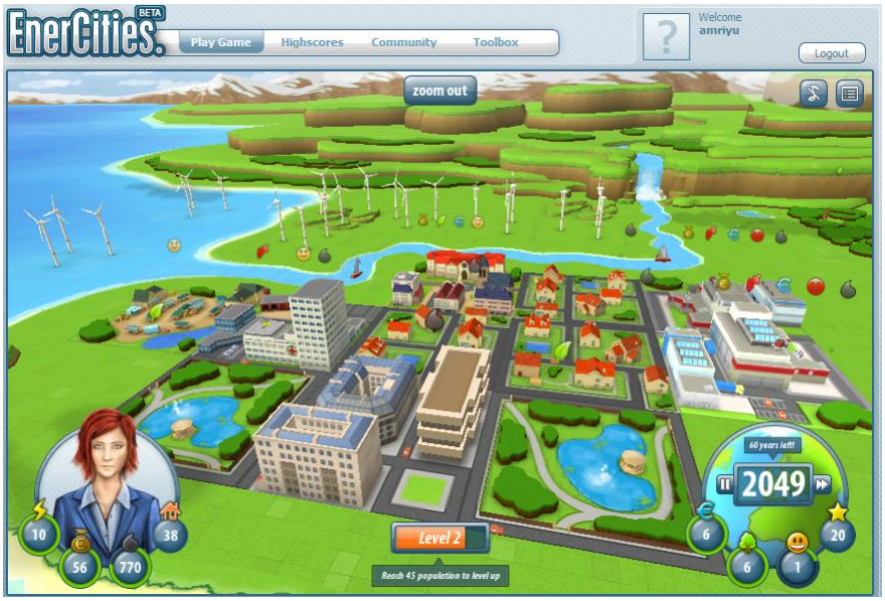

Figure 2-1. Screenshot from the serious game developed for *EnerCities* project

The *Chest Pain Simulator*[4] is an example of good practice in conducting correct medical procedures on a patient, taken from real-life experiences. This serious game teaches medical practitioners to save the life of a patient with a chest pain problem by using virtual examples of medical equipment, testing that the procedures are being performed correctly and in an orderly manner. This serious game was chosen because it is quite convincing and engaging, and is involved with critical thinking by the learner in making correct choices and decisions, see Figure 2-2.

[4] The *Chest Pain Simulator* developed by Madscientist software

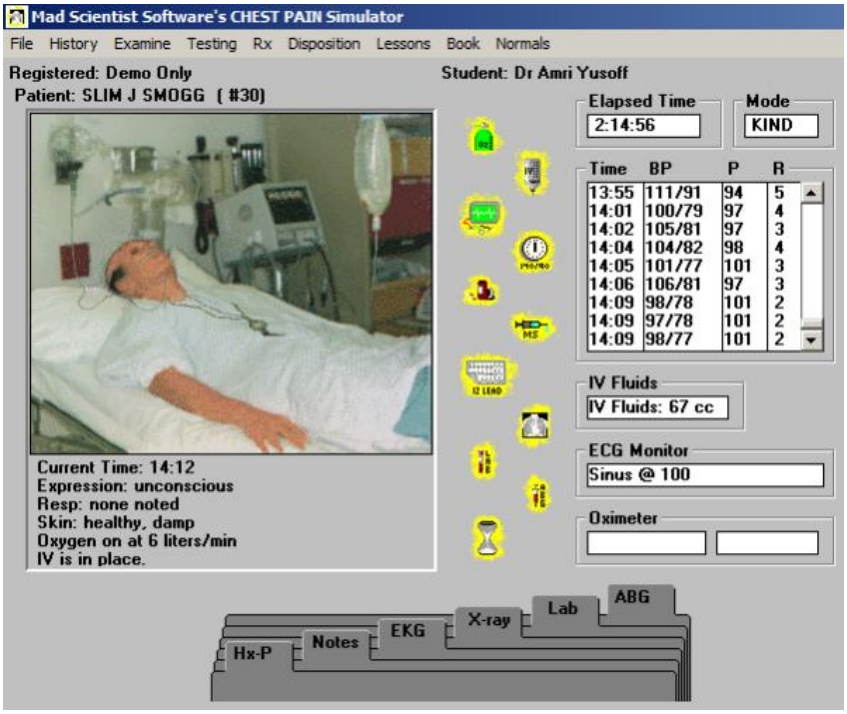

Figure 2-2. Screenshot from *Chest Pain Simulator* serious game

In the role-play genre there are serious games based on the selected role. For example, in this serious game, the learner plays the main actor in the game. Normally, this applies to role-playing for army training, fire-fighter training, hazardous or emergency situations, or travelling inside a microcapsule in a blood vessel learning and examining the blood cell. The serious game, *Darfur is Dying*, illustrates how it is used for survival training during the critical situation in Darfur[5], shown in Figure 2-3.

This game also tries to make the learner understand, and experience the difficulties of, life while 'living' in this area.

Climate Challenge is a real-time strategy serious game in which learners are required to manage the resources and assets efficiently, for example, adopt a strategy to maintain climate control, carbon dioxide emission control, or saving energy. *Climate Challenge*, see Figure 2-4, shows how urban planning can affect the environment and teaches the learner how to reduce carbon dioxide emissions that affect the changes in climate[6].

[5] *Darfur is Dying* from http://www.darfurisdying.com/

[6] *Climate Challenge* from www.bbc.co.uk/sn/hottopics/climatechange/climate_challenge/index_1.shtml

All four of these games will be used as guidance when developing an example of a serious game that will fully adhere to the proposed conceptual serious games framework that will be explained in Chapter 6. The use of these examples would be use to help in reflecting some of the serious games definitions that has been discussed in Section 2.3.

Figure 2-3 Screenshot from Darfur is Dying serious game

Figure 2-4 Screenshot from *Climate Challenge* serious game

2.5 Summary

This chapter discussed a possible serious games definition that will be used in this work. It has given a clear understanding how this definition can be used to resolve the problem statement discussed in Chapter 1. This definition was considered from three perspectives: educational, psychology and computer science.

In this work, the general definition of serious game is as a learning tool that incorporates game technology for the purpose of achieving learning objectives other than pure entertainment. The scope of this definition will be based on the three perspectives .

The next chapter will explore in more detail some of the established theories of education and learning and yields the serious games attributes based on these theories.

Chapter 3

Attributes of Serious Games

3.1 Introduction

An approach to learning with serious games needs to be proven effective in order to be considered at the same level as current teaching. Therefore, the successful aspects of teaching should be incorporated in serious games, and these are described as *serious games educational attributes*, called *serious game attributes* from now on. Serious game attributes are those aspects of a game that support learning and engagement, and are based on the exploration of some of the established theories of education and learning. The attributes are the result of the literature review on behaviourist, cognitive, constructivist, and psychology perspectives. The main objectives of these attributes are to support the learning activity within the game, that is, encourage the use of active learning and critical thinking. Active learning is one of the key ingredients of learning that has been tried and imposed upon learners at school. According to Gee (2007a), active learning is where the learner is engaged in real inquiry, seeks for the answer on their own, and is more willing to take on new identities such as becoming scientific thinkers.

This idea of active learning can be employed within the game where the learner will actively acquire knowledge by exploring the game environment. For example, the learner may explore for a hidden weapon that can only be used to kill the monsters at a particular level, since the existing weapon proves to be ineffective. Secondly, the learner can also be encouraged to think critically. Since the learner has just completed one level, they will be more alert to the need to find a new strategy. Based on the last variation, the learner can find ways to beat this new enemy with a different strategy. Only by playing this game, and applying some critical thinking, will the learner find that the answer is to use a different weapon and then these new enemies can be defeated. Therefore, a game can create an

opportunity for active learning and for critical thinking, when learners actively acquire knowledge by exploration. The learning outcomes will eventually be achieved by the learner upon completion of the game. In the *Chest Pain Simulator*, after succeeding at an earlier and easier level, at the next level the learner will face more challenges where the patient becomes critically ill in a new situation. This challenge will require new critical thinking by the learner overcome it by applying strategic solutions. This chapter explores some of the serious game attributes that may help and support learners to become more engaged and immersed in active learning.

3.2 Rationale for Defining Serious Game Attributes

The true characteristics of any game, including those that are non-electronic, may be thought of as inspiration, engagement and challenge. Serious game attributes are those aspects of a game that support learning and engagement, and are developed from the consideration of educational and learning theory. The educational perspective has already been discussed in Chapter 2, while this section will discuss how the serious game attributes are drawn from those theories. The attributes result from the literature review of behaviourist, cognitive, constructivist, and psychology perspectives. This section also discusses the rationale behind defining and choosing the serious game attributes.

3.2.1 *Behaviourist theory*

Behaviourists believe that learning is organised by a series of events and response sequences during the observable period. Some of the theories are classical conditioning (Pavlov, 1927), law of effect (Thorndike, 1914) and operant conditioning (Skinner, 1993). Pavlov demonstrated classical conditioning by conducting an experiment on a dog. Normally, the dog would produce saliva (response) when food was brought (unconditioned stimulus). In his experiment of the conditioned stimulus, he rang a bell every time he brought food to the dog. After a while, he stopped the food and just rang the bell to see the behaviour of the dog. The result showed that the dog still produced saliva, even though no food was present. This showed that behaviour or learning could be conditioned or trained by this method. Thorndike's law of effect showed that, by giving out a reward in responding to or following a certain action, certain behaviour is strengthened and helps to continue a habitual process. Operant conditioning (also called Reinforcement theory) developed Thorndike's work to examine the role of reinforcement more closely. Learners learn more if they are positively reinforced or if a pleasant experience occurs. Examples of

this pleasant experience can be in the form of rewards or praise. However, unpleasant experiences (such as punishment) are a negative reinforcer. The type of punishment that exists within games can, for example, be a learner's life status that decreases every time a fault is made or suffers damage if their character is unable to avoid certain obstacles.

3.2.2 *Serious game attributes drawn from behaviourist theory*

Attributes developed from the consideration of behaviourist theory are: Interaction, Reward, and Practise and drill. These attributes could provide a design guideline for serious games activities that achieve meaningful and effective learning within the game. Detailed explanations of these attributes follow.

- **Interaction**

  Classical conditioning theory shows how skills can be learned within the game. The interaction between the learner and the game world can be taught and learned through playing a series of games. The skills and learning can be conditioned within the game and it can become routine once the learner is facing the real environment in the outside world. In the example of *Chest Pain Simulator*, learners are tested on applying the correct response based on the patient's skin condition. The interaction observed within this game gives a foretaste of what is happening in the outside world.

- **Reward**

  The law of effect and operant conditioning theories show how important a reward factor is for learning. Reward can be used not only to strengthen learning, but also can be as an incentive for the learner to keep on learning. Negative reward can be use to train or force a learner to learn something that is difficult in a short time, or to remind the learner that any error or mistake done can result in severe consequences in real life.

- **Practice and drill**

  Behaviourist theory shows that repetition of practice and drill can used for reinforcing the learner's memory learning and retention (Bakopoulos & Tsekeridou, 2009; Mitchell & Savill-Smith, 2004). Types of serious games that implement practice and drill are simulation games. Simulation games allow for repeat practice, and encourage learners to learn and think from the mistakes made within the games. Practice and drill attributes allow the experimentation with trial and error, and the learner is able to rewind, rehearse and practise at their own pace.

3.2.3 *Cognitive theory*

Cognitive theory deals with explaining human behaviour by understanding how learning is processed in the brain. Piaget's stages of cognitive development theory (1954) shows how the mind is developed through certain stages in life. Piaget's theory of accommodation states that if new information (learning) is received by a learner, then this information can easily be absorbed into the memory. In contrast, Piaget's theory of assimilation states that if new information received by the learner contradicts existing information, the learner needs time to adjust before assimilating this second information into the memory (Atherton, 2009; McLeod, 2007). Sweller's theory of cognitive load (1988) looks into the capacity and the limitation of human memory in processing incoming information. The level of complexity and the representation of content can influence the amount of information absorbed by the human brain.

3.2.4 *Serious game attributes drawn from cognitive theory*

Attributes developed from consideration of cognitive theory are: Incremental learning, Linearity, Attention span, and Transfer of learnt skill. Detailed explanations of these attributes follow.

- **Incremental learning**

  Piaget's theories of assimilation and accommodation suggest learning would be easier for human processing if the task is delivered in a piecemeal manner and the learning is broken into simpler and manageable tasks. Therefore, the learning material should be introduced in an incremental way. Prerequisite learning should be achieved before the complex task to be mastered. If the learner comes with low or no prior knowledge of what is next to be learnt, then it is better to separate any highly complex material into smaller chunks in separate presentations, so that the learner can easily process this information (Lee, Plass, & Homer, 2006).

- **Linearity**

  According to Piaget's stages of cognitive development theory, the human mind develops according to stages in life. Learning can be easy and uncomplicated if it can be structured in sequence and in a linear fashion. Traditional computer games with predetermined goals normally guide the learner to play in a linear fashion. Games that allow open-ended solutions with no specific goals, are called *sandbox type* (Thompson, Berbank-Green, & Cusworth, 2007d).

- **Attention span**

  Time should be allowed for a learner to focus on the cognitive load when processing information. The theories of accommodation and assimilation show that a learner takes some time to digest new information. Therefore, to be more effective, to provide meaningful learning and to reduce the cognitive load, it is necessary to consider attention span within the games.

- **Transfer of learnt skill**

  In cognitive learning theory, this also known as the transfer effect, which is prior learning being used for the new learning. Whatever knowledge has been learned can then be used at the next level to acquire new knowledge. When facing a new challenge, a learner should be able to assess, and be able to articulately use, the previous learning experience and be able to make a connection with this experience in order to solve the new challenge.

In a multi-collaboration game when working together in group, learning can be faster because every learner contributes knowledge to the learning and skills that are shared among the learners. This promotes faster learning, because any mistake found previously would no longer be repeated by other learners.

3.2.5 *Constructivist theory*

Constructivist theory says knowledge is created, constructed and organised from the learner's own experience. The learner also needs to collaborate within a social community in order to construct knowledge from the social world. Language learning is one example of learning created by experience. Bruner (1983) shows that children learn a new language, not just by themselves, but from close interaction and help from the parent or social community. Vicarious learning (Bandura, 1989) is a learning experience that is gained by observing others in the community of practice performing a task or skills.

3.2.6 *Serious game attributes drawn from constructivist theory*

Attributes developed from constructivist theory are: Scaffolding, and Learner control. Detailed explanations of these attributes follow.

- **Scaffolding**

Constructivist theory states that learning is built up by the learner who collaborates and negotiates with peers or with the community of practice. This requires help and support (*scaffolding*) from the social norm in order to make learners become an expert in certain learning. In serious games, scaffolding should occur in Vygotsky's Zone of Proximal Development (Dunn & Lantolf, 1998), and this refers to a point just beyond the learner's level of understanding, or the point where the learner requires assistance or help from a skilled learner. Scaffolding is a process of helping and guiding a learner from what is presently known to what needs to be learned.

- **Learner control**

A learner can acquire new skills from his own experience of learning, and can take time to do it until he is happy with it. This resembles a learner exploring on his own and picking up skills (experience) within the game in order to continue to the next level at their self-learning pace. Rogers developed the theory of facilitative learning or the humanist approach (C. Rogers & Freiberg, 1994; Zimring, 1994). He suggests that learning will take place where the teacher acts as facilitator, and the learner feels comfortable with exploring new ideas on their own and charting their own learning path.

3.2.7 *Serious game attributes drawn from psychology theory*

Attributes developed from the consideration of psychology theory are: Situated and authentic learning, Accommodating the learner's style, and Intermittent feedback. Detailed explanations of these attributes follow.

- **Situated and authentic learning**

Situated learning describes the concept where the learner needs to become involved with the community of practice, and should be more engaged and active in learning within this community, then becoming an expert in this field (Lave & Wenger, 1991). For a learning to become effective, the learner needs to learn it with, and in, the relevant context. Brown et al. (1989) explains that situated learning is important for effective learning and gives the example of learning new vocabulary from a dictionary. Here, learners find it hard to learn or to remember words, but if this is used, together with accompanying sentences where the words are relevant and situated in the right context, learning becomes much simpler and effective. Suchman (1987) takes this

concept of situated learning further and uses it in a framework of human-computer interaction. A study shows that creating and simulating a virtual clinic, together with the stressful environment of a normal day-to-day operating healthcare clinic, can convey an effective emotional connection and experience between learners and the learning environment (Swarz et al., 2010). With the situated and authentic learning attribute, a serious game can create a learning environment for the learner to experience by making it similar to a real life situation (Langer, 2009).

- **Accommodating the learner's styles**

Knowledge can be learned in variety of ways. "The Cone of Learning", developed by Bruce Hyland from the material by Dale (1954) claims that when involved in learning, the learners tend to remember 10% by reading, 20% by listening, 30% by seeing, 50% by hearing and seeing, 70% by giving lectures or presentations and 90% by doing. The process of learning takes place when there is a match between the content delivered and the learner receiving this information. If there is a mismatch between the learning styles and the teaching styles, then learners tend to get bored, doing poorly in the exam, becoming frustrated, and losing concentration in the classroom. Visual learners learn best when they receive the learning material in pictures, diagrams, and flow charts, whereas the auditory learners remember more when they read, hear or speak in the discussion (Felder & Silverman, 1988). Active learners process information through doing and experimenting, whereas reflective learners tend to work by observation and examination. Active learners are more suited to group working and reflective learners to work by themselves (Felder & Silverman, 1988). Therefore, for effective teaching delivery, the serious game should include and accommodate all the different learner styles by multiple presentations of knowledge, duplicating contents, and strategies with multiple themes.

- **Intermittent feedback**

Timing of feedback must be carefully calibrated within the serious game so that it will not inhibit the learning process, such as making the learner too worried about performance, but instead focus on and encourage deeper learning. Feedback should respond to the learner by asking questions, or trying to elicit some response from the learner. This response will help the learner devise his own meaningful learning experience and learn better.

3.3 Educational Attributes of Serious Games

The previous section identified twelve serious game attributes from the exploration of some of the established theories of education and learning. For a game to become an effective educationally-serious game, Wechselberger (2009) and Conati & Manske (2009) believe that the pedagogic values should be combined with games. Therefore, to have meaningful and effective learning, the serious game should exhibit some of the following twelve attributes identified earlier. The serious game attributes identified are summarised in Table 3-1 and are discussed in more detail in the following sections, as well as and how these attributes are related to serious games examples.

Table 3-1. Serious Game Attributes identified by the author

Attribute	Summary Description
Incremental learning	The learning material is delivered in an incremental way
Linearity	Learning is arranged sequentially
Attention span	Duration for learning concentration
Scaffolding	Support and help during the learning
Transfer of learnt skills	Applying skills to new learning based on previous learning
Interaction	Engagement in learning
Learner control	Self-learning and active learning based on learner pace
Practice and drill	Learning activities and exercises within the game
Intermittent feedback	Inform learner of his progress in learning
Reward	Incentives for the learner
Situated and authentic learning	Placing the learner in an authentic learning environment
Accommodating the learner's styles	Learning to suit learner preferences

3.3.1 *Incremental learning*

Incremental learning is based on the "input" hypothesis. Krashen (1982) explains how learning acquisition takes place and how much information needs to be supplied to the learner so that he can learn comprehensively. For example, if the learner is at stage *i*, then the next correct learning stage for the learner will be $i + 1$. But if the learner is exposed to the $i + 2$ or higher stage, then the learner will find it too difficult or complicated. Similarly, if the learner is exposed to the lower level $i - 1$, then this will be too easy and too simple

for the learner and will not be useful. Therefore, a learner should only receive an $i + 1$ stage that is appropriate for their current stage of competence (Krashen, 1982). The learning material should be introduced in an incremental way. Prerequisite learning should be achieved before the complex task to be mastered. Each task should be broken into simpler tasks. Feedback should be applied to every step of this task, to confirm the learner is following the correct path. If the learner has strayed too far, then a 'course correction' can be applied.

Piaget's theory of accommodation states that if fresh information (learning) is received by a learner, this information can easily absorbed into the memory. In contrast, Piaget's theory of assimilation states that if new information received by the learner contradicts existing information, the learner needs time to adjust before assimilating this second information into the memory (Atherton, 2009; McLeod, 2007). For example, the first time a learner sees a dog it is easy for him to take in the understanding of the animal called *dog*. Then, the learner sees a cat which is also a new animal, and this "cat" shares some of the same characteristics as the "dog", such as furry, licking, four legs. But there are things that are not the same; the cat does not bark, and the cat can climb trees. This new information contradicts existing information because the cat cannot be classed as a dog since some of its behaviour is not the same as the dog. Time is needed for the learner to adjust to this new information. Incremental learning in serious games will assist the learner so that new learning will not be a burden when trying to integrate the new learning into the existing structure (Harteveld, Guimarães, Mayer, & Bidarra, 2007). This incremental learning is illustrated in both *EnerCities* and *Climate Challenge*, by introducing a simpler task first before approaching a more difficult task later.

3.3.2 *Game linearity*

Linear learning is the method where information is delivered in a linear sequence. For example, in classroom teaching, the lesson materials are disseminated according to a predetermined curriculum. According to Carrol (2007) and Ellis (2000), linear learning is akin to reading a textbook from one page, turning to the next page, and it flows in one direction.

Linear games are often linearly structured if the goals or the game objectives are made known explicitly (Thompson, et al., 2007d). Game linearity is the extent to which the learning activities are sequenced by the game (and would suit a serial learning style), and the extent to which an active learner may be able to construct his own sequences based on

his ability. In Piaget's theory of cognitive stages of development (Gori, 2009; Piaget, 1954), learning normally take place in stages, and each stage must be completed before proceeding to the next stage. To this extent, learning needs to be made in stages and thus planned in stages for mental development. To maximise the learning benefits, a serious game should also be planned in a linear sequence. Game linearity is useful because learning takes place step-by-step, without overwhelming the learner by showing everything at once. Game linearity is illustrated in the *Chest Pain Simulator*, where the patient needs to be treated in a systematic sequence. For example, the monitor machine needs to be attached to the patient's chest prior to applying the intravenous drip to the patient, which is the correct method of managing a patient with chest pain.

3.3.3 *Attention span of game users*

Attention span concerns the cognitive processing and short-term memory loads placed upon the learner by the game. These loads need to be carefully calibrated to the target learner. The amount of time allocated for 'real learning' must accommodate the attention span of the learner. On average, the attention learning span for an American adult is 7 minutes, for a British adult is 11 minutes, and elsewhere is up to 20 minutes (Pritchard, 2005a). According to Gupta (2009), the average attention span that a person focuses on the computer screen when web surfing is 9 seconds before clicking onto the next link.

The design of the correct pace of the game should be acceptable to the user, and break up the learning sessions into reflection intervals to produce effective learning. Reflection periods will strengthen the learning and remind the learner of the objectives of the learning activity in the serious game. The game's speed also should be in tandem with the learning momentum. This speed should self-adjust to the learner's capability. Normally, this self-corrective mechanism would appear during the game introduction or during self-practice as part of the game. The points in the attention span at which knowledge can be conveyed effectively to the learner are identified by the theory of serial position effect. Serial position effect consists of *primacy* effect and *recency* effect. Primacy effect deals with the amount of absorption during the first few minutes of learning. Given a list to remember, the learner tends to remember more from the beginning than those things in the middle. From the recency effect, the learner tends to remember the last things in a list rather than those in the middle, which is opposite of the primacy effect.

Based on the study done by Ye and Nicholas (2009), the best place to position a knowledge item for the learner is at the end. Therefore, if there is an important message that needs to

be conveyed to the learner, then the most suitable place to do it is at the very end of the game scenario during the attention span. According to Kiili (2005), focus of attention is one of the most important factors for learners to keep engaging in the game to achieve effective learning. None of the serious game examples illustrated this, the closest being *Darfur is Dying*, where the time available is so short that the learner needs to focus on where to find water or where to find a hiding place if the enemy is approaching.

3.3.4 *Scaffolding within the game*

The concept of 'scaffolding' within the game is to provide some support and help for the learners until they are comfortable doing this on their own during the learning activity. As soon as learners are able to acquire knowledge on their own, this support or help is removed so that the learners can be independent and explore on their own as the support is only temporary (Panselinas & Komis, 2009). An example of scaffolding is making the game easy for those undergoing rehabilitation following a stroke. In this case, an easy game results from adjusting to learner capability, e.g. letting oranges fall slowly into the basket in a game of catching oranges for arm physiotherapy (Burke et al., 2009). Support within the game can also be provided such as giving out useful information in the introductory phase, e.g. collecting a certain object before evacuating the room during a fire which will be useful later, in the serious game that teaches fire drill skills (Chittaro & Ranon, 2009). However, the lending of 'support' within the game should be given at the appropriate time and at an appropriate level of difficulty, to meet the learner's needs. If given too much support, the learning process will be delayed (Mukherji & O'Dea, 2000). The scaffolding attribute can also be illustrated with all serious games examples. These can be shown by providing hints during the game play or assisting the learners with the help menu.

3.3.5 *Transfer of learnt skills within the game*

Transfer of learnt skills means applying previously acquired skills to other learning. This can be done within the game by continuing to the next level. Whatever skills have been acquired can then be used at the next level to acquire new skills. The previous knowledge should be revisited and new knowledge should be gradually added to what was learned most recently. New knowledge should be constructed from previous experience. In cognitive learning theory, this also known as transfer effect, which is prior learning being used for the new learning. A study was conducted by Brown & Gillard (2009) on teaching

road safety skills for disabled students in the classroom. These skills are taught in phases. Each phase has several stages to be completed and judged correct before progressing to the next stage. For example, students are taught to recognise some photographs and to associate them with location (i.e. road safety photograph to be placed next to the stop sign). After this stage is completed, the students are then challenged in the next stage to put these photographs in sequence: walk down the road, then look left, and then stop. The knowledge or skill of recognising some pictures in the previous stage is being transferred to the next stage.

A learner can be motivated by serious games through an increasing challenge. This step-up challenge is only given when the learner has shown some mastery in the previous level to indicate that the learner has acquired some knowledge and learner skills. The transfer of learnt skills is illustrated in the *Chest Pain Simulator*, where every lesson has to sharpen the existing skill before proceeding to a higher lesson that would incorporate the previous learnt skills in acquiring the new skills.

3.3.6 *Interaction*

A game needs to be carefully designed so that the learner is not put off playing because it is either too difficult to play or comprehend, or too easy. A game needs to balance interest, fun, and challenge, while keeping well-paced and allowing the learner to remain immersed and attentive (Vernon, 2006). Interaction is one of the factors that allows the learner to be fully immersed within the game. Interaction can be in the form of conversation or feedback between the player and the game, and this criterion could make such a game more effective, balanced and useful (Frazer, Argles, & Wills, 2007a, 2007b). Good games should not allow the learner to be passive, but require active participation. This is done by means of the character played or the avatar that the learner uses.

For learning to be successful, it cannot just be confined to the individual but also requires the interaction in the form of verbal or non-verbal communication with the outside community (Haneda, 2009). A structure of learning interaction is illustrated in Figure 3-1 from Gilbert and Gale (2008a).

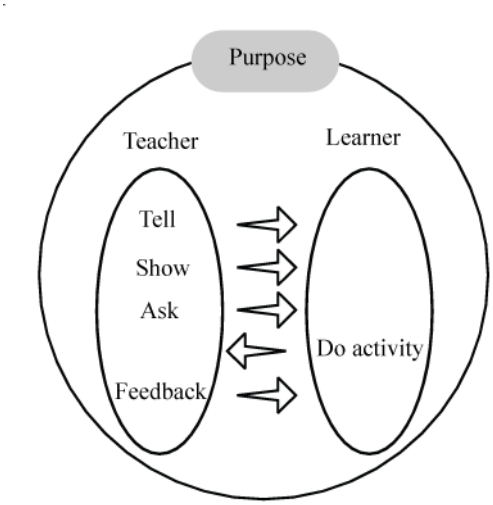

Figure 3-1. Structure of an e-learning transaction
after Gilbert and Gale (2008a).

The element *Purpose* depicts the goal that confines all the interaction to activities between teacher and learner. The sequence of interactions between teacher and learner is *Tell, Show, Ask, Do activity* and *Feedback*. Serious games can assume the teacher role in e-learning activity. First, the teacher informs the learner about the objective that needs to be achieved for this learning. Then, the teacher shows or presents the learning material. The teacher elicits learner understanding by asking the learner. The learner responds to the teacher by doing the activity requested. Finally, the teacher gives feedback to the learner about their performance. The sequence does not suggest that every learning item must be made to follow this order but, depending on the situation, serious games may choose the best sequence deemed appropriate at that particular time. Games can mimic all these actions, by providing choices for the learner and allowing the learner to make his own selection, possibly based on previous learning.

Games are capable of providing many types of interaction. The interaction attribute can be illustrated in the *Chest Pain Simulator,* where interaction with the learner is through the message display or the colour changes on the patient's skin. The success of playing this game tells how well the learner is able to interpret and act based on these interactions.

3.3.7 *Learner control*

Learners like to explore on their own and pick up skills (experience) within the game in order to continue to the next level. Rogers has developed the theory of facilitative learning or humanist approach (C. Rogers & Freiberg, 1994; Zimring, 1994). In this theory, he suggests that learning will take place where the teacher acts as facilitator, and the learner feels comfortable with exploring new ideas on their own and charting their own learning

path. Thus, the teacher will have more time to listen and develop a relationship with the learner, who is encouraged to take responsibility for his own learning. Having a 'guide' within the serious game, acting as facilitator, will manage the learner so that they do not become disoriented within the game or suffer from unmanageable cognitive overload (where the learner loses focus as the task becomes more complex). Another advantage of self-learning, mentioned by Laurillard (2007), is that digital technology provides more benefit to learners because they have an opportunity to improve their learning on their own (through self-exploration), compared with the learning experience just between teacher and learner.

Self-control is not enough. The learner should be able to re-examine and re-assess the action during play, such as questioning whether this is a meaningful way of doing things in the game. The strategy that the learner uses to plan for future learning, and the understanding of the ways in which they learn on their own, is called metacognition (Fox & Riconscente, 2008; Zabrucky, Agler, & Moore, 2008). The appropriate point where a game can introduce the new learning process of self-exploration, would be at the Zone of Proximal Development. Vygotsky's Zone of Proximal Development (Dunn & Lantolf, 1998) refers to a point just beyond the learner's level of understanding, or the point where the learner requires assistance or help from a skilled learner.

The game should allow the learner to gain access to new knowledge or any information links outside the game play. This could create an opportunity to strengthen existing knowledge already acquired in the game. In the case of solving a complex problem, the game could suggest several solutions or the learner can be encouraged to engage this problem by visiting different perspectives. Spiro's cognitive flexibility (Spiro, Feltovich, Jacobson, & Coulson, 1992) corroborates this approach of knowledge being constructed from many sources.

In summary, learner control is the extent to which the learners can direct their learning activities within the game, providing self-study and self-exploration to suit their own pace and experience. This can be illustrated in the *Chest Pain Simulator*, where the learner can have all the control and options to treat the patient and only the end result will show whether the learner did apply the correct exercise in treating the patient. This learning path is self-directed by the learner during the learning process.

3.3.8 *Practice and drill*

According to Thorndike's 'Law of Exercise' (Green, 2008; Thorndike, 1914) and Kaufman's 'Practise Effects' (Kaufman, 2003), learning and retention are strengthened by more practice or exercise. However, while this would benefit some learners, bright learners may find this boring and unsatisfying (Prensky, 2001b).

Practice and drill can be implemented in several ways. In an attempt to help memorisation skills, a game can incorporate a reminder from the previous tasks so that the learner will have some recollection of previously learnt skills. To enforce vocabulary retention, a game can repeat some of the words or exercise these words in a different syntax, so that it keeps reinforcing the learner's memory. As with learning in tertiary education, such as memorising concepts or trying to memorise mathematical formulae, there is no substitute for memorising practice. Learners should be encouraged to recite verbally both what they have read and from their memory.

Negative reinforcement may also have an important role if the aim of the game is to make it compulsory to memorise words or definitions. For example, the learning within the game must be completed within a certain time, otherwise the game terminates early. In this way, the learner will try their best not to fail. Skinner states that negative reinforcement is an effective way of getting rid of unwanted behaviour or forcing someone to learn (McLeod, 2007). However, this learning does not last long because the desire to learn occurs only when negative reinforcement is present, and as soon as this is removed the desire for learning stops. This practice and drill can be best illustrated in the *Chest Pain Simulator* and *Darfur is Dying*. In *Darfur is Dying*, the learner must find a suitable place to hide from the enemy in minimal time and this can be achieved by a lot of practice in the game.

3.3.9 *Intermittent feedback*

According to operant theory, reinforcement by feedback has four basic sequences: fixed ratio, fixed interval, variable ratio, and variable interval (Huitt & Hummel, 1997). The ratio is based on the number of responses received and intervals based on timing.

- Fixed ratio is the delivery of reinforcement after every n^{th} response. For example, the feedback would be given after a specific number of correct responses from the learner. During the initial game activity, when a new concept is being introduced, a higher ratio of feedback is given. This is a measure of how the learner performs at the beginning of

the game. After the learner becomes adapted to the learning, this feedback ratio is reduced.

- Variable ratio is the delivery of reinforcement after an unpredictable number of responses. As the game progresses and the learner is fully immersed in it, feedback may be given more variably depending on the learner's action.

Feedback within a game should be based on one of the ratios above, as best suits the strategy for the intended objective. Feedback to the learner can be in the form of scores, help, hints, progress bar, navigation chart, sound or controller vibration.

A game should respond to the learner by asking questions, or try to elicit some response from the learner. With the help of reinforcement or feedback, the learner will devise his own learning experience and learn better. A game could give some hints to help the learner look for the answer. A different approach entails a collaborative game that allows negotiation to take place between the learner and the learning task, to improve learning. Furthermore, feedback provides opportunities for the learner to reflect through dialogue. The attribute of intermittent feedback can be illustrated in the *Climate Challenge* and *EnerCities* games, where the delivery of feedback is given to the learner through the climate indicator or the inhabitant responses, based on the learner's actions. Learners need to evaluate these responses and act accordingly in the games in order to solve the situation.

3.3.10 *Reward*

Learners need to be praised within the game, thereby increasing their desire to learn (Mukherji & O'Dea, 2000). This should not be just limited to "Well done!", but should also include positive rewards such as points scored, or virtual money to buy new objects (such as new weapons) within the game, or increasing the learner's character's life within the game. Rewards generate confidence that leads to personal satisfaction in the learning process. This is fully supported by Thorndike's 'Law of Effect' (Green, 2008; Thorndike, 1914), where a response followed by a reward strengthens learning. Skinner recognised that pleasant experiences (such as rewards or praise) are positive reinforcers (McLeod, 2007). This leads to an increase in the desire to learn more. Rewards can have a significant influence on human behaviour and, according to Schultz (2004), the human brain produces different kinds of response to the reward given. The reward scheme should be carefully planned so that it has a sense of value, because over-rewarding becomes valueless to the learner and inhibits effective learning. Sensible and finely-tuned reward can lead to learner

satisfaction and increased learner motivation (Habgood & Overmars, 2006). The reward attribute is illustrated in all the serious game examples. In the *Chest Pain Simulator*, the learner is congratulated on every correct measure taken and this makes the learner more satisfied and more engaged in the learning.

3.3.11 *Situated and authentic learning*

Situated learning (Lave & Wenger, 1991) is the concept where the learner needs to become involved in the community of practice, and should be more engaged and active in learning within this community, finally becoming an expert in this field. By placing the learner in an authentic environment, the learner will be able to develop mental models of their experience and potentially relate it to real life. Use of a familiar background or common examples in a game's content, and relevant to the learner's experience, should be incorporated in the game. Furthermore, learning in an authentic situation will hold "more attention, interest and deeper level engagement" by the learner (Prensky, 2001b).

To achieve meaningful play, the learner must be able to choose the correct action in the game to achieve the outcomes (Burke, et al., 2009). The learning would be improved if the game environment is similar to the real situation, in order to achieve meaningful learning, as for example the serious game designed for training staff for fire drill (Chittaro & Ranon, 2009), or the triage training exercise in an emergency situation (Jarvis & de Freitas, 2009). The objects created in the game are similar to the real world, for example, a fire extinguisher. The mental model of situated and authentic learning should try to impersonate the real world and make it relevant for the learner. The attribute of situated and authentic learning is best illustrated with *Darfur is Dying*, where the scenario presented in the game captures the real-life situation of what is happening in Darfur and, by playing this game, learners would feel and experience for themselves the hard life that exists in this situation.

3.3.12 *Accommodating the learner's styles within the game*

It would be difficult to cater for all learner needs and preferences with their wide variety of learning styles (Felder & Silverman, 1988). Game presentation and well-designed activities should be varied so that they can accommodate most learner preferences. For example, for an active and reflective learner, a game should have active learning by talking, discussion, dramas and challenges, and reflection by feedback. This would match an active learner because the learner processes information through doing something or experimenting

within the game. Alternatively, by using the transfer of skills, a reflective learner is able to recollect events from a previous level and use them for the current level. None of the serious game examples is able to cater for different styles of learners. However, all the serious game examples are suitable and can be played by all active learners.

3.4 From Attributes to Design Principles

This section considers how to map the twelve attributes into principles for the design of serious games. These design principles must take into account the serious game attributes and to fit them to the scope and the definition of serious games, as described in Chapter 2.

Incremental learning emphasises that:

- The learning material should be introduced in an incremental way.
- Prerequisite learning should be achieved before the complex task to be mastered. Each task should be broken into simpler and manageable tasks.
- Any high complexity material should be divided into small pieces, which helps the learners process this information in memory, thus reducing the cognitive load.
- If learners are not interacting with the game as intended, for instance learners ignoring the game's directions, then the information should be reduced to simpler and easy to understand terms.

Linearity emphasises that:

- Knowledge is being delivered in a linear sequence.
- Learning content should be relevant and not artificial, and it should not look like a simple marriage of education and games.
- Learners should not feel distracted by doing two separate things within the game and losing focus, as this will corrupt the idea of engaging learning. Instead, the educational content and game should be smoothly integrated so that the learners feel seamless learning.

Attention span emphasises that:

- The cognitive processing and short-term memory loads need to be carefully calibrated to the target learner.
- The method of reducing the cognitive load on the learners can be accomplished by low complexity material being presented with pictures and text together. For high

complexity material, only a picture with little or no text should be shown (Lee, et al., 2006).

Scaffolding emphasises that**:**

- The provision of some support and help to the learners until they are comfortable doing this on their own, and gradual removal of the scaffolding so that the responsibility is shifted to the learners.
- The learners must become active and participate in knowledge construction, while the teacher acts as collaborator and facilitator.
- The learners are encouraged to work with their peers.

Transfer of learnt skills emphasises that**:**

- Applying previously acquired skills to other learning, and new experience being developed from performing every task.
- The ability to connect the solution to the new problem or increasing challenges with previously learned skills to gain new experience.
- The creation of an overlearning situation, whereby learners are encouraged to tackle a new level immediately after mastery of the previous skills and knowledge.
- The learners become producers by commenting, critiquing and improving their own previously learnt skills.

Interaction emphasises that**:**

- The learning needs to be balanced, interesting, fun, and challenging, while keeping well-paced and allowing the learner to remain immersed, attentive and engaged. The learning should never make the learner to feel bored and confused.
- Learners actively participate in gathering intelligence and this is done by trying and collecting different strategies in order to achieve the learning objective.

Learner control emphasises that**:**

- Learners have autonomy in contributing to their knowledge, by allowing them to voluntarily create their own learning path, learning experience and knowledge by exploratory and self-discovery. They must reshaping their own learning skills and create their own learning trajectory.

- The learners should be able to re-examine and re-assess their actions during play, such as questioning whether this is a meaningful way of doing things in the game. This would allow them to learn by doing and to learn through experimentation.
- Applying strategic thinking in solving a complex problem, several solutions could be suggested or the learner can be encouraged to engage this problem by visiting different perspectives.

Practice and drill emphasises that**:**

- New knowledge is fragile and it requires repetition and constant rehearsal.
- If any memory retention is required, then more practice or exercise helps to reinforce the learner's memory.

Intermittent feedback emphasises that**:**

- Feedback is provided informing the learner of progress.
- Learners should be given a prompt response and rapid answer.
- Adjustment to faster or slower, according to learner ability.

Reward emphasises that**:**

- Giving a reward should encourage and bring out some intrinsic motivation from the learner. Intrinsic motivation will push learners to progress freely on their own.
- Over-rewarding becomes valueless to the learner and inhibits effective learning.

Situated and authentic learning emphasises that**:**

- A learning environment should be created to be similar to the real life situation, and with authentic tasks.
- The learners are directed to develop the skill of spatial awareness, which is a skill of understanding, through trying to create a realistic feeling about how and where objects are shown and related to other things. Learners will then be able to have a similar feeling when dealing with the real object or learning in the outside world.

Accommodating the learner's styles emphasises that:

- Game presentation and well-designed activities should be varied so that they can accommodate most learner preferences.

3.5 Summary

Serious game attributes were derived from the literature review and from critically thinking about the educational learning theories. These attributes are the result of extensive literature review and were summarised in Table 3-1 above. These attributes are chosen for use in the design of serious games to create effective learning for the player. The attributes identified in Table 3-1 address the educational attributes of RQ1.

RQ1: What are the relevant educational attributes that would support learning in serious games?

Further inspection of these attributes will be conducted in Chapter 5 to find out which are more important and will result in learner interest in using this game as a learning tool.

The following chapter expands the use of these serious game attributes into one of the components to be included in the conceptual framework for serious games design. The proposed framework will be useful and of practical guidance to designers and educational practitioners in designing effective serious games for learning.

Chapter 4

Serious Games Conceptual Framework

The previous chapter described the attributes that contribute to the learning aspects in serious games. These attributes must be placed in a framework for building serious games. This chapter discusses the development of a framework, since many designers have failed to produce truly engaging and effective learning games. One of the reasons for this is that the tasks are poorly designed within the game and do not really support learning (Kirriemuir & McFarlane, 2004).

Prensky (2001b) claims the ideal model for serious games for learning is to have an equal proportion of engagement and learning. He stated that, by introducing enjoyment into the game, the learner becomes more engaged with the learning. Few studies have suggested serious games frameworks, and they are still unclear and lacking in producing an optimal framework. The Input-Process-Outcome game model by Garris (2002), focuses on a repetitive loop that requires learners to constantly re-engage within the learning process and, due to its nature as a repeating process, it inhibits higher and active learning (Westera, et al., 2008). Charles (2009) presents a model that illustrates the relationship between computer games and learner. He illustrated three layers for a useful game. The first layer deals with game mechanics that needs to be observed by the learner. The second layer is the dynamic link between the learner and the game, and the third layer is the aesthetic design of the game, which creates the learner experience within the game. This model is too basic and intended for fundamental layers of computer games, so does not offer any detailed design for optimal learning.

De Freitas and Oliver (2006) introduce a framework for supporting tutors' evaluation of education games and simulations. However, this framework only looks at the game evaluation not at its design (Westera, et al., 2008). Hu (2008) proposes a game framework called Eduventure that is based on classroom teachings, which uses an adventure game for learning. This model is still too confined to a textbook style and does not offer any freedom for exploratory learning. Amory (2007) proposes Game object model II, which focuses on identifying interface requirements for the game, the challenges and the social space. This model is too general (Westera, et al., 2008) and only provides a little guidance of how to implement it in designing serious games, because it does not take into consideration gameplay and flow theory (Kiili, 2005).

Westera et al. (2008) proposed a framework based on the expansion of the basic architecture of scenario-based game development. The framework is strongly linked to customised software called Emergo (2008). However, this framework is still in the theoretical stage and does not offer any design solutions to work with other game design tools. Kiili (2005) proposes a learning game model based on the four stages of experiential learning by Kolb (1979). This model uses the challenge as a problem-solving activity to keep the learner engaged. Even though this model is trying to integrate learning with games, it still lacking other important pedagogy elements such as reward.

Therefore, in order to address the above problems and to improve the game design to make games more effective for learning, we propose the new framework shown in Figure 4-1. This lightweight model represents a structure that will be used as a conceptual framework for serious games. This framework will include the learning and pedagogy perspectives, in combination with the games, and aims to establish a conceptual model that can be used by a game designer for efficient game development or an educational practitioner when designing serious games for effective and optimal learning. The framework shown in Figure 4-1 is based on the study of pedagogy theories, real games construction and is an evolution from a previous framework (Garris, et al., 2002; Gilbert & Gale, 2008b; Thompson, Berbank-Green, & Cusworth, 2007a).

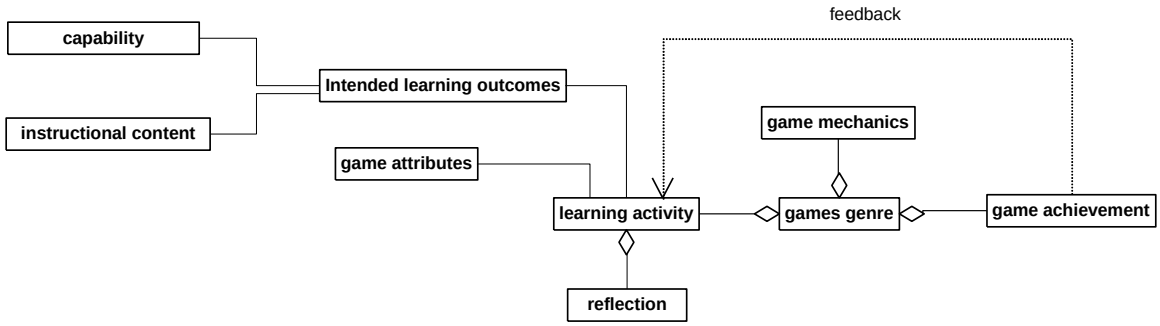

Figure 4-1. Conceptual framework for serious games
shown as an outline class diagram

4.1 The Serious Games Framework

Figure 4-1 is a conceptual model in UML class diagram notation. Because this is a conceptual model, it can be used as a framework that visually represents the arrangement of the serious game elements. The elements of this framework will be briefly explained from left to right. The *capability* is the learner capability to be learned in the game, and the *instructional content* is the subject matter that the learner is required to study. Both are components of the *intended learning outcomes*, which is the aim of playing the serious game. *Game attributes* function as support for learning and engagement. Game attributes and intended learning outcomes are the components that relate to the game's *learning activity*. The *game genre* is the type or category of the game and identifies the kind of environment for the set of activities to be played within the game world. The *game mechanics* are the components that give more engagement and more enjoyment to the game.

Game achievement is the output from playing the game, such as total number or score. This result is also referred to as the learning assessment. How well the learner is coping with the instructional contents depends on this achievement. If the achievement is low, then the game should be dynamically adjusted to the learner's level by lowering the difficulty level within the game activity. In this way, the game will balance itself adaptively to the learner's level. The learning outcomes are the goal and aims for the learner and these outcomes are associated with learning activities and game achievement. Game playing and the learning outcomes exist in two separate worlds, because game playing is an activity where the learner is totally immersed in the game world, while the outcomes are set earlier in the real world. The learner should not have to break away from the game in order to know whether the learning has reached the objectives, because all the learning should take place within the game world. *Reflection* is where the learner finds out whether the learning has reached the goal and is made to understand the relevancy of game activity to the

learning outcome. This reflection process will be made part of the game activity, in order to make sure that the learner remains within the game world.

The following are detailed descriptions of every class component in the serious games framework.

4.1.1 *Capability*

Capability refers to the cognitive, psychomotor, and possibly affective skills, which the learner is to develop as a result of playing the game. These skills have been identified by, for example, Bloom's taxonomy in the cognitive domain (Bloom, 1956), Dave's taxonomy in the psychomotor domain (Kennedy, Hyland, & Ryan, 2007), and Krathwohl's taxonomy in the affective domain (Krathwohl, 2002).

Serious games allow capability to be classified into a learner capability hierarchy, which range from lowest level (basic learning) to highest level (complex learning).

4.1.1.1 Cognitive domain

There are six levels defined in Bloom's taxonomy for the cognitive domain. Starting from the lowest level, they are: Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation. Cognitive ability is the action skills that learners want or the learner capability sought, suitable to the level of the cognitive skill. Table 4-1 summarises the relationship between cognitive ability and the assessable behaviour as illustrated by Gilbert & Gale (2008a). For example, if the aim of the lesson in the game activity is to know about the objects, then the game activity is designed around the object, and the learners are tested by recalling or naming the object. Gradually, this skill can be increased to the next level once the learner has attained the present level. At the highest level is evaluation, where learners have gained all the previous abilities and expect to be able to judge, evaluate or critique a given subject.

Table 4-1. Cognitive domain based on Bloom's taxonomy
taken from Gilbert and Gale (2008b)

Level	Cognitive ability	Assessable behaviour
Knowledge	Knows terms, specific facts, rules, trends, categories, criteria, methods, procedures, principles, concepts, theories.	Name, label, define, state, recognise, list, recall, identify.
Comprehension	Translates and paraphrases communications; interprets, summarises and explains relationships; extrapolates from given data.	Explain, classify, summarise, extrapolate, interpret, convert.
Application	Applies concepts, principles, rules, procedures.	Calculate, solve, plan, construct, use, prepare, predict, demonstrate, apply.
Analysis	Analyses elements, relationships or organisational principles; analyses connections, relationships or arrangements.	Compare, contrast, infer, explain.
Synthesis	Produces new arrangement or new result.	Compose, originate, design, create.
Evaluation	Judges on the basis of criteria and evidence.	Appraise, argue, evaluate, criticise, assess, discriminate.

4.1.1.2 Psychomotor domain

There are five levels defined in Dave's taxonomy (Kennedy, et al., 2007) for the psychomotor domain. Starting from the lowest level, they are: Imitate, Manipulate, Precision, Articulation, Naturalisation. Psychomotor ability is the action skills that the learners want or the learner capability sought, suitable to the level of the psychomotor skill. Table 4-2 summarises the relationship between the psychomotor ability and the assessable behaviour. For example, if learners want to learn about tennis, then a serious game can teach the basic tennis lesson by asking the learner to imitate the observed example of the expert serving a ball. This skill can be taught with the help of additional hardware in serious games, for example by the use of a Wii console (Nintendo, 2009).

Table 4-2. Psychomotor domain based on Dave's taxonomy

Level	Psychomotor ability	Assessable behaviour
Imitate	Observe other person's behaviour and copy it. Replicate the behaviour shown by example.	Impersonate, copy, mimic, imitate, repeat, duplicate, reproduce.
Manipulate	Ability to perform skills by following the instructions.	Follow, demonstrate, perform, execute, present.
Precision	Ability to perform skills with minimal errors and more precision. Smooth and accurate.	Perform skilfully, proficient and becoming expert.
Articulation	Ability to solve and modify skills to fit new requirements.	Adapt, revise, adjust, revise, customise.
Naturalisation	Ability to perform the skills without thinking.	Flawless and perfect.

4.1.1.3 Affective domain

Affective learning is skill or behaviour suggested by attitudes based on Krathwohl's taxonomy. There are five levels defined in Krathwohl's taxonomy (Krathwohl, 2002) for the affective domain. Starting from the lowest level, they are: Receiving, Responding, Valuing, Organisation, Value Complex (characterisation by value or value set). Affective state is the action skills that the learners want or the learner capability sought, suitable to the level of the affective skill. Table 4-3 summarises the relationship between the affective ability and the assessable behaviour as illustrated in Gilbert & Gale (2008a). For example, at the level of valuing, the learner can be tested by a serious game on how they support the democratic process or how they openly support the recycling system of waste management.

Table 4-3. Affective domain based on Krathwohl's taxonomy

Level	Affective Ability	Assessable behaviour
Receiving	Aware and sensitive to certain ideas and attentive to something in the environment.	Locates, names, asks, describes, identifies.
Responding	Active participation, showing interest and willingness.	Complies, volunteers, performs, presents.
Valuing	Valuing and endorsing certain ideas. Showing and accepting some commitment to certain beliefs.	Supports, defends, aligns, justifies.
Organisation	Understanding other values and bringing together different values into harmony.	Combines, arranges, explains, modifies, absorbs.
Value complex	Having his own value system and to act consistently.	Practises, uses, displays.

4.1.2 *Instructional content*

The instructional content is the subject matter that is intended to be learnt. The detail of the actual subject matter, or the type of content, could be an exhaustive list. Gilbert & Gale (2008b) illustrate the classification of content into four types: facts, procedures, concepts, and principles, based on Merrill's Component Display Theory (Reigeluth, 1999).

Learning about facts is learning about specific things, usually based on unique numbers, specific dates or definitions. For example, in the academic study of history, facts are usually associated with names, dates and events. Another example: if the learning action is to name the hierarchy in learning languages, the answer could be learning the meanings of phonology (sound of language), syntax (word order), semantics (meaning) and pragmatics (language use in society) (Meier, 2006). In the *Chest Pain Simulator*, the learners are given an electrocardiograph (ECG or EKG) and need to interpret this chart, based on facts that have been studied previously on the activity of the human heart.

Learning about procedures is equivalent to learning about sequences. A procedure is a step-by-step action in order to achieve a task. For example, to demonstrate the ways an assembly process is taught to operators in a production line is by following procedures. The *Chest Pain Simulator* demonstrates to the learner that the critical procedure for treating the patient with chest pain is to apply the chest monitor first, followed by the oxygen tank.

Learning about concepts is learning about the values, ideas, symbols, events or things that are grouped into a common entity, the concept, that has similar attributes. The *Chest Pain Simulator* teaches how to recognise chest pain. The concept is chest pain and its causes and symptoms. One of the reasons why the *Chest Pain Simulator* was created is the failure of emergency physicians to diagnose a patient with chest pain correctly, such misdiagnoses resulting in a large number of medical malpractice claims.

Learning about principles is about cause and effect relationship. Principles are usually governed by guidelines, rules or parameters. A principle allows predictions to be made or implications to be drawn. For example, *EnerCities* demonstrates the cause and effect on the climate due to city development or excessive building of factories in one area.

Depending on the learning contents chosen by the teacher, the game activity should be designed and matched to the subject matter.

4.1.3 *Intended learning outcomes*

Learning outcomes are the goals to be achieved from playing the serious game. Figure 4-1 shows that the intended learning outcome is a particular combination of capability and subject matter.

Although learning outcomes are one of the key components, or viewed as important reasons for learning, the actual main purpose of learning with games is to allow the learner to feel engaged during the learning process without thinking too much about the outcomes. Huizinga (1970) states that play is a voluntary act within a specific time frame, binding the rules to the objectives to be achieved by the player, and goes together with a feeling of joy, tension and consciousness that is 'different' from 'ordinary life'. One of the advantages of learning with games is that they can improve existing skills by means of blended learning (Clark, 2007; Thorne, 2003). For example, pilots undertake rigorous training in both the classroom and in the aircraft. A study has shown that, by introducing a number of hours playing aviation computer games, pilots have performed better in test flights (Connolly, Johnson, & Lexa, 1998).

The real-world skill acquired from playing games is in proportion to the real world being translated within the game (Quinn, 2005). For example, learning with the *Chest Pain Simulator* depicts the medical control equipment that resembles the operating room with the image of the patient lying on the bed. On the other hand, successfully obtaining a high score by playing a video game of soccer, or being able to do a loop or high jump with a video skateboard game, does not imply that the learner is acquiring a real-world skill. Typing something onto the keyboard, or using the joystick, is not the same as acquiring mastery of new skills in real life. There are simulation games that reflect the real situation, such as treating a patient with chest pain. Although real-world motor skills cannot be gained from playing these games, the learner can still learn about the key concepts of the medical equipment such as oxygen cylinder, cardiac monitor, intravenous therapy and obtaining vital signs of the patient. For example, in the *Chest Pain Simulator*, the learner learns how to perform the correct sequences in managing a patient with chest pain. By clicking the mouse on the control equipment, the learner will be able to learn to apply and test their previous knowledge and to relate to the actual skills required in the actual operating room. The results of the learner's actions do have an impact on learning outcomes and this is shown by the patient's chart or the colour changes in the patient's skin.

One of the pedagogical guidelines is to tell the learner the learning objective or informing the learner about the intended learning outcomes. This guidance is derived from Gagné's nine events of instruction (Killpatrick, 2001). Normally, this announcement happens in the game introduction or in the game help menu. For example, in the *Chest Pain Simulator*, the intended learning outcomes are defined as follows:

> *By the end of this game, the learner will be able to use and to apply the correct procedures in treating a patient presenting with chest pain.*

In this example, the learner capability that the *Chest Pain Simulator* wants learners to achieve contains the keywords *use* and *apply*. Some of the capability keywords are already listed in Table 4-1 under the assessable behaviour in the cognitive domain. The subject matter is procedure, and the procedure example using the intended learning outcome above is *treating a patient presenting with chest pain*.

Typical examples of learning outcomes are based on taxonomies of educational objectives with learner capabilities drawn from the psychomotor, cognitive, and affective domains (Gilbert & Gale, 2008b). Some the learner capability words can be drawn from the assessable behaviour shown in Table 4-1, Table 4-2 and Table 4-3.

The cognitive learning outcomes arise from the cognitive domain in three distinct levels. At first level, the learners will be able to understand the learning material. For example, learners are able to reproduce or recognise some information based on the knowledge learned. At the second level, learners are able to apply or to demonstrate this knowledge in a specific case. At a more advanced level, learners are able to construct or to design new principles based on previous knowledge (based on Merrill's Component Display Theory).

In summary, the intended learning outcomes would be based on the cognitive, skill-based and affective domains. For example, if the learning is concerned with knowing certain facts, which is the first level of the cognitive domain, then the intended learning outcome for the learner is to be able to name or state these facts during the game activity.

4.1.4 *Game attributes*

Serious Game attributes are those aspects of a game that support learning and engagement and were identified from the literature review of behaviourist, cognitive, constructivist, and psychology perspectives. Details of serious game attributes were explained in Chapter 3.

Game attributes will be one of the main factors supporting learning and engagement. Twelve predefined attributes were considered in the previous chapter, while the actual

number of attributes in a particular game may be a subset of these. However, attributes such as intermittent feedback, reward, interaction and learner control, should be included in every activity because these are responsible for the game 'flow'. Game 'flow' is a feature where the learner will keep engaging with the game environment, totally ignoring the outside world. Csikszentmihalyi (1990) has defined the notion of 'flow', which he describes as "*…being completely involved in an activity for its own sake. The ego falls away. Time flies…*" Past study has showed that 'flow' has a positive impact on learning (Kiili, 2005). In order to keep the learner engaged, and to have an equal proportion of engagement in learning, these attributes will be the background driver to make sure that this happens.

4.1.5 *Learning activity*

If the subject matter, capability and intended learning outcomes are considered as a 'lesson' that needs to be taught, then the game can be represented as a 'classroom' or 'curriculum' where the learning activity takes place.

Learning activity is the activity designed to keep the learner engaged and learning in the game world. The deep involvement or immersion by the learner depends on the effective design of these activities. Three types of subject matter are discussed here.

- Learning facts is where the learner is taught to remember or to recall particulars. These activities include showing some examples of the facts and asking the learner to answer later. Commonly used activities within games are filling in the blanks and memorisation with a lot of practice and drills. In the *Chest Pain Simulator*, learners are asked to select and to identify the chest monitor before applying it to the patient.
- Learning concepts deals with invention, classification, categorisation, exploration and definition (Gilbert & Gale, 2008a). Suggested activities within games are creativity, exploring, problem solving, and detection (investigating). In the *Chest Pain Simulator*, learners are tested in applying the correct treatment concept when treating patients with different symptoms.Learning principles covers prediction, exploring problems and explaining cause and effect (Gilbert & Gale, 2008a). Examples that can be used by games are critical thinking, and discussing and debating some phenomena within the game. Learning *procedures involve*s demonstration step-by-step. Game activities for procedure learning can include role-playing, matching and association.

Gilbert & Gale (2008a) suggest a number of methods for constructing learning activities to support given intended learning outcomes. For example, if the teacher wants to solicit the

concept name from the student, the first thing to do is to show an example of the concept to the student, then ask the student for the concept name, and when the student responds, the teacher gives the student feedback on whether the answer is right or wrong (based on Merrill's Component Display Theory).

The frequency of interaction with the learners depends on the game activity. If the activity is to ask the student to develop a brand new concept, the interaction between teacher and student will be more frequent, and the level of teaching higher, such as asking the student to invent their own concepts.

The interaction events between the learner and the game in the learning activity, where it is appropriate, should follow Gagné's nine events of instruction (Killpatrick, 2001) as shown in Table 4-4.

The most important thing about these activities is to ensure the learner stays engaged and learning within the game, and stays immersed without becoming bored. Activities should involve learning materials that are appropriate and challenging for the target learner seeking competency at a level slightly above that of their current competency (Gee, 2007a).

Table 4-4. Gagné's nine events of instruction within the learning game activity

	Instructional event	**Game activity**
1	Gain attention	Get the learner's attention.
2	Tell learners the learning objective	Inform learner of the learning outcomes.
3	Recall prior knowledge	Extract some information that the learner already knows.
4	Present content and learning material	Game activity and lesson to be learnt.
5	Offer guidance and help	Help and support the learner. For example, scaffolding in serious game attributes.
6	Elicit the learning by demonstrating it	Ask learner to do what he has been taught, by performing an action within the game.
7	Provide feedback on performance	Inform learner of his performance. For example, feedback in serious game attributes by means of scoring points, life or health status, vibration keypad or sound.
8	Assess performance, give feedback and reward	Evaluate learner on his knowledge of the subject matter.
9	Enhance retention and transfer to other contexts	Assist learner in remembering and applying the new skill. For example, use similar tasks in the next level but increase the challenge so that new skills can be attained.

The activity should entice the learner, make them willing and show interest in playing games for learning, and taking responsibility for their learning. If the learners are not willing whole-heartedly to learn new materials with games, then learning will not take place. The learner also should submit to the game mechanics and be willing to embrace the suspension of disbelief in the game world (Thompson, Berbank-Green, & Cusworth, 2007b).

Learners also need to be given a sense of enjoyment and motivation when playing these games, which will make the learning more interesting and be hard to stop. Suitable and appropriate challenges should be carefully designed and implemented within the game play in order to keep the learner engaged. Learners need to be fully immersed within the games and willing to go deeper with the learning material. They also must be confident that, when learning with games, they will gain mastery for applying this knowledge later in the real world. Salmon (2003) states that effective activity involves the learner feeling they are being supported, ensuring that they are given access to the technology, and also the belief that they can develop their skills. One of the ways to build up motivation and immersion in the game environment is to apply Keller's ARCS model (Attention, Relevance, Confidence and Satisfaction elements) together with the Gagné's nine events of instruction (Gunter, Kenny, & Vick, 2008).

The design of usability for the learner is also important for the game activity. Bad usability design can lower or halt the learning progress. This is because learners have to sacrifice their learning attention to other improper activities (Kiili, 2005). Consideration of the type of learner who will be using the serious game, can be a guide in designing good usability. For example, in the game for training levee inspection (Harteveld, et al., 2007), the target participants were from 18 to 65 years old, while 45 was the average. Most of the participants did not grow up with the computer and have little and no experience with computers, therefore the simple use of mouse and arrow keys is more appropriate.

4.1.6 *Reflection*

Reflection is where the learner thinks about the purpose of the learning activities that have been undertaken, and decides the strategy to apply during the next activity (Rowntree, 1998). For example, once the learner has successfully achieved any game activity, they should be informed of the correlation between the achievement, the game activity, and the learning outcome. It is very useful because learners may forget about the real objective of playing games if too preoccupied with their enjoyment.

This reflection process should take place without letting the learner step out of the game world, and this can be done by offering reflection activity within the game. This process is important and critical because this is where the learning experiences establish the relationship between the game world and the real world. Garris et al. (2002) have stated that reflection activity can be included within the game by providing a description, an explanation of why this activity is chosen, a discussion of the errors made by the learner, and some corrective suggestions. Learning through reflection also is supported by Kolb's problem solving cycle (Kolb, et al., 1979) and he labelled this as: doing, reflecting, understanding and applying, in the learning process. For reflection, the learner should be able to find a new approach in order to solve the next task, and this is useful because the skills or knowledge gained from the previous level of game activity can be used to solve more challenges in the next round or at the higher level.

4.1.7 *Game genre*

Game genre is the type or category of game played. Genres range from "beat-em-ups", through open-world sandboxes, to strategy games, and simulation (Bergeron, 2006; Thorn, 2007). More recently, game designers have developed serious games adapted for learning purposes according to games genres (Rapeepisarn, Wong, Fung, & Khine, 2008). Some examples are shown below.

- "Beat them up" is a game of combat in an arena, where the user needs to defeat the opponent within the ring. This is can be shoot-them-ups, such as *Space invader* and *Asteroids*.
- "First person shooter" is a game where the user playing the game sees through a character's eyes, such as *Doom* and *Quake live*.
- Movie or film tie-in is a game related to a movie, such as *The Golden Compass* and *Beowulf*.
- An open-world sandbox game is an open-ended game, where the outcome of the game depends on the learner's action, such as *Grand Theft Auto 4.*
- In a strategy game, the learner can have a god's eye view of the property, and govern these assets effectively, such as *The Sims*.
- A third person game is where the learner can see their own character in a distant perspective, as if seen through the camera, such as *Halo3* and *Turok.*

Detailed references for the games surveyed above are provided in Appendix A. The serious games discussed in this thesis fall into the strategy game genre.

4.1.8 *Game mechanics*

Game mechanics are the game operations, and the purpose of this notion is to enable the game to be more fun, enjoyable and more engaging for the player. These are the core functions that games are based on, and the website boardgamegeek.com (Boardgamegeek, 2009), has used game mechanics to classify over 4 000 games. Not all the game mechanics are used, but there should be at least one game mechanic for each game genre, and each type of game genre could consist of several mechanics. The game activity and instructional content may influence the choice of game mechanics in order to design a better game that will suit a particular style of learning. Examples of game mechanics that are commonly used in game design are presented below (Lundgren & Bjork, 2003; Thompson, Berbank-Green, & Cusworth, 2007c).

- Turns-based is a segment of the game that is set aside for certain actions to be completed. The result of this action prompts the player to wait for his turn to play. Sometimes, a stretch of time is used to represent this turn.
- Capture or Eliminate refers to an action in most of the first person shooting games. The objective is to ‘kill’ as many enemies as possible until attempting to eliminate the big boss. The score or the kill count reflects the number of opposing monsters eliminated during the game.
- Role playing is where the user acts as a fictional character in the game. The chances of winning depend on the effectiveness of learner actions such as negotiations and making decisions.
- Computerised clues refers to controlling the distribution of clues to the user, which may vary depending on the game task and game level. Clues can be hidden and the user needs to find them before proceeding to the next level or before the time expires. The user may not be told how reliable this clue is or when the clue will be given.
- Espionage is where the user can zoom into the opponent’s territory to learn how to defeat them, but the level of accuracy of this information is regulated by the game.
- Luck is game prediction that is beyond learner control. The game outcome is purely based on chance.

- Strategy is the opposite of luck, and the outcome of the game is based on the actions of the user.
- Diplomacy is where the user interacts with and collaborates with others. This can be two players at a console (multiplayer), or collaboration playing over the internet by taking part in one of the role-playing characters.
- Resource management is where the user controls and governs the game's assets. Resource or opportunity given during the game must be used diligently.
- Auction and bidding is where the user may need to make a competitive bid in order to get an exclusive right to perform a certain action. If the user makes the winning bid, the user needs to pay a certain amount in tokens for game rewards, such as game life or money to buy other assets.
- Territory control is where the player's area is being developed and defended from enemy attacks. Usually this is a game of real-time strategy.

4.1.9 *Game achievement*

Game achievement is the level of learner achievement in playing these games. This achievement can be indicated by the game scores, total amount of resources or assets collected within the game, or time taken to achieve game goals. In addition, it gives the pleasure of reward to the learner, and serves the purpose of learner assessment.

The learning activities can be modified based on the student's achievements and progress in the game. The game achievement or score would indicate the level of learner knowledge while playing the game. If necessary, the game can choose a new learning activity pattern to suit the user level. Kiili (2005) cautions that this activity is done in a transparent manner because, if the learner gets the idea that learning will become easy if they perform badly in the game, it will not result in optimal and meaningful learning. At the beginning of the game, the user can select the playing level from novice to expert. In the first episode within game play, the learner has normally been coached or introduced to some of the basic learning, prior going to the next level. Once they have passed this level, the learner will be more confident in learning the next or higher level.

In the game *Call of Duty 4*, the first level is where the learner is trained to adapt to the environment, and to give the player an opportunity in rifle aiming and shooting practice. During the learning activities, the achievement of the learner playing at each level is recorded. The learning "delivery" will depend on the result of these scores. If the result

indicates that the learner does not do well, then the delivery of the learning is adjusted to the learner's capability. But, if the learner easily and quickly adapts to the activity, then the delivery will be more challenging and will keep the learner more engaged, motivated and suited to their capability. Thus, the game must be able to make dynamic adjustments to the learning activity during play.

4.2 Summary

A conceptual framework for serious games is proposed in Figure 4-1, based on the study of the pedagogy theories, the construction of real games, and improvements from the analysis of previous framework proposals. The components of this framework are based on the review of learning and pedagogy perspectives in combination with the games, and aims to establish a conceptual model that will be used by the game designer for efficient game development, and the educational practitioner when designing serious games for effective learning. The proposed conceptual framework in Figure 4-1 aims to be the basis for future serious games design and addresses RQ2.

RQ2: What is a common framework that can be used as conceptual guidance in designing serious games?

Further, the experiment in Chapter 6, where a serious game is designed based on this framework, would help to answer this research question. The next chapter is an introduction to the Technology Acceptance Model (TAM), a method to validate learner acceptance of the technology. The TAM will be used to evaluate the serious game attributes, which are one of the major components of the serious games conceptual framework.

Chapter 5

Technology Acceptance Model

5.1 Introduction

The Technology Acceptance Model (TAM) by Davis (Davis, 1989) has been used in information technology to predict the acceptance by users of new technology. It has been employed in applications such as email (Gefen & Straub, 1997), multimedia learning (Saade, Nebebe, & Tan, 2007), World Wide Web (Agarwa & Karahanna, 2000; Lederer, Maupin, Sena, & Zhuang, 2000), online game community (Hsu & Lu, 2007) and e-courseware (Park, Lee, & Cheong, 2007). This research has shown that TAM can be used to find and to confirm learner acceptance; the significant findings are shown in Table 5-1. In this study, we will also use the TAM to validate the serious game framework defined in Figure 4-1. We wish to demonstrate that the proposed framework is effective for learning, and to confirm that serious games, based on the proposed framework, would be both accepted by the learner and would be useful for learning. The following section explains the background theory of the TAM and proposes a TAM for serious games.

Table 5-1. Summary of previous TAM study

Authors	Tested Application	External Variables	Significant findings
Yoon et al. (2005)	Mobile games (Wimbro)	Attractiveness, Sacrifice, Flow experience, Enjoyment, Social norm	Enjoyment → Attitude Ease of use → Attitude Attractiveness → Attitude Social norm → Attitude
Lederer et al. (2000)	World wide web	Usefulness antecedents, Ease of use antecedents	Ease of understanding → Ease of use Information quality → Usefulness
Park et al. (2007)	Internet-based course (Blackboard and Webct)	Motivation, Compliance with school policy, Instructional technology clusters, Evaluation of functions	Motivation → Ease of use Motivation → Usefulness Motivation → Evaluation of functions Compliance of school policy → Evaluation of functions Instructional technology clusters → Evaluation of functions

Authors	Tested Application	External Variables	Significant findings
Saade et al. (2007)	Multimedia learning environments	Usefulness, Ease of use, Attitude	Usefulness → Attitude Usefulness → Intention Ease of use → Usefulness Attitude → Intention
Hsu & Lu (2007)	Online game communities	Social norm, Enjoyment, Ease of use, Group cohesion, Customer preference, Customer loyalty	Cohesion → Preference Social norm → loyalty Ease of use → Preference Enjoyment → Preference Preference → loyalty
Gefen & Straub (1997)	Gender perception and use of e-mail	Gender, Social presence	Gender → Social presence Gender → Usefulness Gender → Ease of use
Agarwa & Karahanna (2000)	Information technology use	Personal innovativeness, Playfulness, Cognitive absorption, self-efficacy	Cognitive absorption → Ease of use Cognitive absorption → Usefulness Personal innovativeness → Cognitive absorption Playfulness → Cognitive absorption

5.2 Background

The original Technology Acceptance Model (TAM) was proposed by Davis (1989), using Azjen and Fishbein's Theory of Reasoned Action (TRA) as a backdrop (Ajzen, 1991; Ajzen & Fishbein, 1980).

TRA describes the psychological determinants of behaviour. A person's performance is considered to be determined by behavioural intention (BI), and the input to BI is a combination of the person's attitude and subjective norm, as illustrated in Figure 5-1. The definition of *Subjective Norm* (S) is: a person believes that most people who are important to him think that he should (or should not) perform the behaviour. *Attitude* (A) is the influence one feels for or against some object or behaviour.

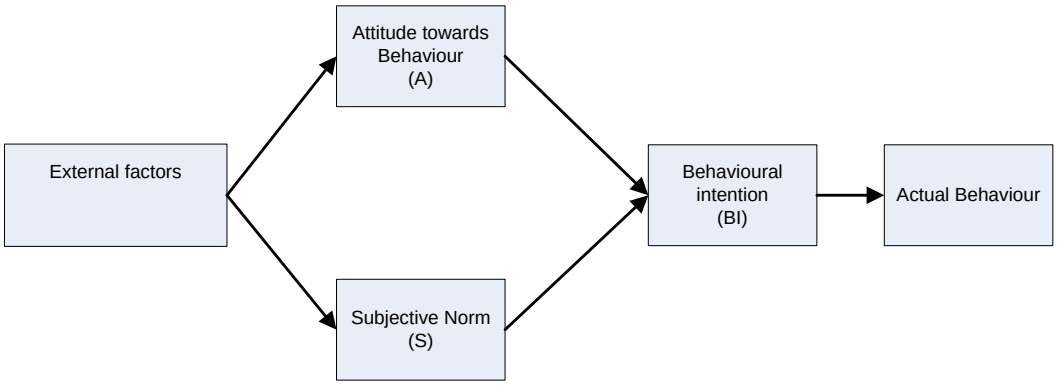

Figure 5-1. The Theory of Reasoned Action
(Ajzen & Fishbein, 1980)

External factors that influence attitude can be made up of beliefs accumulated over someone's lifespan, for example the personality or characteristic of a person. These beliefs

also can come from direct experience (attitude toward object), or are self-generated like the belief concerning some objects. Other examples of external factors could be demographic variables, situational variables or task characteristics. These are the beliefs that influence attitude, and will trigger intention to perform actual behaviour.

For example:

Attitude: “I heard smoking is bad for your health”

Subjective Norm: “I have to quit smoking because my wife hates it”

Intention: “I will stop smoking now”

Behaviour: “I’m now smoke-free and haven’t had any cigarettes for over a month”

Referring to Figure 5-1, from external factors, a learner has come to the knowledge that smoking is bad, which will influence their attitude. Attitude together with subjective norm will shape their intention, which will result in their behaviour to stop smoking.

Using TRA as a basis, Davis (1989) expanded the intention and behaviour to cater for user acceptance of new technology (user wants to use a new system) in the Technology Acceptance Model (TAM). Davis (1989) stated that *actual system use* may be considered to be determined by *behavioural intention* (BI), which comes from the person’s attitude toward using the system (A) and perceived Usefulness (U). Attitude (A) is determined by perceived Usefulness (U) and perceived Ease Of Use (EOU). Perceived Usefulness (U) is determined by perceived Ease Of Use (EOU), as illustrated in Figure 5-2. The two new elements are perceived Usefulness (U) and perceived Ease of Use (EOU).

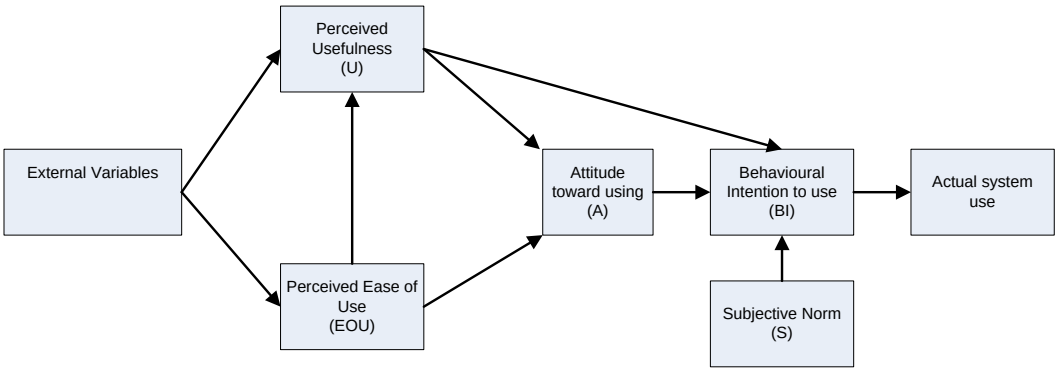

Figure 5-2. The Technology Acceptance Model
as discussed in Davis (1989)

Davis (1989) identified external variables that may include system characteristics, system features, training, documentation and user support. These external variables influence the judgement of the user who wants to employ the system, such as complete documentation or

technical user help and support. This follows the same concept for the external factors as in the TRA model that will influence user attitude to behaviour.

Perceived usefulness refers to the user's belief that by using this technology, their job performance could be enhanced. The input to this also comes from perceived ease of use, because the user is inclined to choose tools that require minimal effort in order to solve the problem.

Perceived ease of use refers to a person's belief that using a particular technology will be relatively free of effort. It has been shown that users will interact with the technology if they feel that little effort is needed to use it in order to accomplish their tasks.

Both Perceived Usefulness and Ease Of Use are important as factors that influence Attitude. Both Attitude and Perceived Usefulness influence the user to actually use or to select this technology (behaviour of intention to use).

Venkatesh & Davis (2000) further revised the TAM by dropping the attitude construct because, in their data analysis, the link between *attitude toward using* and *behavioural intention* as indicated in Figure 5-2 was not significant. The revised TAM is illustrated in Figure 5-3. Venkatesh & Davis (2000) claimed that this is a powerful model for predicting and explaining the user's behaviour.

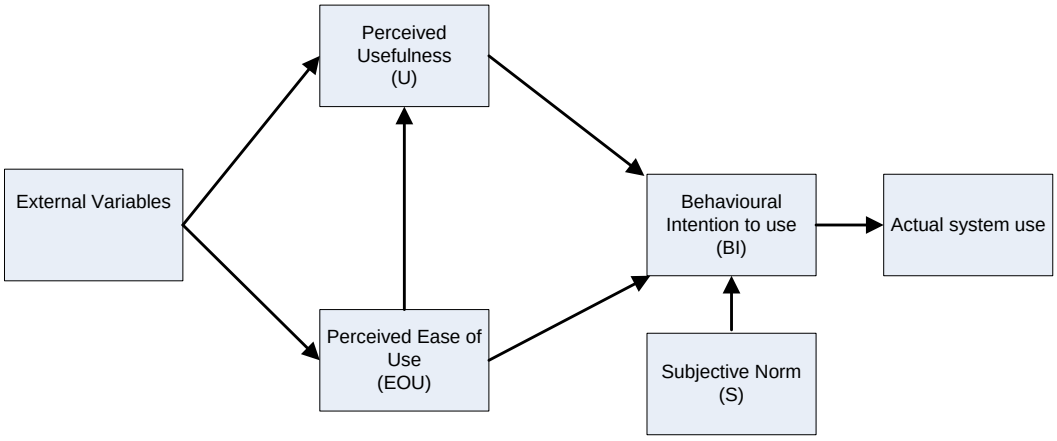

Figure 5-3. The revised Technology Acceptance Model (Revised-TAM)

The external variables are the same examples as the previous model variables used to influence user acceptance of the system. This research employed Venkatesh and Davis's revision of the original TAM.

5.3 Research Question

We uncovered no research that addressed the acceptance of serious games from the learner's viewpoint by using the Technology Acceptance Model. In order to use the TAM to explore how serious games are accepted by the learner, this research investigated game theories, education and learning theories and psychology theories that relate to learning.

The proposed conceptual framework for serious games presented in Figure 4-1 is the result of a detailed literature review covering educational games theory, learning theory, discussion and improvement of existing game model frameworks. The development of this framework was driven by the learning activity, which is defined by the learning outcomes (learning objectives for this game) and the serious game attributes.

The serious game attributes were described in detail in Chapter 3. These attributes are based on the exploration of some of the established theories of education and learning. The attributes result from the detailed literature review and analysis on behaviourist, cognitive, constructivist and psychology perspectives. Twelve attributes were defined that enable serious games to become an effective learning tool. De Freitas (2006) also stated that the use of pedagogic elements within game-based learning enhances the learning.

The proposed conceptual framework supports the design of serious games for effective learning, and we claim that serious games, based on the proposed framework, would be both accepted by the learner and would be useful for learning. It is believed that these issues can be answered by using the Technology Acceptance Model applied to serious games.

According to TAM, there are two variables – Usefulness (U) and Ease Of Use (EOU) – that affect the learner's attitude and intention to use the serious game. Usefulness deals with the user's belief that by using serious games, learner job performance is enhanced. Thus, if this works, the learner will believe serious games help make the present job better compared to current way of doing things. In addition, the EOU suggests that, by embracing serious games, the user will not find it too difficult to learn or adjust the new technology. EOU looks at the transformation from the existing job to using serious games, and this transformation should be painless and not to exert an extra burden on the user.

However, TAM defines both U and EOU as being directly controlled or influenced by the external variables. A metric should be in place that can be used to measure how far the external variable will influence U and EOU. One way is to look at the amount of time taken as a measure of how U and EOU are affected by the external variables.

- For U, time taken can be used as a measure of the job performance within a serious game. A shorter time means the job is performed better with the serious game.
- For EOU, time taken can be used as a measure of the belief that learning with the serious games is free of effort and without any difficulty. A shorter time indicates that the serious game is easy to use.

This concept of looking at the time taken should not be equated to a real measurement in minutes and seconds, because every individual performance varies due to different individual preferences. Instead, it should be used as an indication for the user to make an informed judgment in selecting the criteria to determine the variables that could influence any or both U and EOU. This could be used as a selection criterion for which of the 12 serious game attributes mentioned above can be the variable that is important in the TAM. For example, if we choose *transfer of learnt skills*, the user finds this useful because the knowledge acquired from games can be applied to different areas or other domains. Therefore, by measuring time taken, the future job will be performed better and much more effectively due to shortening of the time to acquire new skills, because previous knowledge can be applied to the new job.

Table 5-2 develops Table 3-1 with detailed explanations of attributes for serious games, their values for learning and their association with the TAM. The attributes in Table 5-2 **left unshaded** identify those attributes (*transfer of learnt skills*, *learner control*, *reward*, and *situated and authentic learning*) selected as the **most important** in their association with the TAM. Figure 5-5 shows the resulting TAM in Structural Equation Modelling (SEM) format.

Table 5-2. The 12 serious game attributes identified. Note the unshaded attributes are considered as the most important for the TAM

Attributes for Serious Games	Values for Learning	Association with TAM from the learner's viewpoint
Incremental learning	Learning material is delivered incrementally. New knowledge is delivered piecemeal and not done all at once. It will have proper start and end sections. Learner feels and learns in a natural way and less complex.	Incremental learning is seen as the normal way of learning. This attribute would not be a factor for the learner to use or reject this technology.
Linearity	Learning will be in sequence. This will suit the sequential learner. However, due to the game's flexibility, an active learner can skip chapters.	Linear also appears to be a natural flow of learning and there is no strong connection for urging the user to choose a serious game for learning.

Attributes for Serious Games	Values for Learning	Association with TAM from the learner's viewpoint
Attention span	This concerns the cognitive processing and short-term memory loads placed upon the learner by the game. These loads need to be carefully calibrated so that the target learner is not overwhelmed and spends too long in the learning process.	There is probably a weak link between learner needs and playing serious games.
Scaffolding	Support and help during learning within the games.	Learner may assume that every game always comes with help, support tips or hints in the form of a game manual or online help.
Transfer of learnt skills	Learnt knowledge to apply to other skills at the next level.	Yes, learner would see this as very useful because the knowledge acquired from games can be applied to different areas or other domains.
Interaction	Higher engagement, higher learning.	Learner may think interaction is common in learning since every basic learning transaction should have an interaction (two-way communication).
Learner control	Active learning, self-study and self-exploration based on individual pace and experience.	Yes, learner may view this as useful because it gives a degree of freedom for the learner to learn at their own pace and likes the idea of all learning happening under his control.
Practice and drill	Repeating for harder tasks, better knowledge retention and can have plenty of game activities for drills.	Learner may think that this is the common way of learning.
Intermittent feedback	Learner to reflect on what has been achieved so far and motivated for higher score (higher learning). Also using just-in-time feedback for learning.	Learner thinks that every learning interaction always has feedback, and this is normal.
Reward	Encourage learner and keep motivated. Negative reward as punishment within the game may also contribute to learning.	Yes, learner may feel this is important to keep him motivated and to keep on going. It would elevate his sense of confidence and self-assurance in learning.
Situated and authentic learning	Learning where the learner can relate what is being learnt within the game to the outside world.	Yes, learner feels this is useful and can relate to what is being learnt thus making the learning process easier.
Accommodating the learner's styles	To suit and to reach out to different learner styles.	This may be a strong factor for learner to use this technology but it is quite difficult to test. The result could be biased if the system happens not to be suited to his learning style but applicable to another group.

Therefore, the TAM would be the tool used to find the learner's response and would be used to resolve the following question:

> *Of these four attributes used with the proposed serious games conceptual model, which configuration will best predict the learner's intention to use serious games?*

The proposed TAM for serious games (Figure 5-4) is a modified version of the TAM revised by Venkatesh & Davis (2000) in Figure 5-3, that includes the variables selected for serious game attributes.

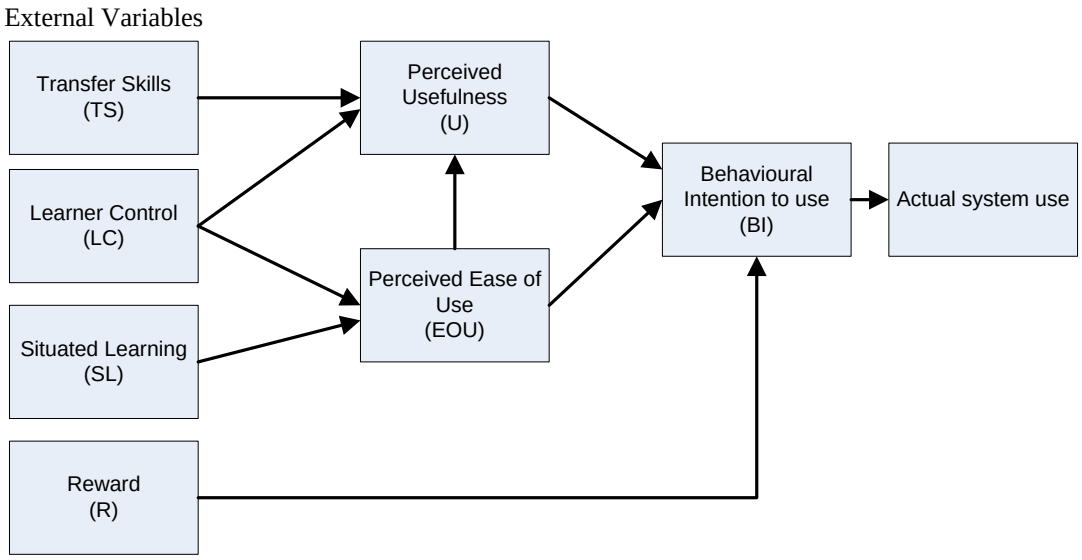

Figure 5-4. The proposed TAM for Serious Games

The validation of this proposed TAM will lead to an answer for RQ3.

RQ3: How can the selected attributes, in the proposed serious games conceptual model, be tested so that the best configuration will result in predicting learner intention to use serious games?

This research will enhance our understanding of individual beliefs regarding the use of serious games for learning, and show how these serious game attributes influence user acceptance of serious games.

The *Subjective norm* from the TAM shown in Figure 5-3 is not included here because it is assumed that *use* of serious games is voluntary and, as long as it is voluntary, Subjective norm would not be a significant factor. Note that the Subjective norm is part of the extension of the TAM but not in the original TAM that this study is based on (Vougel, Guo, Zhou, Tian, & Zhang, 2008).

The external variables in the revised model conceptualised as the game attributes are: Transfer of Learnt Skills, Learner Control, Situated and authentic Learning, and Reward.

These lead to the learner's intention to use the serious game for learning. To shorten these for reference, "Transfer of Learnt Skills" will be called "Transfer Skills", and "Situated and authentic Learning" will be called "Situated Learning". Some of the external variables may influence more than one variable. For example, in Figure 5-4, Learner Control could influence both perceived Usefulness and perceived Ease of Use. Moreover, Transfer Skills primarily influences only one variable, that is, perceived Usefulness.

These relationships can be tested by hypotheses as follows. Transfer Skills means applying previously acquired skills to other learning. This can be done within the game by continuing to the next level. Whatever skills have been acquired can then be used at the next level to acquire new skills. The previous knowledge should be revisited and new knowledge should be gradually added to what had been previously learned. New knowledge should be constructed from previous experience. Therefore, the hypothesis for testing this is:

H_1 : Transfer Skills will have a positive and significant effect on perceived Usefulness.

Metacognition refers to the learners charting their own learning progress and how they will learn best, based on their current awareness and understanding of their mental ability and ways of learning (Pritchard, 2005b). Learner Control is where the learners manage their own learning progress by self-study and self-exploration within the game. The appropriate place where a game can introduce the new learning process of self-exploration would be at the Zone of Proximal Development. Vygotsky's Zone of Proximal Development (Dunn & Lantolf, 1998) refers to a point just beyond the learner's level of understanding, or the point where the learner requires assistance or help from a skilled learner. This is not just to challenge the learner but also to make sure that the material presented to be learnt is just one step ahead of the learner. It will affect Perceived Usefulness because the learner will not be introduced to what has been learned before, and the learner will not be bored repeatedly learning the same material. Therefore, the hypothesis for testing this is:

H_2 : Learner Control will have a positive and significant effect on Perceived Usefulness.

Learners like to explore on their own and pick up skills (experience) within the game in order to continue to the next level. Having a helping 'guide' within the game, acting as facilitator, will manage the learner so that they do not become disoriented or suffer from cognitive overload (where the learner loses focus as the task becomes more complex). The possibility of exploration and being in control will make the learner feel it is easy to use because of the choices that are available. Therefore, the hypothesis for testing this is:

H_3 : Learner Control will have a positive and significant effect on Perceived Ease of Use.

Situated and authentic learning places learners in an authentic environment, where they would be able to develop mental models of their experience and relate it to real life. Use of a familiar background or common examples in a game's content, and relevant to the learner's experience, should be perceived as easy to use when learning with serious games, because the learner is learning within a familiar territory. Therefore, the hypothesis for testing this is:

H_4 : Situated Learning will have a positive and significant effect on Perceived Ease of Use.

Online educational games use a reward system to increase learners' motivation within the game, thereby increasing their desire to learn (Malone, 1980). Reward comprises incentives in the game that are used to encourage the learner and to keep their motivation high. Rewards generate confidence that will lead to personal satisfaction in the learning process. Therefore, the hypothesis for testing this is:

H_5 : Reward will have a positive and significant effect on Behavioural Intention to use serious games.

Ease of Use refers to a person's perception that using a serious game for learning will require minimal effort. It has been shown that users will interact with the technology if they feel that little effort is needed for using this technology in order to accomplish their tasks.

Usefulness refers to the user's perception that the use of the technology could enhance their performance. The input to Usefulness also comes from ease of use, because the user would be inclined to choose tools that require minimal effort in order to solve the problem. Both Perceived Usefulness and Ease Of Use are important factors that influence the user to actually use or select this technology (Behavioural Intention to use).

Behavioural Intention to use is the intention to perform actual behaviour by the learner, influenced or caused by both preceding factors of Usefulness and Ease of Use. Learners intend to use serious games for learning in the future.

The remaining hypotheses are taken from the revised TAM and should be tested together with the model. A similar approach has been used in another study, for example by Agarwa & Karahanna (2000) for cognitive absorption.

H_6 : Perceived Ease of Use will have a positive and significant effect on Perceived Usefulness.

H_7 : Perceived Usefulness will have positive and significant effect on Behavioural Intention to use serious games.

H_8 : Perceived Ease of Use will have positive and significant effect on Behavioural Intention to use serious games.

All eight of these hypotheses, H_1 to H_8 will be tested by using Structural Equation Modelling. Analyzing the result of this experiment will help to answer the research question.

5.4 Process to Validate the TAM for Serious Games

The Serious-Games-TAM in Figure 5-4 is converted to the structural model form shown in Figure 5-5 in order to analyse it with AMOS[7]. The analysis of this structural model will attempt to explain the inter-variable relationships. This method is used by Young et al. (2005) for the mobile gamers' behaviour and Chesney (2006) for Information systems TAM.

All variables (TS, LC, SL, R, U, EOU and BI) shown in Figure 5-5 will be analysed by AMOS. The Serious-Games-TAM consists of independent variables and dependent variables.

- The independent variables are TS, LC, SL and R and these are short notations for Transfer Skills, Learner Control, Situated Learning and Reward.
- Dependent variables are labelled as U, EOU and BI and they represent Usefulness, Ease of Use and Behavioural Intention to use.

[7] A Structural Equation Modelling (SEM) software application by SPSS.

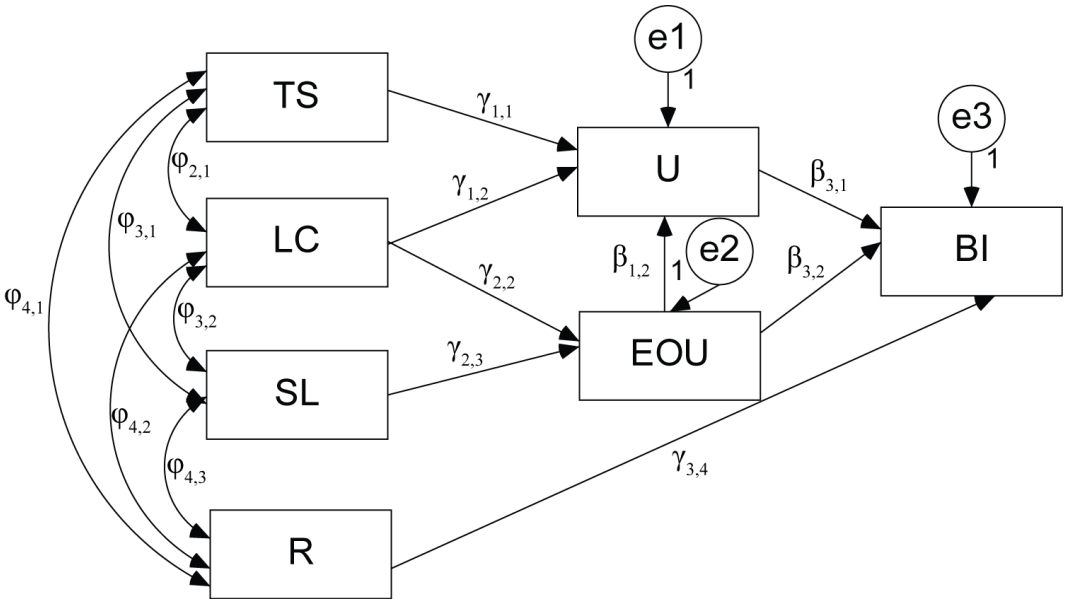

Figure 5-5. Serious-Games-TAM in Structural Equation Modelling format
Doubled head arrows show covariance path and single arrows show regression path.

The dependent variables (U, EOU, BI) may be affected by the independent variables TS, LC, SL and R, and these causal relationships are measured by γ in Figure 5-5, whereas β are paths representing a causal relationship between dependent variables. φ, represented by two-headed arrows, are the covariance or correlations between pairs of independent variables. The dependent variables' errors are represented by *e*1, *e*2 and *e*3.

The regression equations that can be derived from the Figure 5-5 are:

$$U = \gamma_{1,1}TS + \gamma_{1,2}LC + \beta_{1,2}EOU + e1 \quad (1)$$

$$EOU = \gamma_{2,2}LC + \gamma_{2,3}SL + e2 \quad (2)$$

$$BI = \beta_{3,1}U + \beta_{3,2}EOU + \gamma_{3,4}R + e3 \quad (3)$$

The hypotheses to be tested are shown in Table 5-3 and this relates to all hypotheses H_1 to H_8 as listed below.

Table 5-3. Hypotheses and their regression coefficients

Hypothesis	Regression coefficient
$H_1 : TS \rightarrow U$	$\gamma_{1,1}$
$H_2 : LC \rightarrow U$	$\gamma_{1,2}$
$H_3 : LC \rightarrow EOU$	$\gamma_{2,2}$
$H_4 : SL \rightarrow EOU$	$\gamma_{2,3}$
$H_5 : R \rightarrow BI$	$\gamma_{3,4}$
$H_6 : EOU \rightarrow U$	$\beta_{1,2}$
$H_7 : U \rightarrow BI$	$\beta_{3,1}$
$H_8 : EOU \rightarrow BI$	$\beta_{3,2}$

H_1 : Transfer Skills will have a positive and significant effect on perceived Usefulness.

H_2 : Learner Control will have a positive and significant effect on perceived Usefulness.

H_3 : Learner Control will have a positive and significant effect on perceived Ease of Use.

H_4 : Situated Learning will have a positive and significant effect on perceived Ease of Use.

H_5 : Reward will have a positive and significant effect on Behavioural Intention to use serious games.

H_6 : Perceived Ease of Use will have a positive and significant effects on perceived Usefulness.

H_7 : Perceived Usefulness will have positive and significant effect on Behavioural Intention to use serious games.

H_8 : Perceived Ease of Use will have positive and significant effect on Behavioural Intention to use serious games.

The model was programmed into AMOS and the output produced maximum likelihood estimates, standard errors and χ^2 (chi-square) values. The model fit was confirmed by evaluating the result. The variables shown in the Serious-Games-TAM cannot be measured directly because they are abstract, and they are measured by indicators, usually in the form of questionnaires (Blunch, 2008b; Byrne, 2009). The details of these questionnaires will be explained in Chapter 6.

5.5 Summary

The serious games framework shows the critical flow and major components that create an effective model for learning using serious games. This proposed conceptual framework will be the basis for future serious games design platforms, and is to be validated by the Technology Acceptance Model. This will enable the identification of those attributes or combinations that lead the learner to use this type of game for learning. It is anticipated that this research will identify the critical predictors, and will also validate the framework. The recommendations associated with the serious games framework would be a significant asset for game designers and teaching practitioners for designing games for learning.

The following chapter discusses the method that has been used to analyse the Serious-Games-TAM.

Chapter 6

Research Methodology

The Serious-Games-TAM was defined in Figure 5-4. This chapter will explain the steps taken to analyse the Serious-Games-TAM. The analysis involved three stages, discussed below. The first stage was the development of a short serious game, tailored to the participants that would be used in the study. This serious game, *Unilink Bus Game*, was used for the evaluation of Serious-Games-TAM. The second stage was the survey process and the development and delivery of a questionnaire. Discussion of this is followed by details of the participants involved in the survey process. The third stage was the results from the analysis of the survey, which will be elaborated in Chapter 7. The following sections give a more detailed explanation for the initial two stages undertaken.

6.1 The Development of Unilink Bus Game

The work by Prensky (2001a) and by Gee (2007b) has presented a methodology for the design of effective serious games. They both state that games can be reused or designed and employed for educational purposes. On the other hand, Rooney et al. (2009) argue that not all commercial games are suitable, or can be easily modified to suit serious games for learning. This is because commercial game designers think about the game's functionality and the quality of visual effects, whereas teachers or educational practitioners think about the underlying game objective to achieve the purpose and do not focus too much on aesthetic values. Furthermore, some of the characters used for commercial games are not suitable for certain learning. For example, the use of dirty creatures in commercial games is not appropriate for teaching kitchen hygiene (Rooney, et al., 2009).

Therefore, a bespoke game needs to be developed to completely meet the requirement of the serious games framework in Figure 4-1. Existing games are available that might suit

part of the framework but not all of it, and it would require the playing of several other games to fully deal with the framework. This would be hard to control and to implement during the survey, and learners would find that they are being subjected to non-relevant parts of games not covered by the framework. Although the four examples used here do fall within our serious games definition, they are incomplete when compared with the requirements of the serious games framework. For example, the *Chest Pain Simulator* does not show how and when the reflection process occurs during the game activity, and the learners would thus miss their opportunity to evaluate their action and reflect on what they have learned.

For this reason, *Unilink Bus Game* was developed to fully meet the requirement of our serious games framework. *Unilink Bus Game* was used, together with Serious-Games-TAM in Figure 5-5, to complete the evaluation. The anticipated conclusion from the analysis would be the identification of those attributes that would lead the learner to use this type of game for learning. The next section describes the development of *Unilink Bus Game.*

6.1.1 *Profiling of exemplar serious games*

The development of the *Unilink Bus Game* should follow the serious games framework described in Chapter 4 as well as matching the quality of commercial serious games already acceptable to learners. To achieve this, the profile of a serious game exemplar had to be generated. This profile was created by testing some of the components of the serious games framework against the serious game examples. Two genres of serious game examples were selected, based on their popularity with learners. The examples used were the role-play game *Darfur is Dying*, and the strategy game *Climate Challenge*. These games were described in Section 2.4. *Unilink Bus Game* is intended to be similar to the strategy game.

Using the generated profile, the finished *Unilink Bus Game* was compared and rated by the reviewers to assess if it is of the same quality as commercial serious games that are acceptable to learners.

Table B-1 in Appendix B shows the operational definitions for measuring the data for these two serious games. The elements used in this table are the abstraction from the serious games framework of Figure 4-1. The methods of test and decision criteria are shown on every game design element in Table B-1. Both serious games were played on the web and did not require downloading. The reviewers were split into two groups of five, and their

responses were saved on the free online survey form. Each of the elements was assessed by individual question, with each response using a 5-point Likert-type scale, from "fully disagree" at the lowest to "fully agree" at the highest scale. The radar chart in Figure 6-1 resulted from the survey conducted by applying the operational definitions to the two examples. Table 6-1 is the category description used in the radar chart in Figure 6-1 and Figure 6-2.

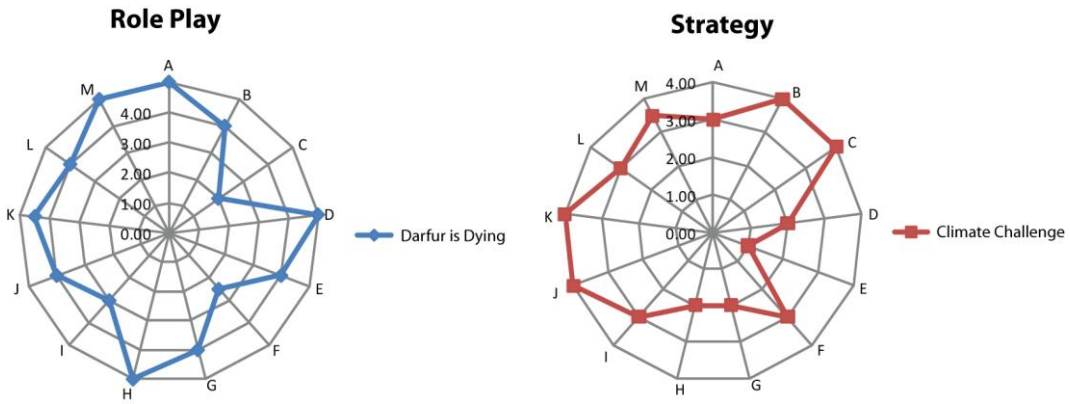

Figure 6-1. Profile resulting from the survey of two serious games

Table 6-1. The description of the categories used in the profile

Category	Serious games framework elements
A	Clear instructions
B	Intended learning outcomes
C	Instructional content
D	Game mechanics
E	Linearity
F	Attention Span
G	Interaction
H	Learner control
I	Game achievement
J	Reward
K	Intermittent feedback
L	Situated and authentic learning
M	Transfer of Learnt Skills

6.1.2 *Unilink Bus Game*

The School of Electronics and Computer Science at the University of Southampton annually provides the Jumpstart programme. The programme involves new students in activities that are designed to provide essential and background skills on learning at the university. According to the Jumpstart leader, one common problem that new students face is how to use the university bus service, Unilink. A similar issue was raised during the International Induction for new students in November 2008 over the lack of information about the facilities in the city of Southampton. Based on this rationale, and after discussion with the Jumpstart leader, the serious game was developed with the aim of assisting new students in learning to use the Unilink bus service. *Unilink Bus Game* was developed to allow international students, who are unfamiliar with the bus service, to use the buses and to help them maximise the benefit of this method of transport. Brightman (2006) states that the design of serious games should also reflect the environment outside the game world.

After reviewing a number of choices for game design tools, it was found that Gamemaker Pro would be the most appropriate tool for building the prototype *Unilink Bus Game*. It offers an extensive game library and, if a new surface, environment, or sprite is needed, then it can be created from scratch or its image can easily be imported from external files. Other tools considered were less complicated, or provided easier migration to web space (Derryberry, 2008). Other games required a games platform (game engine) to be installed on the PC before they could be used. However, such platforms may not be installed on the institution's workstations. Therefore, to permit wide access, *Unilink Bus Game* was designed to be played on university workstations without requiring new installation.

The key features of the game developed were to enable the learner to:

- Recognise the location of the final destination
- Identify the bus routes
- Identify the bus number
- Identify the bus stops and Interchange for bus transfer
- Recognise where to get off the bus.

Figure 6-2 shows a screen shot from *Unilink Bus Game*; additional screenshots are presented in Appendix C.

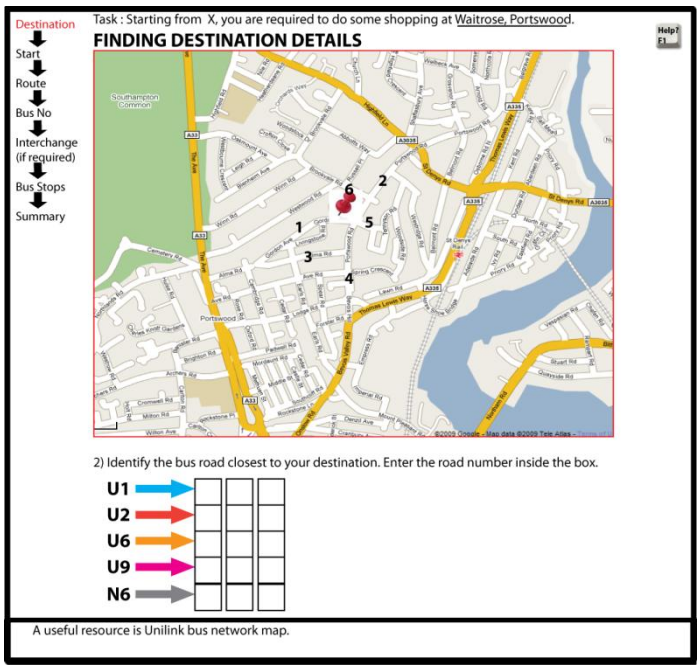

Figure 6-2. Screenshot from *Unilink Bus Game*

After *Unilink Bus Game* had been developed, it was reviewed by the survey participants. Figure 6-3 is the result of this survey. It is interesting to see that its profile falls within the profile set of serious games from Figure 6-1. It is close to the level of other standard serious games while following the conceptual framework of Figure 4-1. Major differences occur in the game mechanics (D) and linearity categories (E) of *Climate Challenge*, where *Unilink Bus Game* is rated higher. Reviewers may have rated this higher because of greater use of graphics for map and video in locating the bus stops. Linearity is the step-by-step sequence of learning, whose progress is monitored by the menu indicator on the left of the screen in Figure 6-2 above.

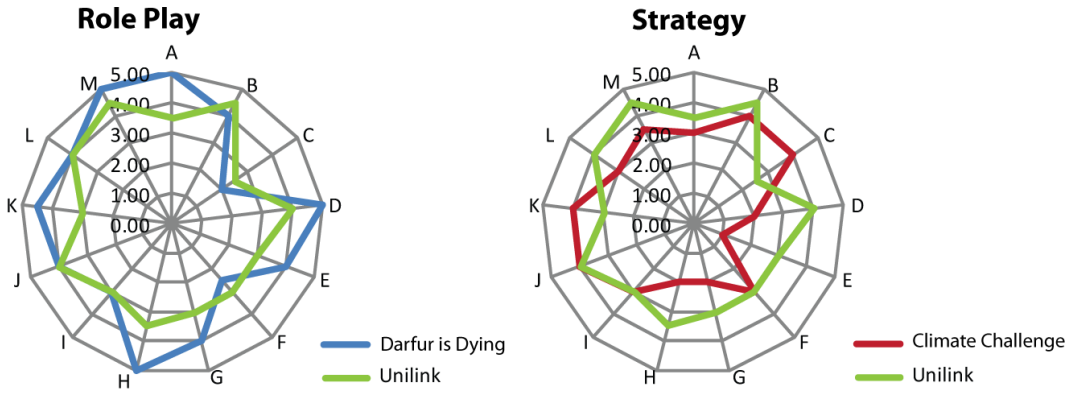

Figure 6-3. *Unilink Bus Game* profile compared to the serious games profile using the same categories as before

Following this, *Unilink Bus Game* was submitted for expert review. Five panellists evaluated the game on criteria ranging from game interface, gamer interaction, aesthetic

design, usability, game functionality to game progression. Then, after modifying the game to satisfy the panellists' recommendations, the study protocol was submitted for ethical review.

Finally, a pilot test was performed prior to the actual game survey to reveal and correct any problems raised before the actual run. The following section describes the questionnaires that were given to the learners for evaluation after playing *Unilink Bus Game*.

6.2 Survey Process

Prior to undertaking the survey, a brief presentation was given to the participants describing the underlying research and serious games. Then, students were invited to participate voluntarily in *Unilink Bus Game*, playing it on university computer workstations or downloading it to their personal computers. The game took 20 minutes, after which they were required to spend about ten minutes completing the questionnaires. The designer of *Unilink Bus Game* was available in the computer room for two short periods during the survey to answer questions on the game and underlying research objectives. The survey was undertaken at the University of Southampton and largly completed between June and August 2009.

The questionnaire used in the survey is shown in Appendix D. At least four indicators are assigned to each variable, as recommended, in order to avoid under-identified or just-identified problems (Hair, Black, Babin, Anderson, & Tatham, 2005). These problems deal with not having enough data to satisfy the positive degree of freedom and to strengthen the result.

6.2.1 *Questionnaire*

A questionnaire was developed to discover how the participants rated the Transfer Skills (TS), Learner Control (LC), Situated Learning (SL), Reward (R), Usefulness (U), Ease of Use (EOU), and Behavioural Intention to use (BI), relating to *Unilink Bus Game*. This questionnaire was reviewed before submission for Ethical review approval, as required by the School. Each of these seven variables was assessed by four individual questions, where each response used a 5-point Likert-type scale, with "fully disagree" at the lowest and "fully agree" at the highest scale. The construction of the questions follows.

- *Transfer of Learnt skills* (TS) is whether the participants can use and apply the skill learned within the game to the real world (e.g. “I feel that I can use my new skills in identifying Unilink bus routes.”)
- *Learner Control* (LC) is what the participants feel within the game; whether they felt in total control of the game activity and were allowed to manipulate the game activity (e.g. “This game allows me to search for the answers at my own speed.”)
- *Situated Learning* (SL) involves the provision of a gaming environment or world where the participants can relate their learning to their needs and interests in the outside world (e.g. “I can learn better if I can relate the experiences within a serious game to my experiences in real life.”)
- *Reward* (R) is the arrangement in the game to encourage the participants and to keep their motivation high (e.g. “I feel encouraged to learn more about the *Unilink Bus Game* when it displays congratulatory messages.”)
- *Usefulness* (U) refers to the participants’ belief that using this game would help them in better planning to ride the Unilink bus (e.g. “This *Unilink Bus Game* will help me use the Unilink bus service better.”)
- *Ease of Use* (EOU) is where participants feel that minimal effort is required to learn the *Unilink Bus Game* (e.g. “I find it easy to use the *Unilink Bus Game* because I am familiar with the operation of buttons and mouse.”)
- *Behavioural Intention to use* (BI) is the participants’ intention to use the *Unilink Bus Game* to help them to perform the actual task (e.g. “If I am given a serious game of this type, I intend to use it.”)

Table 6-2 shows the observed indicators scale and questionnaire for Serious-Games–TAM. The measurement scales that will be used in evaluating the participants after playing the games are presented below where SL stands for Situated Learning, LC is Learner Control, TS is Transfer Skills, R is Reward, EOU is Ease of Use, U is Usefulness and BI is Behaviour Intention to use. Scale Type 5- point Likert: Disagree-Agree.

Table 6-2. The observed indicators scale and questionnaire for Serious Games-TAM

Item	Description	Construct
SL1	I can learn better if I can relate the experiences within a serious game to my experience in real life.	SL
SL2	The maps and videos used in the Unilink Bus Game helped me to understand the Unilink bus service.	SL
SL3	I am motivated if a serious game is similar to what I want to learn.	SL
SL4	It is easy to reference the Unilink Bus Game to the Unilink booklet because the colours used for the bus route are identical.	SL
LC1	I have a full control of the Unilink Bus Game whilst playing.	LC
LC2	I can apply previous knowledge when answering the Unilink Bus Game questions.	LC
LC3	This game allows me to search for the answers at my own speed.	LC
LC4	This game helps me to learn, by allowing me to find answers outside the Unilink Bus Game.	LC
TS1	I feel that I can plan a new journey after playing the Unilink Bus Game.	TS
TS2	I feel that I can use my new skills in identifying Unilink bus routes.	TS
TS3	After playing the Unilink Bus Game, I feel that I have learned and gained new skills.	TS
TS4	I feel that I have acquired knowledge and skills as the game progress.	TS
R1	I felt rewarded when the Unilink Bus Game displays congratulatory messages for my answer.	R
R2	I feel encouraged to learn more when the Unilink Bus Game displays congratulatory messages.	R
R3	It boosts my confident and motivates me to keep on playing when the Unilink Bus Game displays congratulatory messages.	R
R4	I feel that the congratulatory messages are important to my learning.	R
EOU1	Learning to operate this Unilink Bus Game was easy.	EOU
EOU2	I find the Unilink Bus Game easy to use.	EOU
EOU3	I find it easy to use the Unilink Bus Game because I am familiar with the operation of buttons and mouse.	EOU
EOU4	I find it easy to learn if the serious game is simple and straightforward.	EOU
U1	The Unilink Bus Game can help people to use Unilink buses.	U
U2	After playing this Unilink Bus Game, it will be easier for me to plan a bus journey in the future.	U
U3	This Unilink Bus Game will help me use the Unilink bus service better.	U
U4	The Unilink Bus Game will be useful to inform new students of the features of the Unilink Bus Service.	U
BI1	If I am given a serious game of this type, I intend to use it.	BI
BI2	I expect the use of serious games for learning will continue in the future.	BI
BI3	I plan to use serious games for learning in the future.	BI
BI4	I intend to continue using serious games for learning in the future.	BI

6.2.2 *Participants*

The game participants were mostly new students at the University of Southampton attending the pre-sessional courses in June 2009. These courses are designed to improve English skills for international students, enrolled as undergraduates and postgraduates, as

part of the University entry requirements. This group of students was chosen because they are new to the university bus service and it was predicted that, by playing *Unilink Bus Game*, it would help them ride on the Unilink bus around the Southampton bus routes.

Table 6-3 shows the chronology of the survey process, with the pilot done prior to the actual game survey in order to foresee any problems that might arise from the actual run. Every questionnaire was collected and then analysed. The results are shown in Chapter 7.

Table 6-3. Chronological events for the survey process

Date	Event
October 2008	Start of *Unilink Bus Game* development
April 2009	Survey on the serious games examples
May 2009	Evaluation of the *Unilink Bus Game* with serious games examples
May 2009	Expert review of the *Unilink Bus Game* and implementation of modifications
May 2009	Ethical review process
June 2009	Pilot test and corrections
June to September 2009	Survey process

6.3 Summary

This chapter explained the research methodology undertaken for this study. The study involved three stages. The first stage was the development process for a serious game called *Unilink Bus Game* that was custom-made for this study. This *Unilink Bus Game* was used in the survey for evaluating the seven variables used in the Serious-Games–TAM from Chapter 5. *Unilink Bus Game* was evaluated against the profile set by other serious games examples. It then was submitted for expert and ethical review for further evaluation. A pilot run was conducted to foresee any problem that might be raised in the survey. In the second stage, the survey process, the questionnaires, and the recruitment and priming of participants, were explained in detail in this chapter. The following chapter will show the detailed results generated from the survey analysed by AMOS.

Chapter 7 Results

The development of the study methodology was discussed in the previous chapter. This investigation was confined to the use of *Unilink Bus Game* as the example to test learner acceptance for using serious games. The questionnaires and the selection of participants were also discussed and this led to the outcome of the survey that is elaborated later in this chapter. The results are organised in the following way. The first section is a statistical analysis of the participants who took part in the survey. This is followed by results of the survey analysed with AMOS (2009) and SPSS, evaluating the relationships between variables in the Serious-Games-TAM. This is then related to the testing of the hypotheses. Finally, how well the model fits is addressed by examining the indices tables generated from this analysis.

7.1 Statistical Analysis of Participants

Fifty-six participants took part in the survey, the majority of whom (94.6% – 53 students) were from overseas. The remaining 5.4% (3 students) were from the UK. The game participants were mostly overseas students because *Unilink Bus Game* was intended for the new user, and these students were the new cohort attending English classes in order to improve their English skills prior being accepted onto their major courses. Out of the 56 participants, 41% (23 students) were females and 59 % (33 students) were males. The samples were thus almost balanced in representing females and males.

7.1.1 *Age of participants*

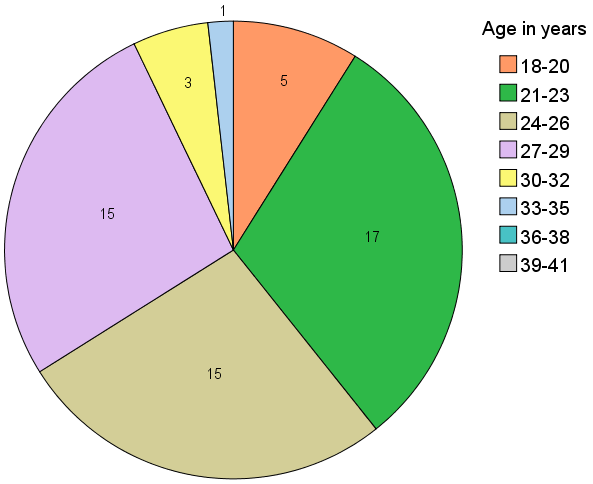

Figure 7-1. Number of students by age in year groups

Figure 7-1 shows that the majority of participants were from 21 to 29 years old, with 21-year-olds (17) representing the biggest sector, followed by the 24 to 26-year-olds (15), and then the 27 to 29-year-olds (15).

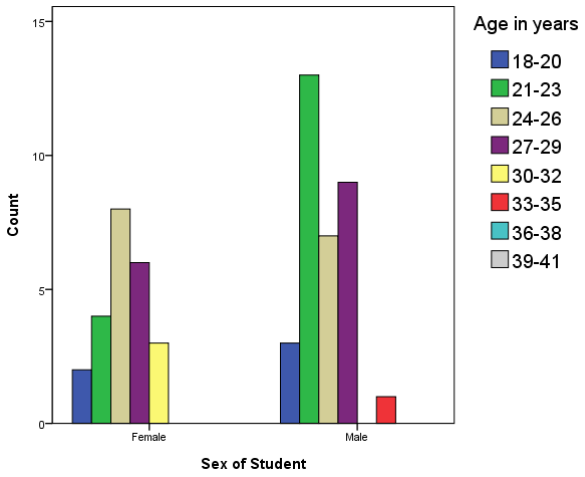

Figure 7-2. Number of students in year groups by gender

As can be seen in Figure 7-2, there was almost an equal age distribution for female and male students from 18 to 29 years old. The maximum female students (8) was reached in the group aged 24 to 26 years old, whereas the male student peak (13) was in the group aged 21 to 23 years old, slightly younger than the females.

7.1.2 *Time spent on computer games by participants*

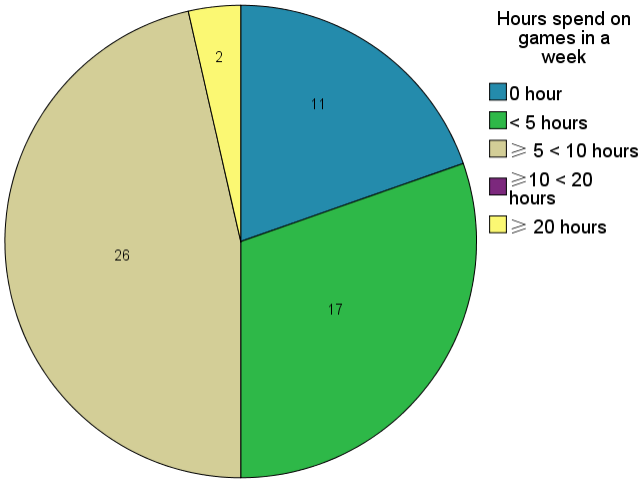

Figure 7-3. Number of hours a week spent on computer games

Figure 7-3 shows that almost half the participants (26) spent between five and ten hours a week playing computer games. This is followed by the 17 participants who spend up to five hours a week on computer games, and by 11 did not play computer games at all.

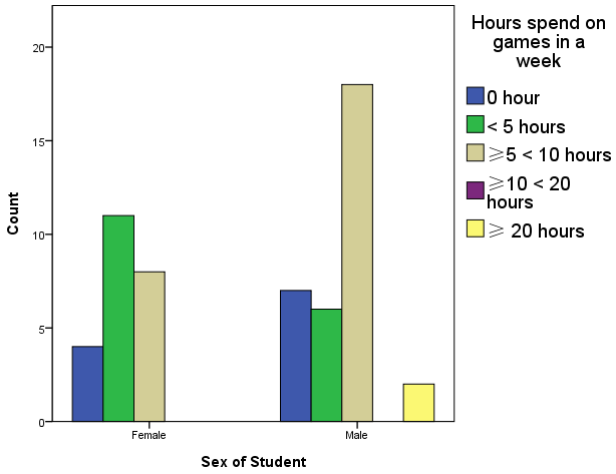

Figure 7-4. Number of hours a week spent on computer games by gender

According to Figure 7-4, almost half the female participants (11) would normally spend up to five hours playing computer games, and slightly more than half of male participants (18) would normally spend five to ten hours playing computer games. In comparing behaviour, males are typically more likely to play computer games than females. However, Figure 7-5 does indicate that all groups from 18 to 35 years do spend about five to ten hours a week playing computer games.

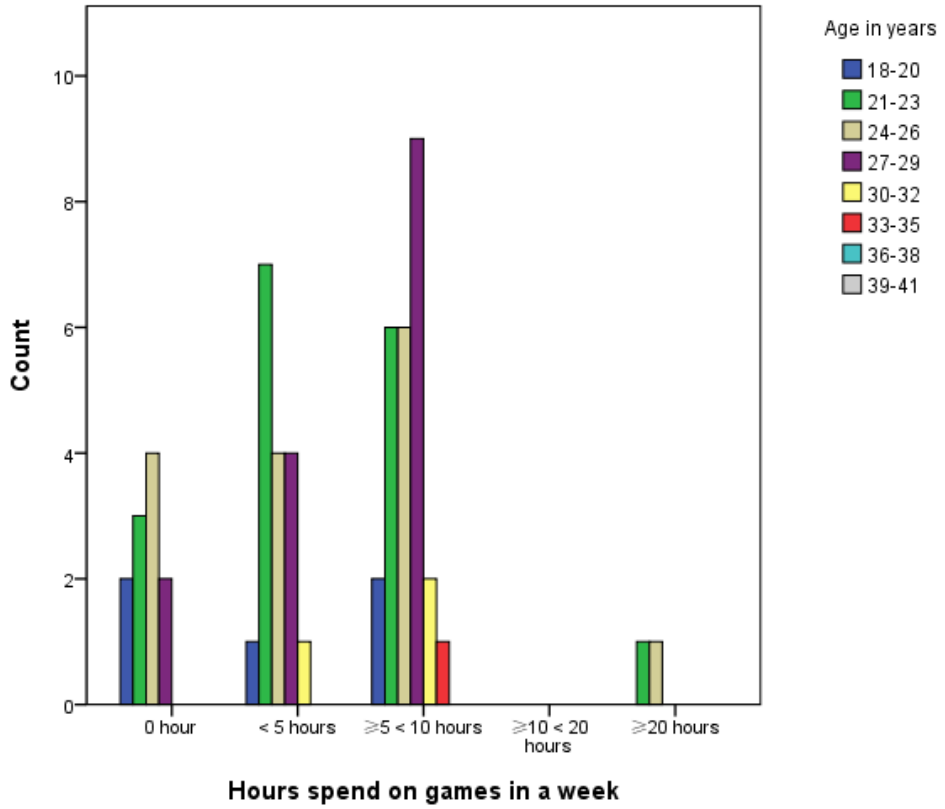

Figure 7-5 Participants' age against weekly time spent on computer games

7.2 Statistical Analysis of Serious-Games-TAM

This section gives the results of the participants' survey analysed by AMOS and SPSS. The questions were designed to look at the variables shown in Figure 5-4 of the Serious-Games-TAM. The short form labels for the variables are used, as before. Table 7-1 shows the questionnaire result from the survey.

Table 7-1. Descriptive statistics of respondent's characteristics

Respondent characteristics *(N=56)*	**Items**	**Frequency**	**Percent**
Origin	UK Student	3	5.4
	Overseas Student	53	94.6
Gender	Female	23	41.1
	Male	33	58.9
Age	18-20	5	8.9
	21-23	17	30.4
	24-26	15	26.8
	27-29	15	26.8
	30-32	3	5.4

Respondent characteristics *(N=56)*	**Items**	**Frequency**	**Percent**
	33-35	1	1.8
Degree of games experiences	0 hour	11	19.6
	< 5 hours	17	30.4
	≥ 5 < 10 hours	26	46.4
	≥ 10 < 20 hours	0	0
	≥ 20 hours	2	3.6

On average, the learners responded positively to *Unilink Bus Game*, and the standard deviation shows the limited spread of learner choices from the means.

Table 7-2. Descriptive statistics of Serious Games-TAM variables

Serious Games-TAM variables	**Description**	**Means[1]**	**SD[1]**
SL	Situated Learning	15.09	2.85
LC	Learner Control	14.35	2.73
TS	Transfer Skills	14.27	3.43
R	Reward	14.43	2.83
EOU	Ease of Use	13.36	2.68
U	Usefulness	15.18	3.18
BI	Behavioural Intention to use	14.16	3.39

[1] Cumulative of all measurement scales for example, SL= SL1+SL2+SL3+SL4

7.2.1 *Sample size*

The minimum sample size was determined by using 'G*Power' version 3.0.10 (Erdfelder, Faul, & Buchner, 1996). The sample size to test a simple correlation coefficient as significantly different from zero was calculated and dependent on the following input parameters.

- Effect size

According to Hair et al. (2005), the effect size is a way of measuring the size of effect or the magnitude difference between two groups (for example, the means difference between two group). It was defined as small (0.2) to moderate (0.5). An effect size of 0.5 implies that the difference in means is one-half of the standard deviation and a 'moderate' effect size was chosen for this study.

- Alpha

Alpha (α) is also known as Type I error. This is the error probability of rejecting the null hypothesis when there is a difference between the sample statistic and the population parameter not due to the luck or random sampling error. For example, if after the calculation the probability (*p*) is found smaller than the alpha level (0.05), and then this null hypothesis is rejected. Alpha was set at the conventional level of 0.05.

- Power (1– β)

Power (1– β) is the probability of rejecting the null hypothesis when in reality, it should indeed be rejected. Power was set to 0.9, as a compromise between lower power such as 0.80 which might be appropriate for smaller N in preliminary studies, and high power such as 0.95 which might be appropriate for larger N in studies where correct rejection of the null hypothesis was of particular importance.

- Tail(s) = Two
- Population correlation ρ = 0

From these parameters, the required sample size was calculated as N = 37, with an actual power of 0.901. Since the sample size used in this survey was 56, this is more than enough to provide the required confidence in the answers.

7.2.2 *Serious-Games-TAM analysis by AMOS/SPSS*

The data collected from the survey, and Serious-Games-TAM in Figure 5-5 in structural equation modelling format, was analysed with AMOS and SPSS.

Table 7-3 shows the simple correlations between the variables tested generated from SPSS. This shows that all the variables are highly correlated with each other at a significance level of 0.05 ($p < 0.05$) and 0.01 ($p < 0.01$).

Table 7-3. Correlation table for the variables

		SL	LC	TS	R	EOU	U	BI
SL	**Pearson Correlation**	1						
LC	**Pearson Correlation**	0.761**	1					
TS	**Pearson Correlation**	0.632**	0.565**	1				
R	**Pearson Correlation**	0.604**	0.499**	0.759**	1			
EOU	**Pearson Correlation**	0.598**	0.522**	0.310*	0.423**	1		
U	**Pearson Correlation**	0.731**	0.653**	0.674**	0.523**	0.530**	1	
BI	**Pearson Correlation**	0.644**	0.492**	0.544**	0.439**	0.342**	0.777**	1

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

F-ratio is defined as the ratio of mean square regression to the mean square residual (error).

Table 7-4(a) and Table 7-4(b) show that BI is significantly correlated with the independent variables (U, EOU and R), $R^2 = 0.617$, F-ratio for (3, 52) = 27.486, $p < 0.01$, with the partial effects of U being significant beyond the 0.01 level. The standardised coefficient (Beta weight, β) for BI from U is 0.801. The shaded result in Table 7-4(c) suggests that there is a significant link between U and BI because of significant $p < 0.05$. Other beta weight coefficients leading to U are –0.111 from EOU and 0.067 from R. *e*3 is 0.617 taken from the R^2 in Table 7-4(a). These are shown, in rounded form, in Figure 7-6.

Table 7-4. Regression analysis output from the dependent variable BI

Table 7-4(a) Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.783[a]	**0.617**	0.591	2.16725

a. Predictors: (Constant), R, EOU, U

Table 7-4(b) ANOVA[b]

Model		Sum of Squares	DoF	Mean Square	F	Sig.
1	Regression	387.311	3	129.104	**27.486**	**0.000**[a]
	Residual	244.243	52	4.697		
	Total	631.554	55			

a. Predictors: (Constant), R, EOU, U
b. Dependent Variable: BI

Table 7-4(c) Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.928	1.814		1.063	0.293
	U	**0.853**	**0.118**	**0.801**	**7.252**	**0.000**
	EOU	–0.140	0.131	–0.111	–1.065	0.292
	R	0.080	0.124	0.067	0.645	0.522

a. Dependent Variable: BI

Table 7-5(a) and Table 7-5(b) show that U is significantly correlated with the independent variables (TS, LC and EOU), $R^2 = 0.616$, F-ratio for (3, 52) = 26.984, $p < 0.01$, with the partial effects of TS, LC and EOU being significant beyond the 0.05 level. The standardised coefficients (Beta weights, β) for U from TS, LC and EOU are 0.443, 0.272 and 0.251 respectively. The shaded results in Table 7-5(c) suggest that there are significant links between TS and U, between LC and U, and between EOU and U. *e*1 is 0.616 taken from R^2 in Table 7-5(a).

Table 7-5. Regression analysis output from the dependent variable U

Table 7-5(a) Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.780[a]	**0.616**	0.586	2.04538

a. Predictors: (Constant), EOU, TS, LC

Table 7-5(b) ANOVA[b]

Model		Sum of Squares	DoF	Mean Square	F	Sig.
1	Regression	338.669	3	112.890	**26.984**	**0.000**[a]
	Residual	217.545	52	4.184		
	Total	556.214	55			

a. Predictors: (Constant), EOU, TS, LC
b. Dependent Variable: U

Table 7-5(c) Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.792	1.689		0.469	0.641
	TS	**0.410**	**0.097**	**0.443**	**4.209**	**0.000**
	LC	**0.317**	**0.137**	**0.272**	**2.319**	**0.024**
	EOU	**0.298**	**0.121**	**0.251**	**2.467**	**0.017**

a. Dependent Variable: U

Table 7-6(a) and Table 7-6(b) show that EOU is significantly correlated with the independent variables (LC and SL), $R^2 = 0.369$, F-ratio for (2, 53) = 15.468, $p < 0.01$, with the partial effects of TS, LC and EOU being significant beyond the 0.01 level. The standardised coefficient (Beta weight, β) for EOU from SL is 0.477. The shaded result in Table 7-6(c) suggests that there is a significant link between SL and EOU. Other beta weight coefficients leading to EOU is 0.165 from LC. *e*2 is 0.37 taken from R^2 in Table 7-6(a).

Table 7-6. Regression analysis output from the dependent variable EOU

Table 7-6(a) model summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.607[a]	**0.369**	0.345	2.16893

a. Predictors: (Constant), SL, LC

Table 7-6(b) ANOVA[b]

Model		Sum of Squares	DoF	Mean Square	F	Sig.
1	Regression	145.532	2	72.766	**15.468**	**0.000**[a]
	Residual	249.325	53	4.704		
	Total	394.857	55			

a. Predictors: (Constant), SL, LC
b. Dependent Variable: EOU

Table 7-6(c) Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.342	1.671		2.598	0.012
	LC	0.156	0.165	0.159	0.946	0.349
	SL	**0.449**	**0.158**	**0.477**	**20.835**	**0.006**

a. Dependent Variable: EOU

Figure 7-6 shows the output generated from AMOS based on the survey of 56 samples. The parameters generated in Figure 7-6 were estimated using the Maximum Likelihood method. This method was chosen over Generalised Least Squares because Maximum Likelihood attempts to maximise the probability of getting the data for covariance or correlation matrix (Blunch, 2008a). In all cases, the coefficients were rounded to 2 decimal places.

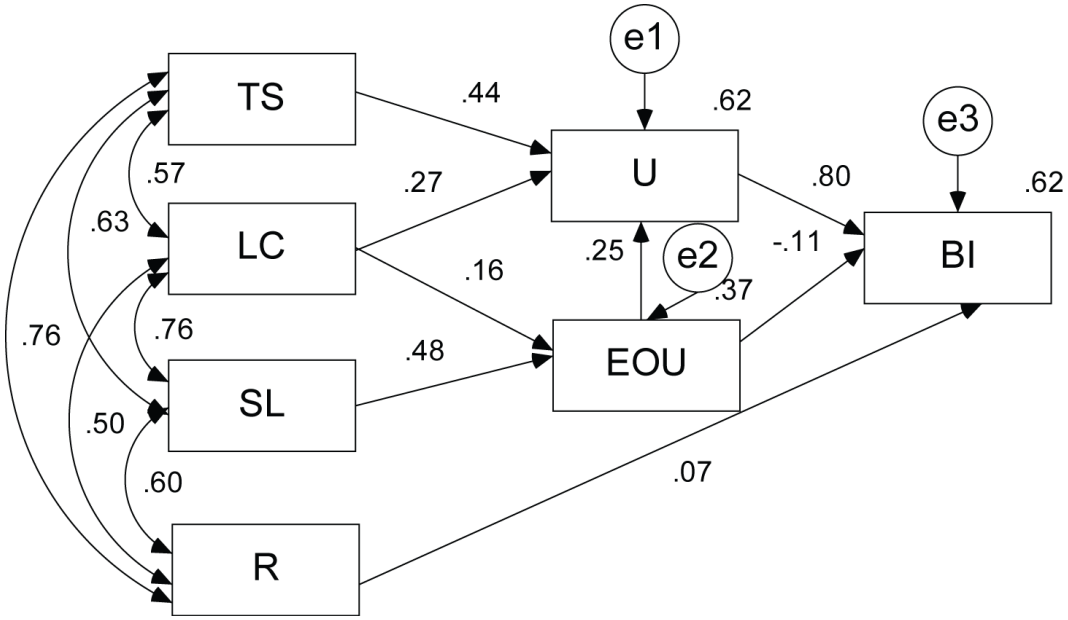

Figure 7-6. Standardised output estimates for Serious-Games-TAM

Table 7-7 identifies the significant path, based on the critical ratio (CR) being outside the interval ±1.96 (significant at 0.05 level). SE is standard error and *p* the probability.

Table 7-7. Significant paths for the regression and covariance data

Regression			Estimate	SE	CR	*p*	Significant Path
SL	→	EOU	0.449	0.155	2.888	0.004	✓
LC	→	EOU	0.156	0.162	0.963	0.335	
TS	→	U	0.410	0.096	4.289	< 0.01	✓
LC	→	U	0.317	0.130	2.442	0.015	✓
EOU	→	U	0.298	0.118	2.514	0.012	✓
R	→	BI	0.080	0.122	0.657	0.511	
EOU	→	BI	–0.140	0.129	–1.088	0.276	
U	→	BI	0.853	0.120	7.090	< 0.01	✓

Covariance			Estimate	SE	CR	p	Significant Path
TS	↔	LC	5.190	1.422	3.649	< 0.01	
LC	↔	SL	5.807	1.293	4.492	< 0.01	✓
SL	↔	R	4.783	1.247	3.836	< 0.01	
TS	↔	SL	6.065	1.531	3.962	< 0.01	
LC	↔	R	3.776	1.141	3.309	< 0.01	
TS	↔	R	7.224	1.612	4.482	< 0.01	✓

Table 7-8. Value of regression coefficient

Regression coefficient	Value
$\gamma_{1,1}$	0.44
$\gamma_{1,2}$	0.27
$\gamma_{2,2}$	0.16
$\gamma_{2,3}$	0.48
$\gamma_{3,4}$	0.07
$\beta_{1,2}$	0.25
$\beta_{3,1}$	0.80
$\beta_{3,2}$	–0.11

Figure 7-7 shows the regression coefficients from Table 7-8 and associates them correctly on the regression path in the Serious-Games-TAM model.

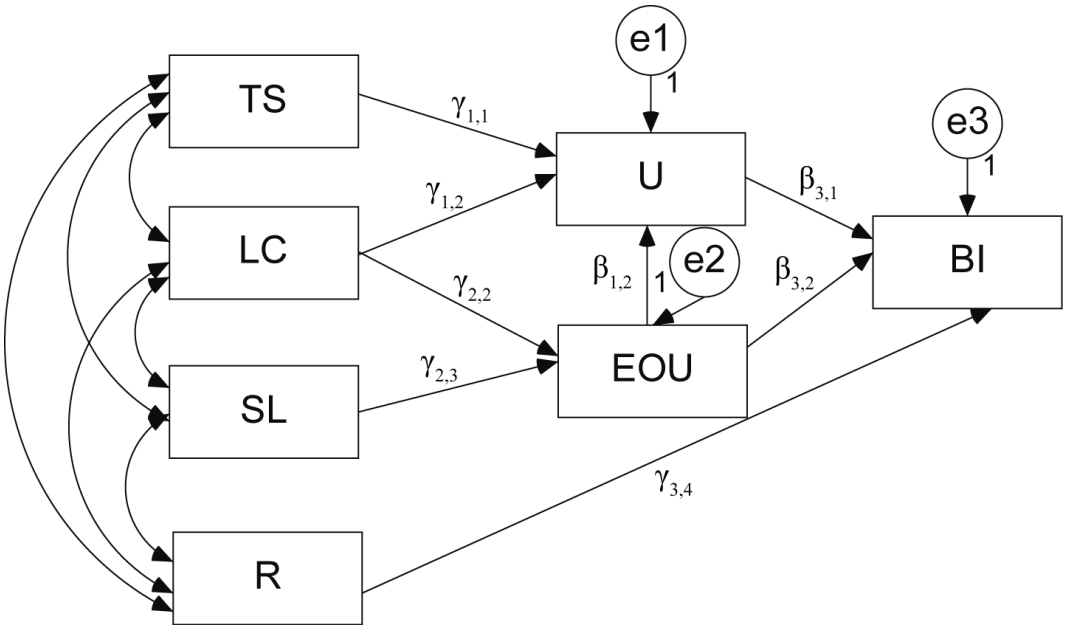

Figure 7-7. Regression coefficients and Serious-Games-TAM

The relationship between all the variables in Figure 7-7, as expressed in regression equations were given in section 5.4, repeated here:

$$U = \gamma_{1,1}TS + \gamma_{1,2}LC + \beta_{1,2}EOU + e1 \quad (1)$$

$$EOU = \gamma_{2,2}LC + \gamma_{2,3}SL + e2 \quad (2)$$

$$BI = \beta_{3,1}U + \beta_{3,2}EOU + \gamma_{3,4}R + e3 \quad (3)$$

The error values $e1 = 0.62$, $e2 = 0.37$, and $e3 = 0.63$ are taken from R^2 in Table 7-4, Table 7-5 and Table 7-6. Substituting these and the values from Table 7-8, the regression equations can be rewritten as:

$$U = 0.44TS + 0.27LC + 0.25EOU + 0.62 \quad (4)$$

$$EOU = 0.16LC + 0.48SL + 0.37 \quad (5)$$

$$BI = 0.80U - 0.11EOU + 0.07R + 0.62 \quad (6)$$

Detailed analysis of Table 7-7 identified a number of statistically significant paths within the model, shown in Figure 7-8 with solid lines.

- Reward (R) and Transfer Skills (TS) are strongly correlated
- Learner Control (LC) and Situated Learning (SL) are strongly correlated

- Transfer Skills (TS) to Usefulness (U) is significant
- Learner Control (LC) to Usefulness (U) is significant
- Situated Learning (SL) to Ease of Use (EOU) is significant
- Ease of Use (EOU) to Usefulness (U) to Behavioural Intention to use (BI) is significant

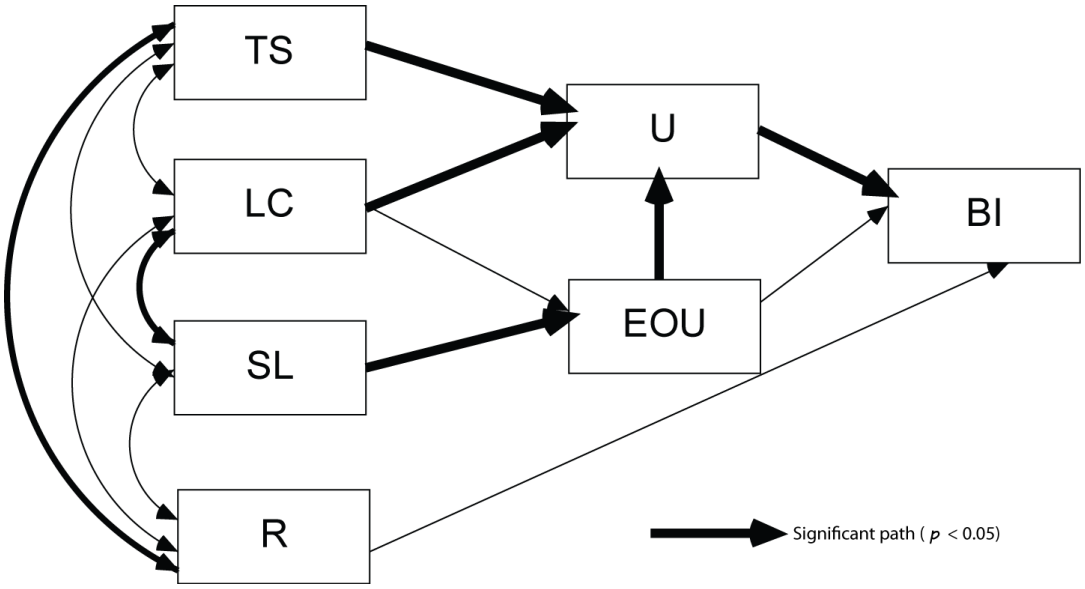

Figure 7-8. Serious-Games-TAM showing the statistically significant paths

7.3 Analysis of Indices

The indices analysis presented in Table 7-9 to Table 7-13 indicate that the Serious-Games-TAM fits the data. A good fitting model is one that can reproduce the variance-covariance matrix (correlation matrix) from the path regression values with little error. The regression coefficient in the Serious-Games-TAM closely matches the correlation matrix.

Table 7-9. Model fit indices: CMIN

Model	NPAR	CMIN	DoF	*p*	CMIN/DoF
Default model	21	13.928	7	0.052	1.990
Saturated model	28	0.000	0		
Independence model	7	270.972	21	0.000	12.903

Chi-square compares the default model and the independence model with the saturated model. The χ^2 (chi-square) or CMIN = 13.928 in Table 7-9 shows that the TAM serious games model (default model) is far closer to the saturated model than the independence model. It is statistically significant with $p = 0.052$, which is small.

This result shows that this model still has 7 degrees of freedom (DoF) and with CMIN/DoF = 1.99, it demonstrates that no other path can be dropped in the Serious-Games-TAM in

order to make it a closer fit. If CMIN/DF were above 3, then too many paths have been dropped in the tested model.

Table 7-10. Model fit indices: RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	0.392	0.935	0.742	0.234
Saturated model	0.000	1.000		
Independence model	4.609	0.326	0.102	0.245

Table 7-11. Model fit indices: Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	0.949	0.846	0.974	0.917	0.972
Saturated model	1.000		1.000		1.000
Independence model	0.000	0.000	0.000	0.000	0.000

Goodness of fit index (GFI) shows the proportion of the variance in the correlation matrix, and the value should be between 0 and 1. Table 7-10 shows that Goodness of fit (GFI) = 0.935 is more that 0.90 and this indicates that the model is a good fit. The same rule also can be applied to the default model in Baseline comparisons for Table 7-11. All the results show more than 0.90.

Table 7-12. Model fit indices: RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	0.134	0.000	0.237	0.092
Independence model	0.465	0.417	0.515	0.000

In Goodness of fit index (GFI) shows the proportion of the variance in the correlation matrix, and the value should be between 0 and 1. Table 7 10 shows that Goodness of fit (GFI) = 0.935 is more that 0.90 and this indicates that the model is a good fit. The same rule also can be applied to the default model in Baseline comparisons for Table 7 11. All the results show more than 0.90.

Table 7-12 of RMSEA, the Standard Root Mean Residual (SRMR) should be |4.0| and Root Mean Square Error (RMSEA) should be small and closer to 0. The parameter for RMR = 0.392 (from Table 7-10) and RMSEA = 0.134, which is within this range.

Table 7-13. Model fit indices: HOELTER
(Blunch, 2008a)

Model	HOELTER 0.05	HOELTER 0.01
Default model	56	73
Independence model	7	8

Lastly, the Hoelter result in Table 7-13, our collected data (sample size) is 56, which is sufficient in this analysis for achieving a significance of 0.05.

7.4 Summary

The Serious-Games-TAM was analysed with AMOS by testing the relationship between the variables, based on the proposed model of serious games acceptance. The results were organised in three sections. The first section was about the participants who took part in this survey. This was followed by results, analysed with AMOS and SPSS, evaluating the relationships between variables in the Serious-Games-TAM discussed in Chapter 5. Finally, the result confirmed that the model is a good fit by examining the indices tables generated from this analysis.

The following chapter is the detailed discussion of these results, and will address the research question of identifying the critical predictors of serious game attributes. It will also validate the serious games framework.

Chapter 8 Discussion

The results obtained from the previous chapter reveal several findings. Statistically significant paths were identified in the Serious-Games-TAM. In this chapter, we discuss these results and examine how these findings support, or fail to support, the hypotheses to be tested. This chapter also discusses the limitations and shortcomings of the current research and suggests ways to remedy them. We first revisit the research questions and hypotheses.

8.1 Research Question 1

What are the relevant educational attributes that would support learning in serious games?

RQ1 was addressed in Chapter 3 where the attributes of educational serious games were selected based on a literature review and critical thinking from learning theories with educational perspectives. Twelve attributes that support learning in serious games were identified, and were summarised in Table 3-1. Chapter 3 provides experimental support for the educational attributes. Some of these attributes were part of the experimental test covered in Chapter 7, and the result of the experiment answered the question on educational attributes that support learning.

8.2 Research Question 2

What is a common framework that can be used as conceptual guidance in designing serious games?

RQ2 was addressed in Chapter 4 where the proposed conceptual framework for serious games was shown as Figure 4-1. It was based on the study of pedagogy theories, real games construction, and improvements from the analysis of previous frameworks. Chapter 4 provided a literature review for the serious games framework and *Unilink Bus Game* was

then developed as an example serious game using this framework. The value of this game, and the data provided by the participants in the experiment, answered this question.

8.3 Research Question 3

How can the selected attributes, in the proposed serious games conceptual model, be tested so that the best configuration will result in predicting learner intention to use serious games?

In Section 5.3, a number of problems were identified that the Technology Acceptance Model could be used to answer. TAM would be the tool to identify learner behaviour in using serious games. The results from this analysis led to further understanding of user acceptance of serious games.

The four attributes selected were: Transfer Skills (TS), Learner Control (LC), Situated Learning (SL), and Reward (R). The justification for the selection of these attributes was discussed in Table 5-2. These variables were used, together with the Serious-Games-TAM, to determine their significant relationships to learner acceptance and to answer the hypotheses below that belong to the Serious-Games-TAM.

H_1 : Transfer Skills will have a positive and significant effect on perceived Usefulness.

H_2 : Learner Control will have a positive and significant effect on perceived Usefulness.

H_3 : Learner Control will have a positive and significant effect on perceived Ease of Use.

H_4 : Situated Learning will have a positive and significant effect on perceived Ease of Use.

H_5 : Reward will have a positive and significant effect on Behavioural Intention to use serious games.

H_6 : Perceived Ease of Use will have a positive and significant effect on perceived Usefulness.

H_7 : Perceived Usefulness will have positive and significant effect on Behavioural Intention to use serious games.

H_8 : Perceived Ease of Use will have positive and significant effect on Behavioural Intention to use serious games.

The statistically significant paths of the Serious-Games-TAM are indicated with solid lines in Figure 8-1 below, which also shows the hypotheses H_1 to H_8, labelled on the regression

paths. The analysis allowed the identification of attributes or combinations of attributes that lead a learner to use this type of game for learning.

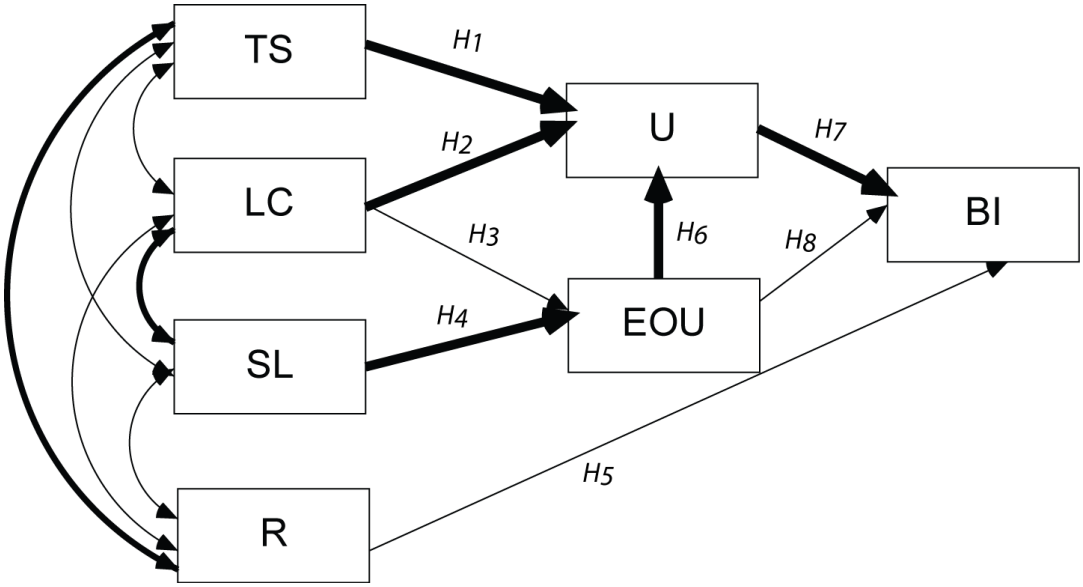

Figure 8-1. Serious-Games-TAM showing statistically significant paths and associated hypotheses

As described in Chapter 7, the following are the significant paths:

- Reward (R) and Transfer Skills (TS) were strongly correlated
- Learner Control (LC) and Situated Learning (SL) were strongly correlated
- Transfer Skills (TS) to Usefulness (U) was significant
- Learner Control (LC) to Usefulness (U) was significant
- Situated Learning (SL) to Ease of Use (EOU) was significant
- Ease of Use (EOU) to Usefulness (U) to Behavioural Intention to use (BI) was significant

Detailed explanations of these significant relationships are given in the subsections below with reference to Table 8-1. The effects decomposition generated by AMOS for standardised direct effect, indirect effect and total effect, are reported in Table 8-1, estimated across 56 samples generated from the correlation matrix in Table 7-3. The total effects are the sum of respective direct and indirect effects.

Table 8-1. Effects decomposition for Serious-Games-TAM path for independent variables

Independent or Exogenous Variables						
Endogenous Variables	**R**	**SL**	**LC**	**TS**	**EOU**	**U**
EOU						
Standardised direct effect	0.000	0.477	0.159	0.000	0.000	0.000
Standardised indirect effect	0.000	0.000	0.000	0.000	0.000	0.000
Total effect	0.000	0.477	0.159	0.000	0.000	0.000
U						
Standardised direct effect	0.000	0.000	0.269	0.439	0.249	0.000
Standardised indirect effect	0.000	0.119	0.040	0.000	0.000	0.000
Total effect	0.000	0.119	0.309	0.439	0.249	0.000
BI						
Standardised direct effect	0.066	0.000	0.000	0.000	–0.110	0.804
Standardised indirect effect	0.000	0.043	0.231	0.352	0.200	0.000
Total effect	0.066	0.043	0.231	0.352	0.090	0.804

8.3.1 *Reward and Transfer Skills are strongly correlated*

Reward (R) comprises incentives given to the learner in response to learner actions within the serious game. This approach, of giving out reward by scoring points or congratulatory messages, encourages and motivates learners further in learning with serious games. The learners answered the questions with comments such as "It boosts my confidence and motivates me to keep on playing when *Unilink Bus Game* displays congratulatory messages." The covariance path between Reward (R) and Transfer Skills (TS) had the highest correlation weight with 0.76 as shown in Figure 7-6. Figure 8-1 showed that Reward (R) and Transfer Skills (TS) have a strong correlation link and this is supported by the second highest critical ratio value of 4.482 in Table 7-7 of covariance data. This can be interpreted as transfer of skills seems to be rewarding, or reward supports the transfer of skills. The results show that Reward (R) was not significantly linked to Behavioural Intention (BI). A possible path for the Reward (R) to Behavioural Intention (BI) is actually "working through" Transfer Skills (TS). For a direct path from Reward (R) to Behavioural Intention (BI), the correlation weight is 0.07 as shown in Figure 7-6. However, Reward (R) showed more strongly when it works indirectly toward Behaviour Intention (BI). Using

Figure 7-6, one tracing from R ↔ TS, TS → U, and U → BI can be calculated as (0.76) × (0.44) × (0.80) equal to 0.27, and this is more than the direct value 0.07. The result 0.27 implies that Behavioural Intention (BI) is expected to increase by about 0.27 standard deviations for every 1 standard deviation increase in Reward (R) via all presumed indirect causal links between these variables.

Therefore, the hypothesis H_5 can be rejected.

8.3.2 *Learner Control and Situated Learning are strongly correlated*

The total effect of Situated Learning (SL) on Ease of Use (EOU) was 0.477, as shown in Table 8-1. This was also indicated by a correlation weight of 0.48 (rounded from 0.477) from SL to EOU in Figure 7-6. Table 8-1 also showed that the 0.119 total effect of Situated Learning (SL) on Usefulness (U) is caused by an indirect effect. Therefore, in order for SL to get to U via EOU, the effect is reduced by 0.358 (0.477 – 0.119). There are many possible tracings from SL to U in Figure 7-6. However, the covariance path between Situated Learning (SL) and Learner Control (LC) indicated the highest correlation weight with 0.76 as shown in Figure 7-6. Figure 8-1 showed that Situated Learning (SL) and Learner Control (LC) have a strong correlation link and this is supported by the second highest critical ratio value of 4.492 in Table 7-7 of covariance data.

The interpretation of this is that Learner Control (LC) and Situated Learning (SL) are strongly correlated. In Learner Control (LC), learners require that every action should be decided by them and they have full control of the game, rather than the serious game dictating what the learner should do next. Thus, any mistakes in the game made by the learner would contribute to better learning because they would not cause them any harm, the learner would not be afraid to try new things, and it would not be a burden or be associated with any cost. Serious games not only have to closely mirror what needs to be learnt (situated learning), but should also allow the learner to have full control or allow them to experience the learning by themselves.

This suggests that learner control supports situated learning, and situated learning is associated with perceived learner control. The learning experienced gained with learner control and situated learning would definitely shorten and enhance memory retention if the learners were to experience it for themselves (Bakopoulos & Tsekeridou, 2009; Mitchell & Savill-Smith, 2004; Swarz, et al., 2010).

8.3.3 *Transfer Skills to Usefulness was significant*

Transfer Skills (TS) means applying previously acquired skills to other learning. This can be done within the game by continuing to the next level. Whatever skills have been acquired can then be used at the next level to acquire new skills. The previous knowledge should be revisited and new knowledge should be gradually added to what has been previously learned. New knowledge should be constructed from previous experience.

The learners answered the questions with comments such as "I can plan a new journey after playing *Unilink Bus Game*" and "I feel that I acquired knowledge and skills as the game progressed."

The total effect of Transfer Skills (TS) on Usefulness (U) was 0.439, as shown in Table 8-1. It was caused by the direct effect. This is also indicated by a correlation weight of 0.44 (rounded from 0.439) from TS to U in Figure 7-6. A high rating of Transfer Skills (TS) leads to high perceived Usefulness (U). This result suggests learners found this serious game useful, partly because they could apply previously acquired skills to their learning, and could add new knowledge to what had been most recently learned. Learners felt motivated in the game with an increase in challenge. This step-up challenge was given only when the learners had shown some mastery in performance and abilities at the previous level, implying that learners had acquired some level of knowledge and achieved learner skills.

The highest total effect between the variables was from TS to BI at 0.352, as shown in Table 8-1. The result 0.352 implies that Behavioural Intention (BI) is expected to increase by about 0.352 standard deviations for every 1 standard deviation increase in Transfer Skills (TS) via all presumed indirect causal links between these variables. This suggests that learner intention to use the game is strongly influenced by Transfer Skills (TS) within the serious game.

Therefore, the hypothesis H_1 can be accepted.

H_1 : Transfer Skills will have a positive and significant effect on perceived Usefulness.

8.3.4 *Learner Control to Usefulness was significant*

The effect of Learner Control (LC) on Usefulness (U) was 0.269, as shown in Table 8-1, and was a direct effect. This is also indicated by correlation weight of 0.27 (rounded from 0.269) from LC to U in Figure 7-6. Table 8-1 also showed that there is an indirect effect of

0.04 of Learner Control (LC) on Usefulness (U). Calculating by using the indirect paths of LC → EOU and EOU → U, (0.16) × (0.25) gives the value 0.04, as indicated in Figure 7-6. Both direct effect and indirect effect give the total effect of 0.309 shown in Table 8-1. The result 0.309 implies that Usefulness (U) is expected to increase by about 0.309 standard deviations for every 1 standard deviation increase in Learner Control (LC) via all presumed indirect and direct causal links between these variables. However, Figure 8-1 showed that only the direct path from Learner Control (LC) to Usefulness (U) is significant in order to get to Behaviour Intentional to use (BI).

Usefulness (U) refers to the user's belief that by using this technology, it can enhance their job performance. The learners answered the questions with comments such as "This game allows me to search for the answer at my own speed." A high rating of Learner Control (LC) leads to high perceived Usefulness (U). This result suggests learners found the game useful, partly because it allowed self-exploration and active learning within the game. Learner control is useful because they were able to chart their own learning and further improve their learning at their own pace. Furthermore, learners could plan their learning by self-direction through re-examining and re-assessing the action during play, such as questioning whether this was a meaningful way of doing things in the game. Another factor why *Unilink Bus Game* was useful for the student is because it allowed learners to gain access to new knowledge or information links outside the game play. This created an opportunity to strengthen existing knowledge that had already been acquired within the game. Moreover, in the case of solving a complex problem, the game suggested several solutions, or the learner was encouraged to engage this problem by visiting different perspectives.

Therefore, the hypothesis H_2 can be accepted and the hypothesis H_3 can be rejected.

H_2 : Learner Control will have a positive and significant effect on perceived Usefulness.

8.3.5 *Situated Learning to Ease of Use was significant*

The effect of Situated Learning (SL) on Ease of Use (EOU) was 0.477, as shown in Table 8-1, and was a direct effect. This is also indicated by a correlation weight of 0.48 (rounded from 0.477) from SL to EOU in Figure 7-6. The result 0.477 implies that the Ease of Use (EOU) is expected to increase by about 0.477 standard deviations for every 1 standard deviation increase in Situated Learning (SL) via all presumed direct causal links between these variables. Figure 8-1 shows that Situated Learning (SL) has a significant path to Ease of Use (EOU).

Situated Learning places the learner in an authentic environment, where they are able to develop mental models of their experience and relate it to real life. Use of a familiar background or common examples in the game's content, and relevance to the learner's experience, should be perceived as easy to use when learning with serious games, because they are learning within familiar territory.

Ease of use (EOU) refers to a person's belief that using serious games for learning will be free of effort. It has been shown that users will interact with the technology if they feel that little effort is needed for using this technology in order to accomplish their tasks. In our survey, learners were asked whether they found it easy to use *Unilink Bus Game* because they are familiar with the operation of buttons and mouse, or whether they found it easy to learn because the serious game was simple and straightforward.

Learners answered the questions with comments such as "I can learn better if I can relate the experiences within a serious game to my experience in real life" or "I am motivated if a serious game is similar to what I want to learn."

A high rating of Situated Learning (SL) led to high perceived Ease of Use (EOU) as shown in Table 7-7. This suggests that learners felt that the mental models of their experience led to minimal effort in the game. Learning in authentic situations gives the learner the pleasure of deeper level engagement, interest and relevance because the serious game is closely impersonating the real world. The achievement of meaningful learning is easier and more promising where the game environment is similar to the real learning environment.

The results showed that Learner Control (LC) was not significantly linked to Ease of Use (EOU), contrary to the expectation of the TAM.

Therefore, the hypothesis H_4 can be accepted and hypothesis H_3 can be rejected.

H_4 : Situated Learning will have a positive and significant effect on perceived Ease of Use.

8.3.6 *Ease of Use to Usefulness to Behavioural Intention to use was significant*

The effect of Ease of Use (EOU) on Behavioural Intention (BI) was –0.110, as shown in Table 8-1, and was a direct effect. This is also indicated by a correlation weight of –0.11 (reverse effect) from EOU to BI in Figure 7-6. The result showed that learner intention to use the game (BI) is not significantly linked to the game's ease of use (EOU). Instead, the result shows that Ease of Use (EOU) is significantly linked to Usefulness (U), and it is Usefulness (U) that is significantly linked to Behavioural Intention to use (BI).

Table 8-1 also showed that there is an indirect effect of 0.200 from Ease of Use (EOU) on Behavioural Intention (BI). Calculating by using the indirect paths of EOU → U and U → BI which is equal to (0.25) × (0.80) gives the value 0.200, as indicated in Figure 7-6. Both direct effects and indirect effects give the total effect of 0.090 as shown in Table 8-1. The result 0.090 implies that Behavioural Intention (BI) is expected to increase by about 0.090 standard deviations for every 1 standard deviation increase in Ease of Use (EOU) via all presumed indirect and direct causal links between these variables.

The significant paths to Usefulness (U) were from Transfer Skills (TS), Learner Control (LC), and Ease of Use (EOU). Usefulness (U) was the only significant link to Behavioural Intention to use (BI), strongly suggesting that learners must perceive that the serious game is useful before they would want or intend to use it.

Finally, all of the TAM components and all of the identified serious game attributes showed significant linkages and correlations, and were all relevant to Behavioural Intention to use. These findings suggest that serious game design should encompass all these attributes, while development should carefully consider the exact links between game attributes and the resulting Behavioural Intention to use.

Therefore, the hypotheses H_6 and H_7 can be accepted and hypothesis H_8 can be rejected.

H_6 : Ease of Use will have a positive and significant effect on perceived Usefulness.

H_7 : Usefulness have a positive and significant effect on Behaviour Intention to use (BI).

8.4 Research Question 4

What recommendations can be offered to serious game designers and educational practitioners who intend to use serious games for effective learning?

The recommendations to designers and educational practitioners are to focus on and use the significant relations and best configurations elaborated below when designing serious games. These recommendations and findings are based on the discussion in the previous section.

> Reward (R) link to Behavioural Intention (BI) is actually "working through" Transfer Skills (TS).

Reward in serious games should be delivered after the learners have successfully completed and acquired new skills, based on the learners' competence in employing previously learnt skills in the learning activity. The serious game should carefully harness

together the skill and the delivery of reward. The analysis also shows that giving out rewards freely in a serious game will not encourage the learner to use the serious game for learning and thus will inhibit effective learning.

Situated Learning (SL) leads to high perceived Ease of Use (EOU).

The learner will perceive that the serious game is easy to use if its design is close to real life experienced by the learner. This shows that the learner believes that the mental models of their experience lead to minimal effort within the game. Learning in authentic situations gives the learner the pleasure of deeper level engagement, interest and relevance because the serious game is closely impersonating the real world. The learning will be easier, more promising and more meaningful if the game environment is similar to reality.

Learner Control (LC) supports Situated Learning (SL), and Situated Learning (SL) is associated with perceived Learner Control (LC).

The relationship between learner control and situated learning is strong. This implies that the serious games designer should allow access by the learner to experiences in the learning environment that are designed close to real life experienced by the learner.

Learner Control (LC) leads to high perceived Usefulness (U).

Learners will perceive that the serious game is useful for them if it allows total learner control. Learners believe that this serious game is useful partly as the game allowed them self-exploration and active learning within the game. Learners' control is useful because learners will be able to chart their own learning and further improve their learning at their own pace. Furthermore, learners are able to plan their learning themselves by re-examining and re-assessing the action during play, such as questioning whether this is a meaningful way of doing things within the game. Another factor why *Unilink Bus Game* is useful for the student is because it allows learners to gain access to new knowledge or information links outside the game play. This creates an opportunity to strengthen knowledge that has already been acquired within the game. Moreover, in the case of solving a complex problem, the game could suggest several solutions or the learner can be encouraged to engage this problem by visiting different perspectives.

Transfer Skills (TS) leads to high perceived Usefulness (U).

Learners will perceive that the serious game is useful for them if it allows a transfer of skills within the game. Learners found this serious game useful partly because they could apply previous acquired skills to their learning, and new knowledge was gradually added to what had been most recently learned. Learners felt motivated in the game with an increase

in challenge. This step-up challenge was given only when the learners had shown some mastery in performance and abilities at the previous level, implying that learners had acquired some level of knowledge and achieved learner skills.

> Ease of Use (EOU) is linked to Usefulness (U), and Usefulness (U) is linked to Behavioural Intention to use (BI).

Usefulness (U) is influenced by three significant factors of Transfer of Skills (TS), Learner Control (LC) and Ease of Use (EOU). Usefulness (U) is the only significant link that is connected to Behavioural Intention to use (BI), which could be interpreted as the learner will intend to use the serious game if he perceives that it is useful, and not because the serious game is easy to use. The serious game is only useful when it is easy to use.

The serious game would be more attractive to the learner if these recommendations are followed. Thus, any increase in learner intention would definitely make the learning more engaging and more motivating. Serious games designers should cover all these attributes when developing a serious game and apply suitable attributes or combinations of attributes that have been accepted by the learner who intends to use the serious game for learning.

8.5 Examples of applying the changes to Unilink Bus Game

This section will discuss some examples of how to apply these recommendations within *Unilink Bus Game*, following a consideration of the analysis. Table 8-2 shows how the mappings of external variables are done within the existing *Unilink Bus Game*.

Table 8-2. Serious game attributes mapping within Unilink Bus Game

	Serious game attributes				
Screen	**TS**	**LC**	**SL**	**R**	**Description**
Screen 1 Drag with the mouse in order to locate the destination.		✓	✓	✓	Learner control 1) Learner trying to pinpoint the location at his own pace and self-exploration. 2) Learner also finding information about the destination through self-exploring on the web. Situated Learning Using the real and clear map, learner would be able to relate to outside world. Reward Score is given and message displayed if the answer is right to motivate learner.

	Serious game attributes				
Screen	**TS**	**LC**	**SL**	**R**	**Description**
Screens 2 & 3 Identify the buses that operate near to the start position and destination.	✓	✓	✓	✓	Transfer Skills 1) Skill from the previous level applies to the next level. 2) Learner would be able to apply this skill to identify any Unilink bus operating in Southampton. Learner Control Self-exploration and self-learning. Situated Learning Learner would be able to use the Unilink booklet and relate to the Southampton map. Reward Score is given and message displayed if the answer is right to motivate learner.
Screen 4 Critical Thinking in finding the most convenient bus route.	✓		✓	✓	Transfer Skills 1) Skill from the previous level applies to the next level. 2) Learner would be able to apply this skill to choose the best bus routes using Unilink bus. Situated Learning Learner would be able to use the Unilink booklet and relate to the Southampton map in terms of bus timing and frequency, shortest route, and find the journey with fewest bus transfers. Reward Score is given and message displayed if the answer is right to motivate learner.
Screen 5 Identify Bus No and direction.	✓	✓	✓	✓	Transfer Skills 1) Skill from the previous level applies to the next level. 2) Learner would be able to apply this skill to identify any Unilink bus operating in Southampton. Learner Control Self-exploration and self-learning. Situated Learning Learner would be able to use the Unilink booklet and relate to the Southampton map in terms of direction and end points. Reward Score is given and message displayed if the answer is right to motivate learner.
Screens 6 & 7 Recognising the proper bus stops for interchange and destination.	✓	✓	✓	✓	Transfer Skills 1) Skill from the previous level applies to the next level. 2) Learner would be able to apply this skill to identify any Unilink bus stops. Learner Control Self-exploration and self-learning Situated Learning Learner would be able to identify and recognise the bus stops from real image and pictures. Reward Score is given and message displayed if the answer is right to motivate learner.

Based on the recommendations above, the following are suggestions that can be applied to the design of *Unilink Bus Game* to improve its use in the manner intended by the learner.

- The present reward delivery should be redesigned. These rewards should only be given only when there is evidence of Transfer Skills, that is, the learners have successfully completed and acquired new skills within the game.
- Add some elements of Learner Control to Screen 4. Presently, this screen does not cater for learner control. This can be adjusted within the game to make it more active for the learners to explore on their own in searching for the answer.
- Tune the game levels for usefulness, because the learners will use *Unilink Bus Game* if they perceive that it is useful and not because it is easy to use.

8.6 Shortcomings and Limitations

This section discusses the shortcomings and limitations of the experiment and *Unilink Bus Game.*

8.6.1 *Shortcomings of the experiment*

- Gender preferences

This survey did not examine the difference in gender preferences in the acceptance of serious games. The development of the questionnaires was gender neutral. A separate study is required to find out if there is a predictor influenced by the different genders in using serious games.

- Age

The participants involved in this survey were from 18 to 33 years old, and university students. A wider range of age is required, including children, and up to a working age group, for a study to examine the preferences for serious games based on age.

- Subjective norm

Subjective norm is a belief that other people can influence someone's behaviour, or perform certain behavioural actions under social pressure, such as an outside group. A separate variable or predictor would need to be tested and added to the Serious-Games-TAM to find out whether the result can be influenced by a subjective norm.

- Type of participants

The majority of the participants were international students that were new to the UK bus system. The result could be different if the survey was applied to native British students because the native student may not favour using *Unilink Bus Game* as part of the learning requirement. Since they are already accustomed to the operation of UK bus systems, they might use this game as a leisure activity instead. Would the model still apply if the learner wants to use the serious game but, at the same time, he already knows about bus systems without going through it?

8.6.2 *Shortcomings of Unilink Bus Game*

The participants provided four sets of feedback on *Unilink Bus Game*. These comments were treated as shortcomings and create the need for further improvement. These are the comments from the participants.

- Better to include the bus timetable in the game.

Unilink Bus Game could be improved by integrating it with the bus timetable. The participant felt that having to use the timetable would make the *Unilink Bus Game* more challenging.

- It is more difficult than real life.

The participant felt that the current game is more difficult than real life. More help or hints are needed to support the learning in the game.

- Unable to remove an individual answer.

The participant felt that the system should allow the learner to remove or erase an individual answer and not to erase everything if only one answer is wrong.

- Expand the *Unilink Bus Game* to the city centre, Romero Hall, Asda and the main railway station.

The participant felt that *Unilink Bus Game* would be more useful if the task or the objective of the game was expanded to be more inclusive of student destinations, such as the city centre, supermarket and train station.

8.7 Summary

This chapter began with a restatement of the research objectives, research questions and the hypotheses. It demonstrated how the results and the findings were use to answer the research question and test the hypotheses. The significant findings are:

1. The Reward (R) link to Behavioural Intention (BI) is actually "working through" Transfer Skills (TS).
2. Learner Control (LC) supports Situated Learning (SL), and Situated Learning (SL) is associated with perceived Learner Control (LC).
3. Transfer Skills (TS) leads to high perceived Usefulness (U).
4. Situated Learning (SL) leads to high perceived Ease of Use (EOU).
5. Ease of Use (EOU) is linked to Usefulness (U), and Usefulness (U) is linked to Behavioural Intention to use (BI).

These findings suggest that serious game design should encompass all these attributes, while development should carefully consider the exact links between game attributes and the resulting Behavioural Intention to use. The findings also show that the serious game attributes used in this model are well correlated, based on learner results and the bespoke game that was use for this survey. The game was based on the conceptual serious game framework, which received good outcomes based on learner feedback.

Therefore, this analysis did identify those attributes or combinations that lead the learner to use this type of game for learning. This analysis was not only able to identify the critical predictors of serious game attributes, but also validates the serious games framework because the major component of learning activity within the framework was supported by serious game attributes.

Chapter 9 Conclusion

Chapter 1 highlighted some of the problems related to the learning situation in the education area. This thesis addressed some of these issues by developing an improved and effective method of using serious games that can be meaningful and acceptable to the learners. The first step was to define a serious game. As explained in Chapter 2, this was based on three main perspectives (educational, psychology, and computer science), which were expected to become the focus for addressing the problems discussed in Chapter 1.

From the literature review in Chapter 2, the serious games definition was developed to cover:

- The learner capability within the serious game framework. This defines what capability the learner wants to achieve by playing this game.
- Standards of assessment, game achievement and feedback, defined inside the framework, will act as a quality control for the serious game learning standards.
- Determination of the correct skill to be learnt by defining the instructional content within the serious games framework of the subject matter that the learner is supposed to learn, and this is related to the learning objective or intended learning outcomes.
- Activity, incorporating some the educational attributes that are based on the pedagogy theories that result in successful learning theory, should be implemented within the serious game.

The serious games framework proposed here would allow for student innovation and creativity. There should be a mechanism that is able to modify the learning activity within the game so it would continue to challenge the thinking of the learners. The learning outcomes should not just be tailored to the learner's capability, but should also be able to increase their skill with more challenging, self-adjusted, game learning activity.

From the psychological and computer science perspective, there was a need to confirm learner acceptance, and the willingness of the learner to use serious games for learning. By applying the TAM to serious games, some measurements could be made of how external variables are capable of influencing learner behaviour in using serious games.

Steps taken by this research began with verifying that some of the previously identified attributes can be used for predicting the learner's intention to use serious games. The initial study was to identify, to develop, and to evaluate, an effective serious games frameworkfor serious games and then, using the proposed framework to create a serious game, to validate it by collecting and analysing the data from learners using it.

The following are the research objectives re-stated, and some explanation as to how far these objectives have been achieved.

9.1 Research Objectives

The objectives of this research were to:

- Identify serious game attributes that would support learning effectively by using serious games.
- Develop a serious games conceptual framework that would aid the game designers and educationists in designing serious games.
- Demonstrate an implementation of the framework by designing an actual serious game for experiment and evaluation.
- Validate the attributes of serious game, or a combination of these attributes, that contribute to learner acceptance of the use of serious games based on the serious games framework.

The first objective has been resolved by identifying twelve serious game attributes based on learning theory. These attributes were discussed in Chapter 3 and are: Incremental learning, Linearity, Attention span, Scaffolding, Transfer of learnt skills, Interaction, Learner control, Practice and drill, Intermittent feedback, Reward, Situated and authentic learning, and Accommodating the learner's styles. Brief descriptions of these attributes were shown in Table 3-1.

The second objective was achieved by developing the serious games conceptual framework shown in Figure 4-1. All the major elements, including the serious game attributes, were

formed together to describe effective learning with serious games. This framework aims to help designers and educational practitioners towards a working concept of designing serious games for effective learning.

For the third objective, *Unilink Bus Game*, a bespoke application, was developed. It was based on the serious games conceptual framework and details about it can be found in Chapter 6. The experiment and evaluation process also was discussed in the same chapter. The research design and the research methods employed achieved the objectives of this research.

The fourth objective is the major contribution of this study. With the aid of the Technology Acceptance Model, the serious game attributes, one of most important elements in the serious game conceptual framework, were tested and were validated. This is important because the findings of this evaluation suggest what makes serious games acceptable to the learner, and how to make serious games that are perceived as useful, so that the learner would intend to use them. If a system is deemed unacceptable by the learner, then it would not be effective.

9.2 Contribution

Previous work undertaken by serious games researchers, described in Chapter 4, demonstrated their own interpretation of serious games models, but most of these models are still theoretical. This research aimed to answer the four research questions that would contribute to the originality of knowledge by proposing an overall design model for serious games, called the conceptual framework of serious games, and validate that framework according to the way in which learners preferred and intended to use the games. Whilst answering these research questions, two models were developed: the conceptual serious games framework and the Serious-Games-TAM. Both were later analysed. The results of the analysis also contributed to the discipline of serious games design applications. The major contributions to knowledge are now shown.

9.2.1 *Guidelines for learner acceptance in learning serious games*

The recommendations for answering the research question (RQ4), given in section 8.4, suggest how these guidelines can be integrated with a serious game. These findings suggest that serious game design should cover all the designated attributes, while development should carefully consider the exact links between game attributes and the resulting

Behavioural Intention to use. The results allow us to predict the learner's intention to use the serious game. The correct configuration of Transfer of Learnt Skills, Situated and authentic learning, Learner Control, and Reward, provides an indication of how to design successful and effective serious games that would ensure learners use them for learning.

9.2.2 *Serious game attributes*

Serious game attributes were selected based on the literature review and critical thinking of learning theories from educational perspectives. A number of serious game attributes applied to education were identified, and are summarised in Table 3-1. These attributes should be employed in the design of serious games to create effective learning.

9.2.3 *Conceptual serious games framework*

The conceptual framework for serious games proposed in Figure 4-1 is based on the study of theories of pedagogy, the construction of real games, and improvements from the analysis of earlier frameworks. The components of this framework are based on the review of learning and pedagogy perspectives in combination with the games, and aims to establish the conceptual model that will be used by the game designer for efficient game development or by the educational practitioner when designing serious games for effective learning. This proposed conceptual framework should be the basis for future serious games design.

9.2.4 *The profile of serious games*

The profile was created by testing some of the components of the serious games framework against examples of existing serious games. Using the profile shown in Figure 6-1, any newly-developed serious game can be evaluated against it, to ensure the standard of the new game is at the same level as those commercial serious games that are acceptable by learners.

9.2.5 *The use of TAM to validate the framework*

The proposed Technology Acceptance Model for serious games in Figure 5-4 shows some of the selected educational game attributes that are used in the conceptual serious games framework. This research showed how an experiment could be performed to test this model

and apply it to finding learner acceptance of serious games. Section 5.4 showed the process to validate the TAM for serious games. This process can be used by serious game designers to test other variables for predicting learner behaviour to use and accept serious games for learning.

9.3 Future Research

The current research has some shortcomings and limitations, listed in section 8.6. These problems need to be addressed in future work. These are now elaborated.

9.3.1 *Recommendations for the field of serious games research*

Future research can build on this research by developing serious games based on the recommendations outlined in Section 8.4. Further experiments can be undertaken for developing learner feedback. This experiment should be made with a control group and an experimental group. Both groups should be administered pre- and post-tests in order to find the effectiveness of the serious games with the learners. This approach would further validate the recommendations outlined in the field of serious games design.

9.3.2 *Guidelines for the serious game conceptual framework*

Detailed design guidelines, based on the conceptual serious games framework, should be developed and serve as a design manual for serious game designers. These guidelines can be referred to by the game design documentation, which is the source material the game designer uses when designing an actual game. One of the educational serious game attributes mentioned in Chapter 3 is to accommodate the learners' styles within the game. Future work in this area could expand the serious games guidelines to provide a detailed template of serious games design according to the types of learner preference.

9.3.3 *Improving Unilink Bus Game*

The help system is one area that needs further improvement in *Unilink Bus Game*. A better designed help system and better feedback would make learning more effective. Also, adding more challenging tasks to *Unilink Bus Game* would make the learner more engaged and feel more motivated. The recommendations in section 8.5 should be followed to make a better *Unilink Bus Game* for the learners.

9.3.4 *Subjective norm*

Subjective norm is a belief that other people can influence someone's behaviour, or perform certain behavioural actions under social pressure, such as an outside group. A separate variable or predictor would need to be tested and added to the Serious-Games-TAM to find out whether the result can be influenced by subjective norm.

9.3.5 *Gender preferences*

A future study is required to find out if there is a predictor influenced by the different genders using serious games. A set of questionnaires and the use of a separate control group should be planned for this study. Studies shows that games can be perceived as positive or negative based on gender preference (Dondlinger, 2007; Hayes & King, 2009; Mitchell & Savill-Smith, 2004; Paraskeva, et al., 2010; Steinkuehler & King, 2009). The outcomes of these studies are as follows.

- Male and female learners choose to react differently when they play the game. Males prefer to achieve scores, whereas females like to play games because they can build relationships.
- Females incline more toward shorter games, that are more casual and have fewer graphics, for example, puzzles or quizes, than action types of game where the female is viewed and stereotyped as a victim that needs to be rescued.
- Females look for relevance and usefulness to socialising within the game than males. Males play to win, for example, in a sports game or adventure game.
- Females prefer to try to resolve emotional issues by compromise or diplomacy, but males tend towards head-to-head conflict.
- Males are more motivated if the game can be modified ("modding") to their needs, and they can create their own games

9.3.6 *Age*

A wider range of age is required that includes a group of working age, in order to examine the preference for using serious games based on age and to evaluate whether is there a common link between learner's age and learner's learning styles when learning with serious games.

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Appendix A Games Survey

This appendix discussed those games that were noted in the research.

- *Space invader*

A game to shoot vertically up the screen towards endless numbers of aliens organised in rows and columns. The shooting tank can move to the left or right behind a fragile shield or block in order to avoid the alien shots. This game was designed and programmed by Toshihiro Nishikado in 1978. This game can still be played online at www.spaceinvaders.de.

- *Asteroids*

A video arcade game by *Atari* in 1979. This game is played by using the up or arrow keys to avoid the incoming asteroids. The score is given by numbers of asteroids destroyed. This game can be played online at www.atari.com/arcade/asteroids.

- *Doom*

First person shooter game by *id Software* in 1993. This game story is based in the near future on Mars, featuring a marine being stalked by soldiers who have been turned into zombies due to a teleportation problem. The marine has to shoot and kill as many zombies as possible in order to survive. This game can be played online at www.gamesfreak.net/games/Doom-Flash_3503.html.

- *Quake live*

As with *Doom*, this first person shooter is off to fight an enemy by collecting weapons, armour and ammo in the combat arena. The player needs to shoot the enemy and collect

game points in order to achieve the game objective. This game can be played online at www.quakelive.com/#home.

- *The Golden Compass*

A game is adapted from the novel and movie of the same name in 2007. It was developed by *Shinny Entertainment* and published by *Sega*. It can be played on Xbox360, PS2, PS3 and PSP.

- *Beowulf*

Action adventure game based on the movie released in 2007. This game was developed by *Ubisoft* for Xbox360, PS2, PS3 and PSP.

- *Grand Theft Auto 4*

A sandbox style of game and the highest rated game of all time. The player takes the role of *Niko Bellic*, a war veteran from Eastern Europe who comes to the United States. The whole action takes place in Liberty City. Based on the clues on the hand phone, the player needs to solve certain tasks to save his cousin. The outcome of the story is based on the player's actions.

- *The Sims*

A real-time strategy game based on the simulation of daily life activities by one or more virtual persons in *SimCity*. It was developed by *EA* for PC games, PS2 and Xbox.

- *Halo3*

It can be either first person or third person shooter. This can be set by using the camera option on the controller pad. The player takes the role of Master chief to combat the aliens, such as brutes of the Covenant army. The player may select different weapons, drive or even fly a plane. The game is not a sandbox type and it has to finish one level at a time until the grand finale of destroying the Covenant. This game was developed by *Bungie* for Xbox360.

- *Turok*

A one-man army fight in the jungle in the future against an enemy and dinosaurs in order to survive. The player takes the role of a futuristic marine *Turok*. This game was developed by Propaganda games and for Xbox360, PS3 and PC games.

Appendix B Operational Definitions

Table B-1. Operational definitions for serious game components

Serious Games Framework elements	**Definition**	**Method of test and decision criteria**	**Implementation in *Unilink Bus Game***
Clear instructions	Instructions to the learners how to interact with the game and tell the learners how to play. For example, in using the keyboard or keypad, which keys to press and its association to game world. *"I think this game comes with clear instructions. For example the instructions on how to play this game, how to use keyboard or keypad, which key to press and its relationship to game world."*	**Characteristic of interest:** Instructions or descriptions or illustrations of how to play. **Method of test:** Follow the instructions and evaluate the game. **Decision criteria:** Is the given instruction unambiguous and easy to understand? Observe the response when pressing of keyboard or keypad or help key.	Instruction and detail explanations on how to play this game, brief summary about Unilink Bus Game and the controls keys are clearly stated at the welcome screen. Learner can access this by clicking the 'Help' button on the welcome screen.

Serious Games Framework elements	**Definition**	**Method of test and decision criteria**	**Implementation in *Unilink Bus Game***
Intended learning outcomes	The aim or objective for playing the game or accomplishments during the game activity. Solicit learners to experience and sound achievement by the end of the game. *"I understand the objectives very well for playing this game."*	**Characteristic of interest:** The ultimate aim or objective of playing the game is explicitly declared. **Method of test:** Examine at the start of the game and find the game objective. **Decision criteria:** Is the given objective achievable by the end of the game. Does the game activity agree with the objective?	The intended learning outcomes of playing this games is clearly displayed on the welcome screen. This aim states as "The game will teach you how to use the Unilink Bus Services." In game information (by clicking the help button), it states: By the end of this game, the learner will be able to plan the best route using the Unilink bus in Southampton. Supporting objectives to achieve the above, learner must be able to: • Recognise the location for final destination. • Identify the bus routes. • Identify the bus no. • Identify the bus stops and Interchange for bus transfer. • Accurately recognise where to get off the bus.

Serious Games Framework elements	**Definition**	**Method of test and decision criteria**	**Implementation in *Unilink Bus Game***
Instructional content	The content narrative is well structured and well-paced, gives a satisfactory mood level of learning while playing. For example, learner does not feel any superficial learning. The content dissemination is efficient and useful. Learners seeking out or negotiating for information during the game activity demonstrates effectively in learning. *"I can easily search for the answer within the game and the game provides me with enough information in answering the question."*	**Characteristic of interest:** The subject matter and delivery techniques. **Method of test:** What is the method used in seeking out the information. Investigate the approach used to convey information or answer to the learner. For example, if the games want to inspire the learners to be active learners, then the burden of finding the answer must be their own self exploring. If little information is given, learners must perform analytical thinking in order to solve the problems. **Decision criteria:** Does the content dissemination and seeking out or negotiating for answers during the game activity prove to be effective in learning?	The Unilink Bus Game teaches the learner how to use the bus service. The tasks assigned to learner to solve try to invite and directed the learner how to actually use the Unilink bus service. The instructional content that is intended for the learner to learn covers: • Learning about facts is about identifying and locating the correct destination, finding the Unilink buses operated within the vicinity of the destination area, identifying bus number and routes and finally identifying the bus stops at both at starting and destination point. • Learning about procedure is about teaching correct sequences to be undertaken by learner when using the bus system. It begins with locating the final destination and ends with identifying the bus stops.

Serious Games Framework elements	**Definition**	**Method of test and decision criteria**	**Implementation in *Unilink Bus Game***
Game mechanics	All the movements and actions such as switches and button actions are consistent throughout the game. For example, the characters within the games move smoothly by using the control keys. The game mechanics have been appropriately designed and used for producing a good game. *"All the movements and actions (for example, switches and button actions or pop up screens) are consistent throughout the game"*	**Characteristic of interest:** Consistency in movements and actions. **Method of test:** How smooth are the character moves by using the control keys? The operation of switches and buttons are consistent throughout the game play. Is the explosion or collision sound uniform through out the play? **Decision criteria**: Try out the action and notice any irregularity. Any surprise or unexpected response or unwanted encounter should be removed because it would sidetrack learners from focussing on learning.	The game mechanics used within this game is turn based. The Unilink Bus Game progresses to the next level based on the learner's responses and answers. The learner gives the inputs through the familiar process of clicking the mouse to select the answer and using the keyboard for typing an answer. The graphic and colour correspond to the actual colour used by the Unilink bus system.

Serious Games Framework elements	**Definition**	**Method of test and decision criteria**	**Implementation in *Unilink Bus Game***
Linearity	The learning contents are delivered in an orderly manner and properly sequenced within the game. Learners do not feel confused because of inconsistency in teaching flow. *"I don't feel confused and the game flow is delivered in an orderly manner and properly sequenced."*	**Characteristic of interest:** Proper sequence and orderly manner in teaching. **Method of test:** Try out the game to the end and take notice of any confusion or inconsistency in the teaching flow. **Decision criteria:** The teaching is delivered smoothly and in orderly fashion and properly sequenced from one screen to the next or one level up to another level in the story or narrative flow.	The learning content topic is consistently display in the left area while the game is progressing. The arrows show how the learning direction and game level are sequenced in order for the learner to complete this game. This game level will be highlighted in red to inform the learner about the level where the learner is currently playing.
Attention Span	The amount of attention span given is adequate for the learner to process the cognitive activity. Is there any plausible pause to allow for a game reflection? *"The timing given to absorb information and solving the problems is adequate and enough for me."*	**Characteristic of interest:** The amount of attention period. **Method of test:** Try out the challenge within the game. Is the amount of time spent answering or performing certain activity adequate? Is it too long and bores the learner or causes the user to lose concentration? **Decision criteria:** If the timing is too short, extend the timing. If the learning process too complicated, modify it to make it simple.	This Unilink Bus Game is progress at the learner own pace and speed. A lot of graphic (pictures or images) is used and with less text. This is intended to reduce the cognitive load on the learner. This excess load can be used and released it for the learner to do the thinking process.

Serious Games Framework elements	**Definition**	**Method of test and decision criteria**	**Implementation in *Unilink Bus Game***
Interaction	The challenge augurs well and fits with the target audiences giving the learners the feeling of comprehension and satisfaction. *"I think the challenge augurs well and fits with the target audience. Leaving me with the feeling of comprehension and satisfaction."*	**Characteristic of interest:** Learner Interaction. **Method of test:** At the end of the game, what kind of feeling is generated from playing this game? Any feeling of satisfaction and self assurance of learning? **Decision criteria:** If it does not meet the target audience's needs, modify the narrative or adjust the storyboard.	In every game level, the interaction with learner is well intended to be interesting and challenging, while keeping well-paced and allowing the learner to remain immersed, attentive and engaging within the game. This game interaction is learned by doing.
Learner control	Games must give a sense of fairness and allow the learners to win and not to make it too difficult. Learners will be bored because they feel that they cannot overcome the obstacles or challenges. *"I think this game is fair and gives me a chance to win and not making it too difficult for me to overcome the obstacles regardless if I am male or female."*	**Characteristic of interest:** Be fair. **Method of test:** In all the activities or challenges, the possibility of winning is there. **Decision criteria:** If it is not fair, adjust the challenges. Don't make it too easy or too complicated and difficult to play. It should be at the zone of proximal development or at the level of competency .	In finding the location of destination point where learner is asked to pin point the exact location of Waitrose, the learners are allowed to explore on the their own on the map and provide access link to outside information to explore for finding the answer and this will prepare them to create their own learning path and self learning experience.

Serious Games Framework elements	**Definition**	**Method of test and decision criteria**	**Implementation in *Unilink Bus Game***
Game achievement	The results from the learning assessment are allowed to influence the delivery of game flow and adjusted to match the learners' level of capability. *"I feel that this game has auto adjusted mode to match my knowledge and capability."*	**Characteristic of interest:** Matching capability. **Method of test:** If the achievement is low, can the game dynamically adjust to the learner level by lowering the level activity. If the achievement is too high, does the game dynamically adjust to the learner level by increasing the activity level? **Decision criteria:** The activities should be well balanced. The adjustment mechanism should be implemented within the game based on how well the learner played. This adjustment is implemented by offering hints in the help system or auto adjustment in game's narrative flow.	The game achievement informs the learner through the menu bar displayed on the left showing how the learner is advancing from one level to the next level. Since this particular game is not an action-based genre but closed to a direct simulation genre and the target user capability is already known in advanced therefore it is not regulated to be a self adjusted system to correct the content delivery in order to match to the learner capability.
Reward	The learner feels motivated and engaged because of the given reward. The offered reward measured up and matched to the degree of challenge within the game. *"I feel happy and self motivated from the games reward."*	**Characteristic of interest:** Reward. **Method of test:** Does the reward measure up to and match the degree of challenge within the game? **Decision criteria:** The reward scheme should have a sense of value to it because over-rewarding could become valueless to the learner and useless.	Reward is given by a pop-up display based on how well the learner progressing within the game.

Serious Games Framework elements	**Definition**	**Method of test and decision criteria**	**Implementation in *Unilink Bus Game***
Intermittent feedback	The help support mechanism demonstrates sufficiently in supporting and in assisting the learners. The feedback given is relevant and valued important by the learners. *"The help mechanism is relevant and important in supporting and assisting me during the game."*	**Characteristic of interest:** Help and feedback. **Method of test:** Is the help sufficient in supporting and in assisting the learner? Is the feedback timing appropriate to the learner? **Decision criteria:** The help should provide some support for the learners until they are comfortable working on their own and this help should be given at appropriate times and at appropriate level of difficulty. Too much help would delay the learning process.	The feedback within the Unilink Bus Game provide the learners with a prompt response and rapid answer in either in the bottom screen, next to the answer selected by the learner and also in the pop up display or by clicking the help button on game screen.

Serious Games Framework elements	**Definition**	**Method of test and decision criteria**	**Implementation in *Unilink Bus Game***
Situated and authentic learning	Learners can relate and direct their learning relevant to the outside world. *"While playing this game, I can relate and feel as if it is similar and feel similar experience to the outside world."*	**Characteristic of interest:** Situated and authentic learning. **Method of test:** Does the game world demonstrate situated and authentic learning, where the learners can relate their learning to outside world? **Decision criteria:** By placing the learner in an authentic environment, the learner would be able to develop mental models of their experience and potentially relate it to real life.	All the learning contents taking place within the Unilink Bus Game is similar to the actual learning in the real life situation. This is because the materials used are identical in the actual use such as the Unilink bus map, the colour of bus routes and the videos showing the bus stops.
Transfer of Learnt Skills	Transfer of learnt skills is where the learner would feel confident that the learned knowledge can be applied to other skills at the next level. *"After playing this game, I feel confident that my game experiences can be applied to other skills at the next level or to the outside world."*	**Characteristic of interest:** Valued aftermath. **Method of test:** Is there any evidence of transferred skills, where the learners feel confident that the learned knowledge can be applied to other skills at the next level? **Decision criteria:** Whatever skills have been acquired can then be used at the next level to acquire new skills. The previous knowledge should be revisited and new knowledge should be gradually added to what has been most recently learned.	Based on the learner's feedback on the questionnaires, the learners feel strongly that the Unilink Bus Game does provide a transfer of skills. One test is included in the final level of Unilink Bus Game to checked or gauged the learner understanding and to confirm whether learner able to transfer their skills from the previous game to solve the next task.

Appendix C Unilink Bus Game

This was the serious game developed as part of this research. The aim of *Unilink Bus Game* was to help international students use the university's bus service (*Unilink*[8]).

Figure C-1. The Introduction page with the *START*, *LOAD*, *HELP* and *QUIT* buttons

The *START* button is to enter the game, *LOAD* button is to load previous saved game, *HELP* button is to display the help menu, and *QUIT* button is to end the game.

[8] More on Unilink at www.unilinkbus.co.uk

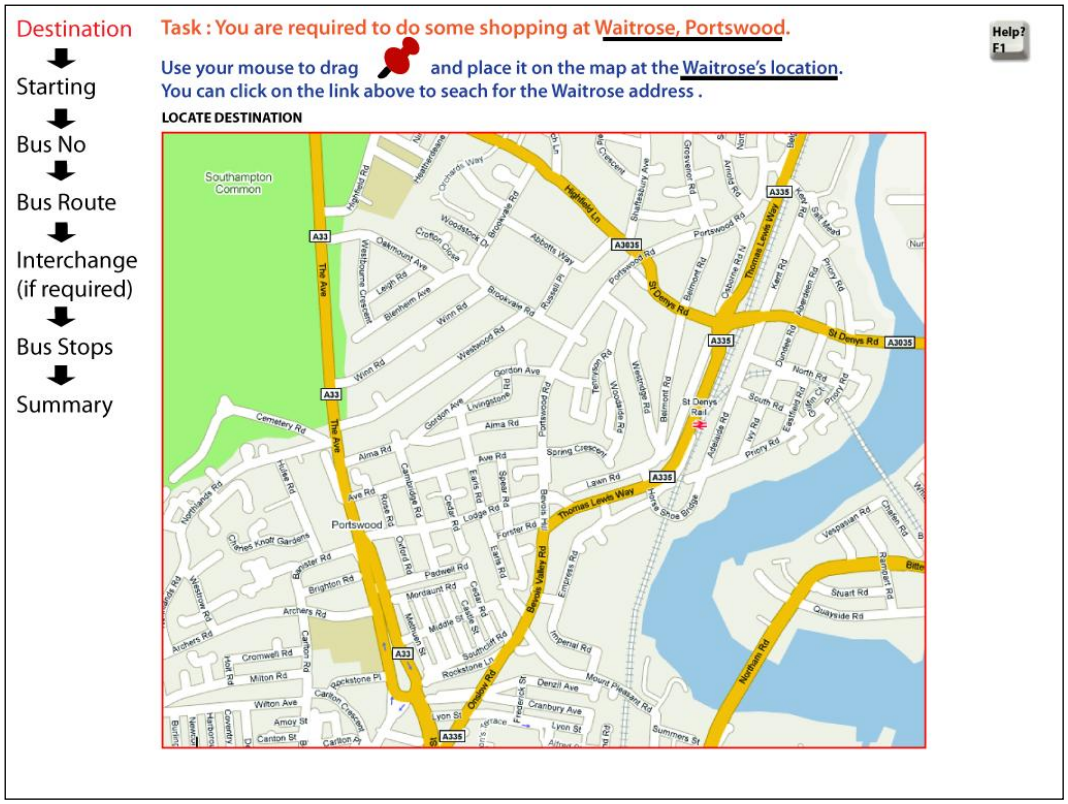

Figure C-2. The first task is to learn how to get to the destination and to look for the necessary information about the destination

The learner needs to use the mouse and drag the "thumb tack", and use this to pinpoint the exact location of the Waitrose supermarket on the map. If the thumb tack is placed at the wrong location, the system will display an error and ask the learner to try again. More information on Waitrose can be found at the link above.

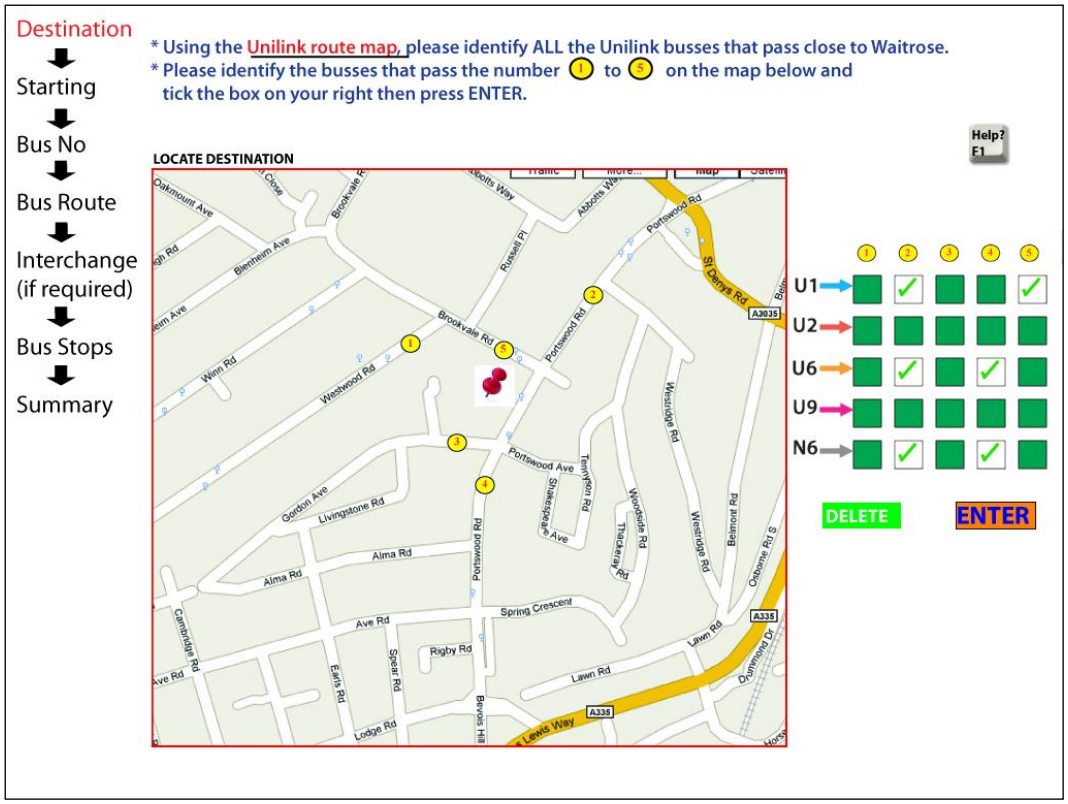

Figure C-3. The learner needs to familiar with all the bus routes
and to identify all the *Unilink* buses that operate around the destination area

By using the actual *Unilink* route map, the learner can compare routes and identify which buses are operating along the road marked by the number 1 to 5. The learner needs to enter this information by selecting the appropriate green box corresponding to the bus number and press “enter” in order to submit the answer, or press “delete” to re-enter a new answer for any mistake. The game will provide feedback based on the learner’s answer before proceeding to the next level.

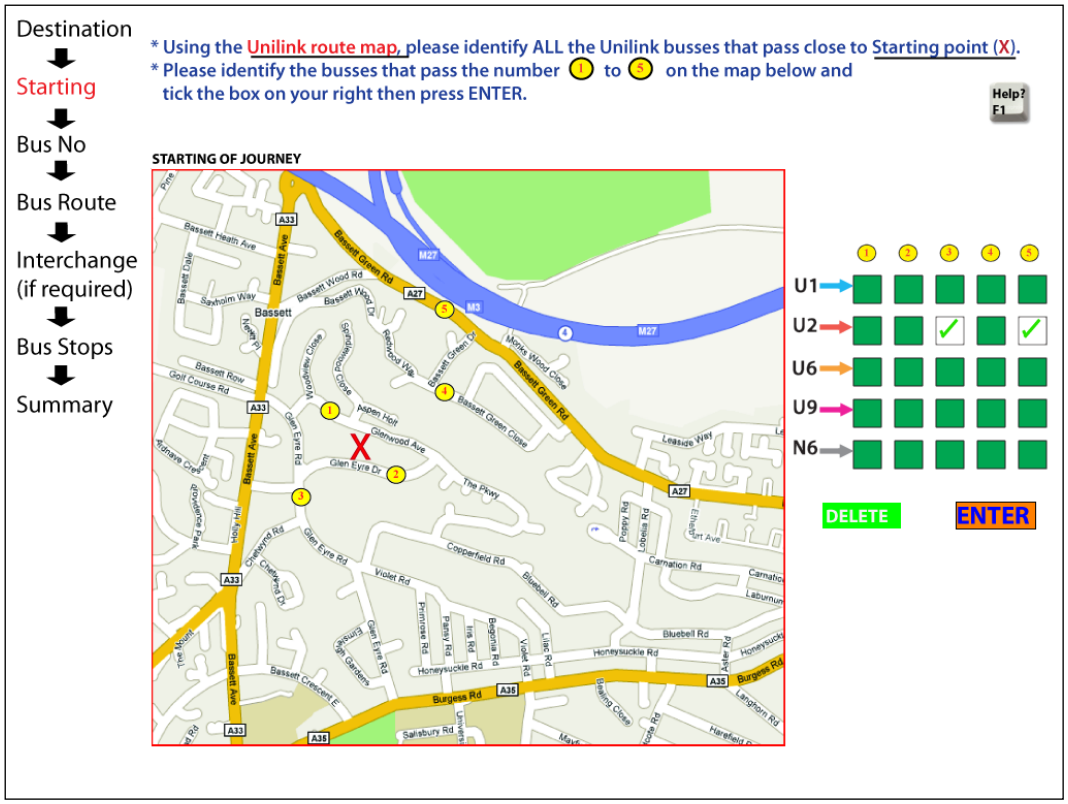

Figure C-4. The learner needs to familiar with all the bus routes and to identify all the *Unilink* buses operating around the starting area

Similar to the previous level for learning about the destination, the identical approach will be applied here for the starting point, which is now to begin from the Glen Eyre student accommodation. By using the actual *Unilink* route map, the learner can compare routes and identify which buses are operating along the road marked by the number 1 to 5. The learner need to enter this information by selecting the appropriate green box corresponding to the bus number and press "enter" in order to submit the answer, or press "delete" to re-enter a new answer for any mistake. The game will provide feedback based on the learner's answer before proceeding to the next level.

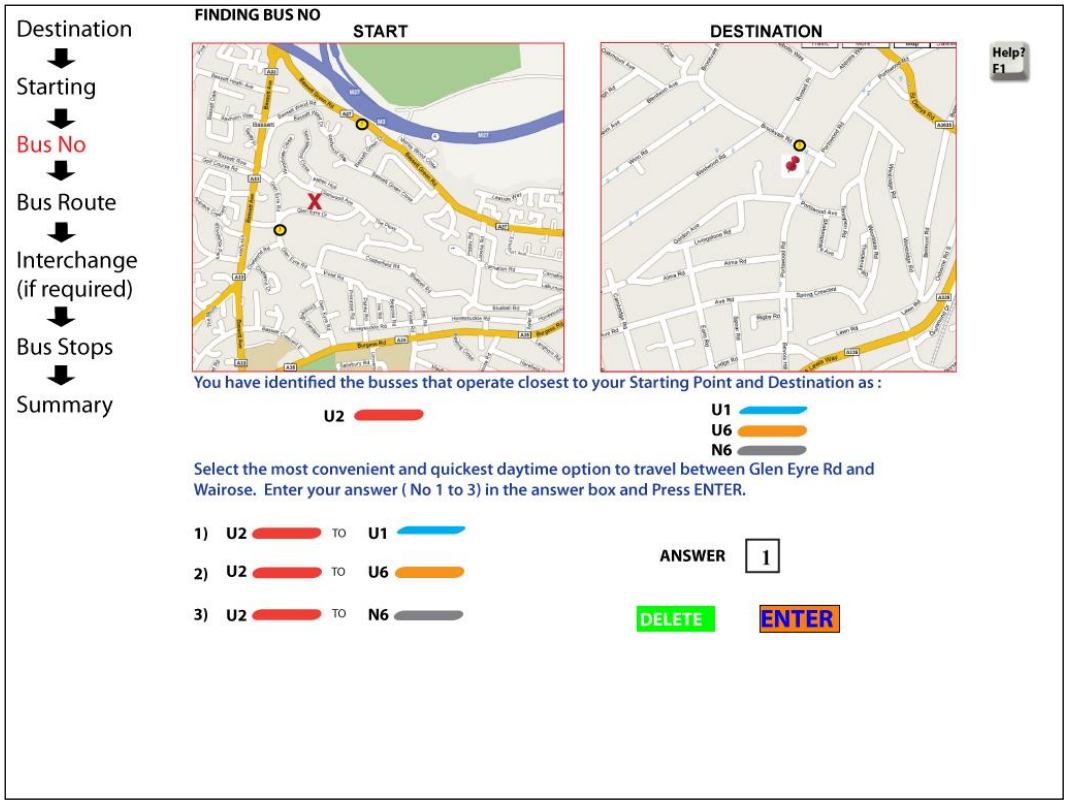

Figure C-5. The learner needs to make a careful selection of the most suitable buses to use from the start to the destination

At this level, the game gradually increases the challenge to the learner. Based on the previous game level, the learner needs to make a critical judgement and to correctly select the most convenient and the quickest bus journey from the start to the destination. At this level, the learner is learning by thinking and exploring all possible routes for the interconnecting buses until the end of the journey. The game will provide feedback based on the learner's answer before proceeding to the next level.

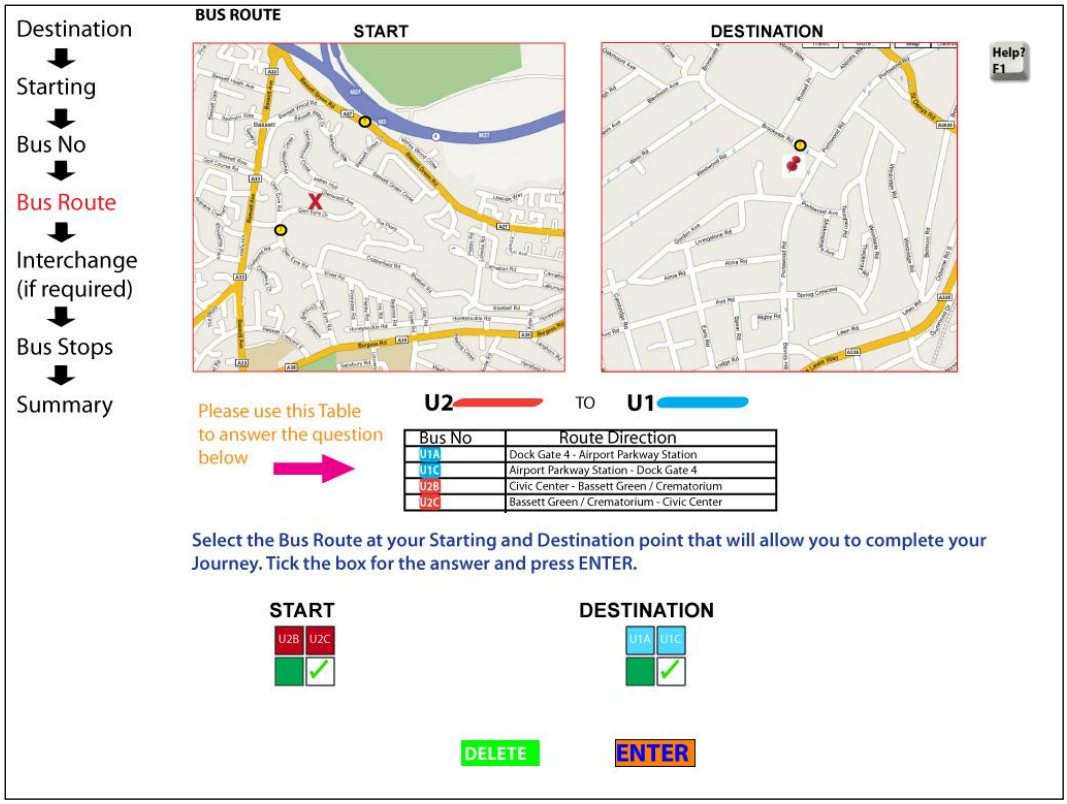

Figure C-6. The learner needs to choose the correct bus number to board according to the bus route direction

After successfully selecting the correct bus number in the previous level, the learner needs to recognise the correct bus routes. The bus routes are shown by the bus number that is displayed on the front and side of the bus. At this level, the user learns how to relate the bus number to the route direction, e.g. U1A goes to the Airport, U1C goes to the city centre. By selecting the correct answer, the game will proceed to the next level.

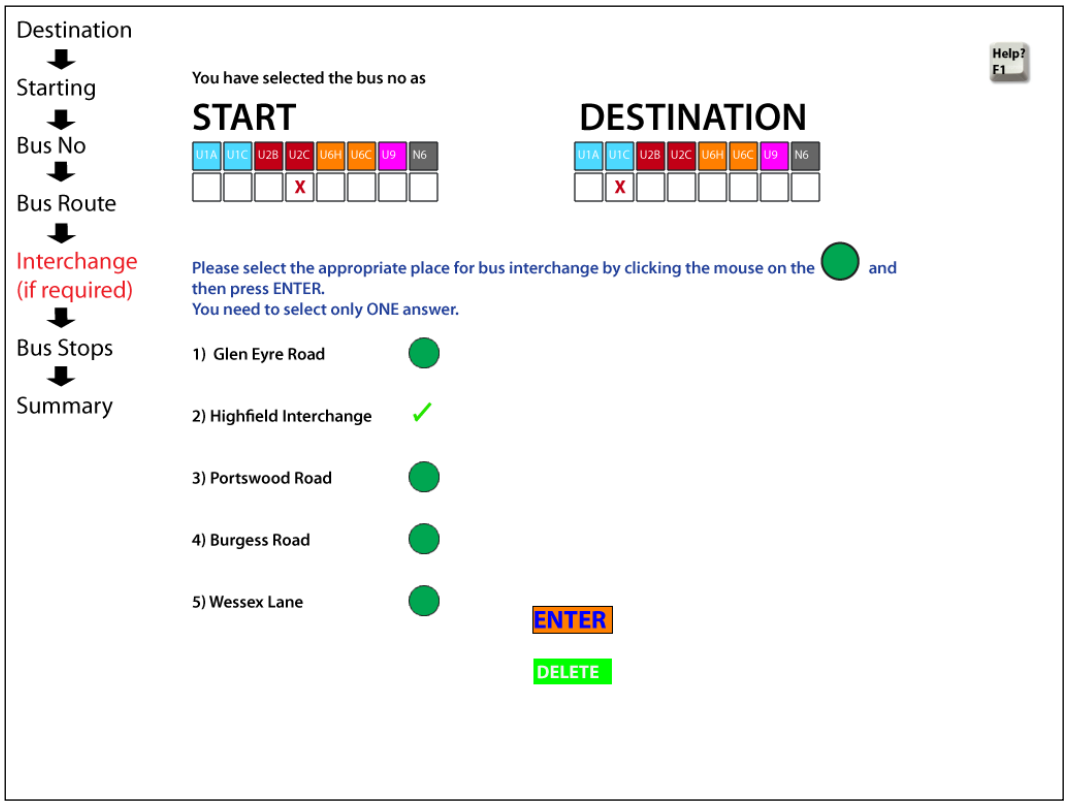

Figure C-7. The learner needs to choose the correct location for the bus transfer

If the user needs two different buses to reach the destination, the learner must locate the best place for the bus transfer. At this level, learner will apply the skill learned previously and use the *Unilink* bus map in order to locate exactly where this bus transfer can happen.

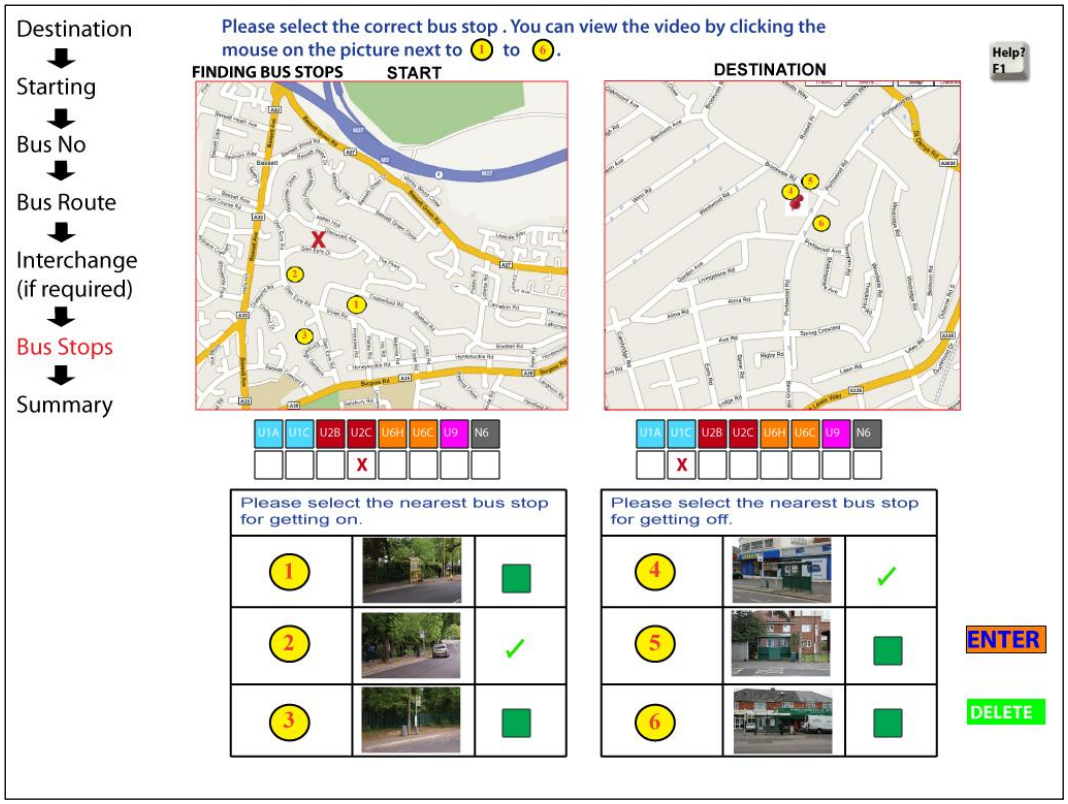

Figure C-8. The learner needs to find the correct location for the bus stop, both at the start and at the destination

With the help of the YouTube videos, the user can view the actual place where the correct bus stops, for getting on and for getting off. This applies situated and authentic learning to the learning process, where the learning closely matches the actual learning environment.

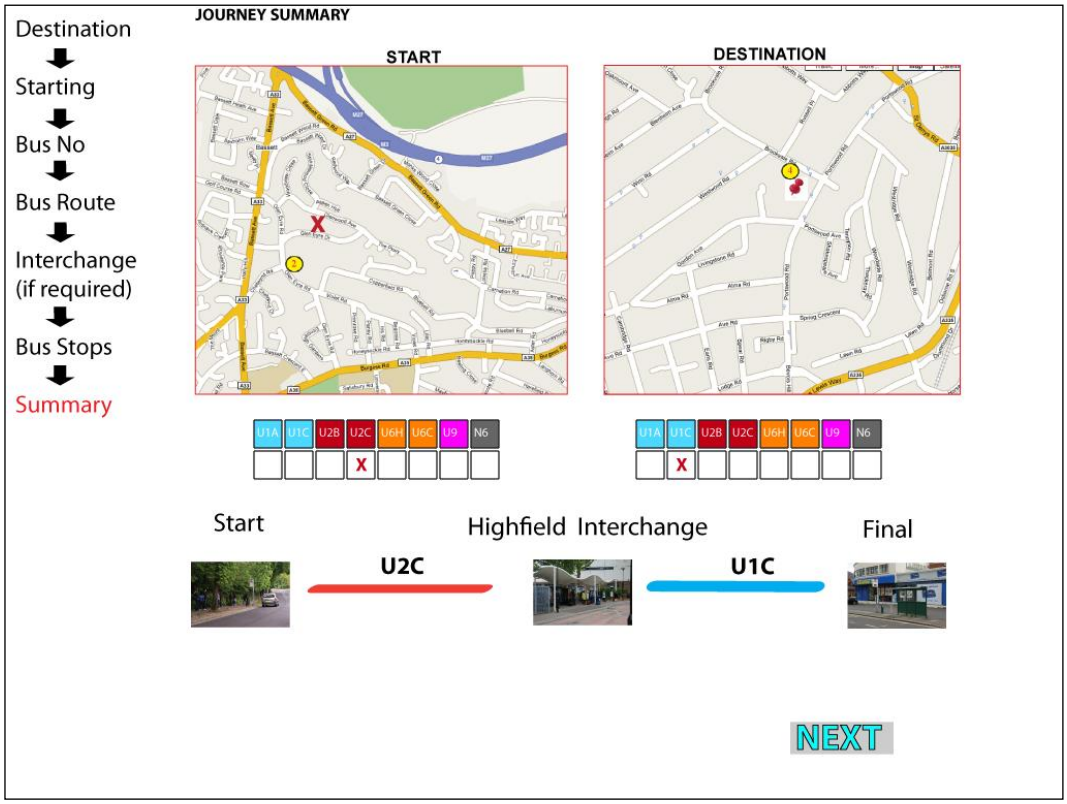

Figure C-9. The reflective part of the learner's learning process

Based on the proposed conceptual model in Figure 4-1, this is the place for the learner's reflection, and to evaluate whether the game objective has been achieved by learning with the game.

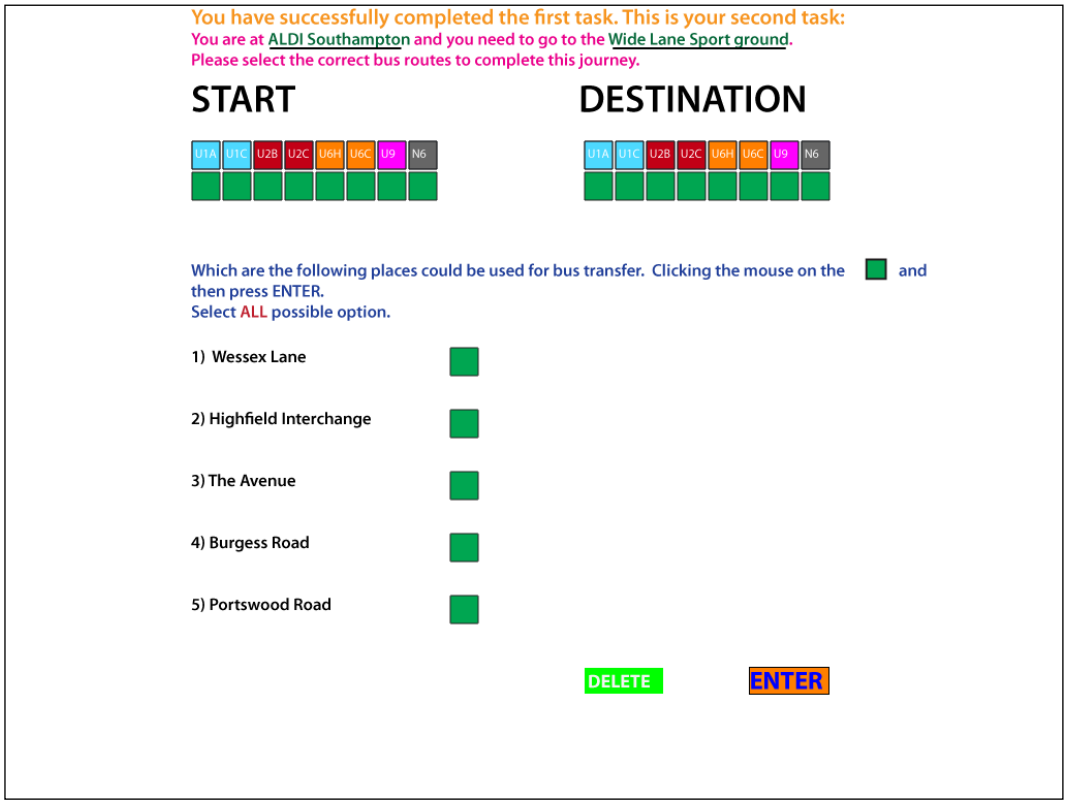

Figure C-10. A new task for testing the learner's ability in using *Unilink* bus service

This is where the practice and drill attribute is applied within the game. A new task (or repetitive task) is given to the learner for further testing of the learner's understanding of what has been learned before.

Appendix D Questionnaire

Please TICK the box:

I am a ☐ UK Student ☐ Overseas Student

I am ☐ Male ☐ Female

My Age is between ☐ Under 17 ☐ 18-20 ☐ 21-23 ☐ 24-26 ☐ 27- 29
☐ 30-32 ☐ 33-35 ☐ 36-38 ☐ 39-41 ☐ Above 40

In a lifetime, hours I spend on computer games in one week:

☐ 0 hr ☐ < 5 hrs ☐ <10hrs ☐ <20hrs ☐ >20hrs

Please give only ONE answer for each question by circling the number 1 to 5 below.

	Fully disagree	Disagree	No opinion	Agree	Fully agree
I can learn better if I can relate the experiences within a serious game to my experience in real life.	1	2	3	4	5
The maps and videos used in the Unilink Bus Game helped me to understand the Unilink bus service.	1	2	3	4	5
I am motivated if a serious game is similar to what I want to learn.	1	2	3	4	5
It is easy to reference the Unilink Bus Game to the Unilink booklet because the colours used for the bus route are identical.	1	2	3	4	5
I have a full control of Unilink Bus Game whilst playing.	1	2	3	4	5
I can apply previous knowledge when answering the Unilink Bus Game questions.	1	2	3	4	5
This game allows me to search for the answers at my own speed.	1	2	3	4	5
This game helps me to learn, by allowing me to find answers outside the Unilink Bus Game.	1	2	3	4	5
I feel that I can plan a new journey after playing the Unilink Bus Game.	1	2	3	4	5

	Fully disagree	Disagree	No opinion	Agree	Fully agree
I feel that I can use my new skills in identifying Unilink bus routes.	1	2	3	4	5
After playing the Unilink Bus Game, I feel that I have learned and gained new skills.	1	2	3	4	5
I feel that I have acquired knowledge and skills as the game progress.	1	2	3	4	5
I felt rewarded when the Unilink Bus Game displays congratulatory messages for my answer.	1	2	3	4	5
I feel encouraged to learn more when the Unilink Bus Game displays congratulatory messages.	1	2	3	4	5
It boosts my confident and motivates me to keep on playing when the Unilink Bus Game displays congratulatory messages.	1	2	3	4	5
I feel that the congratulatory messages are important to my learning.	1	2	3	4	5
Learning to operate this Unilink Bus Game was easy.	1	2	3	4	5
I find the Unilink Bus Game easy to use.	1	2	3	4	5
I find it easy to use the Unilink Bus Game because I am familiar with the operation of buttons and mouse.	1	2	3	4	5
I find it easy to learn if the serious game is simple and straightforward.	1	2	3	4	5
The Unilink Bus Game can help people to use Unilink buses.	1	2	3	4	5
After playing this Unilink Bus Game, it will be easier for me to plan a bus journey in the future.	1	2	3	4	5
This Unilink Bus Game will help me use the Unilink bus service better.	1	2	3	4	5
The Unilink Bus Game will be useful to inform new students of the features of the Unilink Bus Service.	1	2	3	4	5
If I am given a serious game, I intend to use it.	1	2	3	4	5
I expect the use of serious games for learning will continue in the future.	1	2	3	4	5
I plan to use serious games for learning in the future.	1	2	3	4	5
I intend to continue using serious games for learning in the future.	1	2	3	4	5

Thank you very much for your participation.

Appendix F

Pilot Study of the Unilink Bus Game

The following table presents a summary of the pilot test of *Unilink Bus Game* in May 2009. The study was conducted at the University of Southampton's ECS computer room, and *Unilink Bus Game* was played on the university workstations.

Participant	Comments	Justification and Modification
A	Full screen button (F4) should be explicitly written (all screens)	F4 button is explained in help menu and displayed on every screen
	Task should be written bigger and catchy (screen no 2)	Task font is acceptable and viewable
	Map is not clear enough (blur) (Screen no 2)	Depends on the individual PC graphic card resolution
	Delete function (Delete all or delete by clicking inside the box again) (screen no 3)	Rectified (Done)
	Should have instructions how to use the bus direction table (screen no 5)	Rectified (Done)
	Should use circle button instead of square button in Interchange screen	Should remain as it is – consistency through out the game
B	Selecting all boxes in the 1st row can get the right answer (Screen no 2)	Rectified (Done)
	Selecting both U1C and U1A also gets the answer correct (screen no 5)	Rectified (Done)
	Overall not complicated and direct to students	

Participant	Comments	Justification and Modification
C	The game is ok but it is fixed in sequence	No action
	Unable to remove answer (erase only 1 mistake)	Rectified (Done)
	Delete everything (screen no 3)	
	Need more info on the feedback rather than try again (screen no 3)	Rectified (Done)
	Why not use the tick on screen no 4	This is Multiple choice question (need to select 1 answer)
	In Quiz screen, instruction should tell the student to answer 3 questions	Rectified (Done)
D	Need more hint on the feedback (screen no 3)	Rectified (Done)
	Make it more fun	

Appendix G Published Papers

The followings are the two published papers based on this work. These papers were presented at:

- The 9th International IEEE Conference on Advanced Learning Technologies (ICALT 2009), July 15-17, 2009, Riga, Latvia.
- The 2nd International IEEE Conference on Serious Games and Virtual Worlds for serious applications (VSGAMES 2010), March 25-26, 2010, Braga, Portugal.

A CONCEPTUAL FRAMEWORK FOR SERIOUS GAMES

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Abstract

A considerable number of serious games have been developed over the last ten years, with varying degrees of success. Due to a lack of clear standards and guidelines for game developers, it is difficult to justify claims that a specific game meets the learner's *requirements and/or expectations. This paper defines a conceptual model for serious games that will contribute to their design and the measurement of achievement in meeting their learning outcomes.*

1. Introduction

There are a number of definitions for serious games and Susi et al [1] define them as games that engage the user and contribute to the achievement of predefined objectives. For example, the U.S. Army uses serious games for tactical and strategic training which allows trainees to participate in simulated real world battles [2].

The growth of serious games in education can be ascribed to learning which can be more engaging with the introduction of an underlying game, and to the current generation of learners who have grown up in a digital environment and are familiar with its operation. It is apparent that the delivery and organization of teaching material needs to be changed to accommodate young learners and to meet their expectations [3]. Providing these learners with suitable games could be one of the solutions for meeting these needs, together with the support of traditional teaching in the classroom.

However, due to unclear standards and guidelines, it is difficult to claim that serious games really meet the learner's requirements or expectations. One view is that most of the available games for learning have not been created by language or pedagogy experts [4].

In order to address the problems caused by unclear standards, this paper defines a conceptual model for serious games based on learning theory. This will assist developers in ensuring that the resultant serious game will provide effective learning.

2. Serious Games Conceptual Framework

The proposed framework includes learning and pedagogy theory in combination with gaming requirements[5-8] and aims to establish a conceptual model that will be used by the game designer or educational practitioner when designing serious games for effective learning.

The framework in Figure 1 is an evolution of the input-process-outcome game model discussed by Garris et al [5].

2.1 Capability

Capability refers to the cognitive, psychomotor, and possibly affective skills which the learner is to develop as a result of playing the game. Cognitive skills include the capabilities of recall, analysis, synthesis, and evaluation. Psychomotor skills include the capabilities of well-timed, fluid execution. Affective skills include the capabilities of identifying, adopting, and valuing appropriate attitudes and points of view.

2.2 Instructional content

The instructional content is the subject matter that it is intended that the learner should learn. The detail of the actual subject matter to learn, or the type of content that the learner learns, could be an exhaustive list. Gilbert & Gale [7] state that contents can be classified into four types: facts, procedures, concepts, and principles.

2.3 Intended learning outcomes

Learning outcomes are the goals to be achieved from playing the serious game. An intended learning.

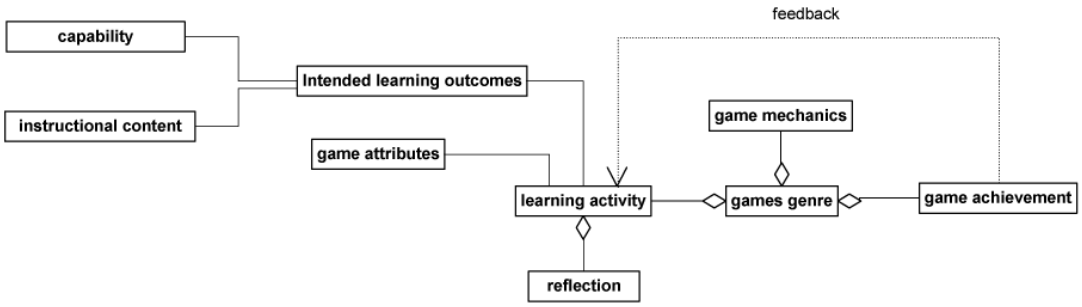

Figure 1. Conceptual Framework for Serious Games shown as a Structural Class diagram.

outcome is a particular combination of capability and subject matter. For example, the learner should be able to recall the date of the battle of Hastings or should be able to analyse whether a particular bird is a raptor

Typical examples of learning outcomes are based on taxonomies of educational objectives with learner capabilities drawn from the psychomotor, cognitive, and affective domains [7] For example, pilots undertake rigorous training in both the classroom and in aircraft. A study has shown that by introducing a number of hours playing aviation computer games, pilots have performed better in test flights.

2.4 Game attributes

Game attributes are those aspects of a game which support learning and engagement. The game attributes are developed based on the critical thinking resulting from the literature review on behaviourist, cognitive, constructivist, educationist, and neuroscience perspectives. The game attributes include:

- Incremental learning provides the learning materials and introduces the learning activities incrementally. Intended learning outcomes are addressed one by one and not all at once.
- Linearity is the extent to which the learning activities are sequenced by the game (and would suit a serial learning style), and the extent to which an active learner may be able to construct their own sequences.
- Attention span concerns the cognitive processing and short-term memory loads placed upon the learner by the game. These loads need to be carefully calibrated to the target learner.
- Scaffolding is the support and help given by the game during the learning activities.
- Transfer of learned skills is the support provided by the game to enhance the application of previously learned knowledge to other game levels.
- Interaction is the extent to which the game activities require responses and engagement from the learner.
- Learner control is the extent to which the learner can direct their learning activities within the game, providing self study and self exploration to suit their own pace and experience.
- Practice and drill provides for repeating learning activities with increasingly harder tasks for better achievement of the intended learning outcomes.
- Intermittent feedback is the extent to which every game interaction receives feedback, or whether feedback is provided less frequently.
- Rewards are arrangements in the game to encourage the learner and to keep their motivation high.
- Situated and authentic learning involves the provision of a gaming environment or world where the learner can relate their learning to their needs and interests in the outside world.
- Accommodating to the learner's styles refers to the game's ability to suit and to reach out to different learner styles by offering variation in game play.

2.5 Learning activity

Learning activity is the activity designed to keep the learner engaged and learning in the game world. The deep involvement or immersion by the learner depends on the effectiveness on the delivery of these activities.

Gilbert & Gale [7] suggested a number of methods for constructing learning activities to support given intended learning outcomes. For example, if a learner

needs to be able to recall a concept, the learning activities would include showing an example of the concept and asking the learner for the concept name, followed by feedback on the answer.

The activity should involve learning materials that are appropriate and challenging for the target learner seeking competency at a level slightly above that of the learner's current competency [9]. The majority of the game designers spend considerable time in perfecting this area of "game play" in order to make the game successful.

2.6 Reflection

Reflection is where the learner thinks about the purpose of the learning activities that have been undertaken, and decides the strategy to apply during the next activity. Reflection should take place within the game without letting the learner step out of the game world, and this can be done by offering reflection activities within the game. Garris et al [5] have stated that the reflection activity can be included within the game by providing a description, an explanation of why this activity is chosen, a discussion of the errors made by the learner, and some corrective suggestions.

2.7 Games genre

Game genre is the type or category of the game played. Genres range from "beat-em-ups", through open-world sandboxes, to strategy games, and simulation. More recently game designers have developed serious games adopted for learning purposes according to games genres..

2.8 Game mechanics

Game mechanics and game rules define the details of the game [6]. If the game genre is a Real Time Strategy (RTS), for example, then it may require game mechanics of resource management and territory control. The desired learning activities and required instructional content influence the selected game mechanics in order to design a better game that will suit a particular style of learning, a particular target learner, or a particular set of intended outcomes.

2.9 Game achievement

Game achievement is the level of learner achievement in playing these games. This achievement can be indicated by the game scores, total amount of resources or assets collected within the game, or time taken to achieve game goals. In addition, it gives the pleasure of reward to the learner, and also serves a purpose of learner assessment.

The learning activities can be modified based on the game achievement's feedback. The game achievement or score would indicate the level of learner knowledge while playing games and, if necessary, newly chosen learning activities should be changed to suit the learner level.

3. Conclusion

The serious games framework shows the major components that create an effective model for learning through the use of serious games. Every component inside this framework plays a role to ensure that learning would take place while playing the game. We propose this framework as an appropriate basis for effective serious games design for designers and teaching practitioners.

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Validation of Serious Games Attributes Using the Technology Acceptance Model

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Abstract*—The paper introduces a conceptual model for the design of serious games and uses the Technology Acceptance Model (TAM) for its validation. A specially developed game introduced international students to public transport in Southampton. After completing the game, participants completed a short questionnaire and the data was analysed using structural equation modelling (SEM). The results identified the attributes and combinations of attributes that led the learner to accept and to use the serious game for learning. These findings are relevant in helping game designers and educational practitioners design serious games for effective learning.

Keywords: Technology Acceptance Model; Serious games; framework; model; Attributes, Acceptance

I. INTRODUCTION

One of the current challenges in education is to develop improved and more effective teaching methods. Shadbolt [1] noted that in the near future, a significant proportion of education will utilise game technologies as part of the learning experience. One of the given reasons is that this approach can attract a wide range of learners to "play" and keep them engaged until they have achieved the learning objectives.

In addition, the current generation of learners has grown up in a digital environment and are surrounded by modern technologies such as computers and mobile phones. They are playing more games on computers, or on games devices, compared with previous generations. It is apparent that the delivery and organization of teaching material needs to be changed to accommodate young learners and to meet their expectations [2]. Providing these learners with suitable games could be one of the solutions for meeting these needs, together with the support of traditional teaching in the classroom.

Many companies, researchers and educationists are developing serious games for learning [3], for example, the U.S. Army has developed ALTSIM (Advanced Leadership Training Simulation), where the trainee is presented with a virtual environment of a tactical command center [3]. With the use of realistic characters and events, trainees are trained to give a correct response based on the decision made using information from the virtual environment.

However, due to unclear standards and guidelines, it is difficult to claim that these games really meet the learner's requirements or expectations. There are also numbers of games being developed for educational purposes but the games are too easy for their level or just too difficult [4]. It could be that most of the available games for learning have not been created by pedagogy experts [4].

In order to address these problems, this research will take two approaches to the consideration of serious games. First, we will define a model for serious games based on learning theory that will result in effective learning. Secondly, we will use the Technology Acceptance Model (TAM) to evaluate our model.

In this paper we define a serious game as a learning tool that incorporates game technology for the purpose of achieving learning objectives other than for pure entertainment.

II. SERIOUS GAMES FRAMEWORK

The framework that we have developed includes learning and pedagogy theory in combination with gaming requirements [5-8] and aims to establish a conceptual model that will be used by the game designer or educational practitioner when designing serious games for effective learning. The framework is illustrated in Figure 1 and is an evolution of the input-process-outcome game model discussed by Garris et al [5] and presented by Yusoff et al [9]. The individual components of the model are discussed in this section.

1) Capability

Capability refers to the cognitive, psychomotor, and possibly affective skills which the learner is to develop as a result of playing the game. These skills have been identified by, for example, Bloom [10] in the cognitive domain, Dave [11] in the psychomotor domain, and Krathwohl [12] in the affective domain.

2) Instructional content

The instructional content is the subject matter that it is intended that the learner should learn. The detail of the actual subject matter to learn, or the type of content that the learner learns, could be an exhaustive list. Gilbert & Gale [7] illustrate the classification of content into four types: facts, procedures, concepts, and principles.

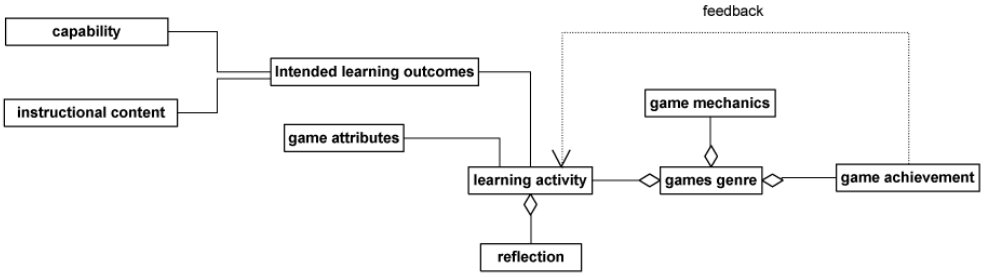

Figure 1 Conceptual Framework for Serious Games shown as a Structural Class diagram [9]

3) Intended learning outcomes

Learning outcomes are the goals to be achieved from playing the serious game. An intended learning outcome is a particular combination of capability and subject matter. For example, the learner should be able to recall the date of the battle of Hastings or should be able to analyse whether a particular bird is a raptor.

Typical examples of learning outcomes are based on taxonomies of educational objectives with learner capabilities drawn from the psychomotor, cognitive, and affective domains [7]. For example, pilots undertake rigorous training in both the classroom and in aircraft. A study has shown that by introducing a number of hours playing aviation computer games, pilots have performed better in test flights [13].

4) Serious Game attributes

Game attributes are those aspects of a game which support learning and engagement and were identified from a literature review of behaviourist, cognitive, constructivist, educationist, and neuroscience perspectives [9], as listed in Table 1.

5) Learning activity

Learning activity is the activity designed to keep the learner engaged and learning in the game world. The deep involvement or immersion by the learner depends on the effective design of these activities.

Gilbert & Gale [7] suggested a number of methods for constructing learning activities to support given intended learning outcomes. For example, if a learner needs to be able to recall a concept, the learning activities would include showing an example of the concept and asking the learner for the concept name, followed by feedback on the answer.

Activities should involve learning materials that are appropriate and challenging for the target learner seeking competency at a level slightly above that of their current competency [14]. The majority of game designers spend considerable time in perfecting this area of "game play" in order to make the game successful.

6) Reflection

Reflection is where the learner thinks about the purpose of the learning activities that have been undertaken, and decides the strategy to apply during the next activity. Reflection should take place within the game without letting the learner step out of the game world, and this can be done by offering reflection activities within the game. Garris et al [5] have stated that the reflection activity can be included within the game by providing a description, an explanation of why this activity is chosen, a discussion of the errors made by the learner, and some corrective suggestions.

7) Games genre

Game genre is the type or category of the game played. Genres range from "beat-em-ups", through open-world sandboxes, to strategy games, and simulation. More recently game designers have developed serious games adopted for learning purposes according to games genres.

8) Game mechanics

Game mechanics and game rules define the details of the game [6]. If the game genre is a Real Time Strategy (RTS), for example, then it may require game mechanics of resource management and territory control. The desired learning activities and required instructional content influence the selected game mechanics in order to design a better game that will suit a particular style of learning, a particular target learner, or a particular set of intended outcomes.

9) Game achievement

Game achievement is the level of learner achievement in playing these games. This achievement can be indicated by the game scores, total amount of resources or assets collected within the game, or time taken to achieve game goals. In addition, it gives the pleasure of reward to the learner, and also serves a purpose of learner assessment. The learning activities can be modified based on the student's achievements and progress in the game.

This paper demonstrates that the proposed conceptual framework for serious games supports the design of serious games for effective learning, and to confirm that serious games, based on the proposed framework, would be both accepted by the learner and would be useful for learning. It is believed that these issues can be answered by using the Technology Acceptance Model applied to serious games.

III. TECHNOLOGY ACCEPTANCE MODEL.

The Technology Acceptance Model (TAM) [15] has been used in information technology to predict the user acceptance of new technology, and has been applied to

applications such as email [16], multimedia learning [17], World Wide Web [18, 19] and e-courseware [20]. We employed Venkatesh's revision of the TAM model [21] in this paper. There is no research known to us that considers the acceptance of serious games from the learner's viewpoint by using the Technology Acceptance Model.

We wish to demonstrate that the proposed framework is effective for learning, and to confirm that serious games, based on the proposed framework, would be both accepted by the learner and would be useful for learning. We believe these issues can be answered by using the Technology Acceptance Model applied to serious games.

The highlighted serious games attributes in Table 1 identifies four of the attributes (transfer of learnt skills, learner control, reward, and situated learning) selected as the most important in their association with the TAM model. Figure 2 shows the resulting TAM model in the SEM format.

TABLE I THE SELECTED SERIOUS GAMES ATTRIBUTES WITH THEIR MOST IMPORTANT ASSOCIATION WITH TECHNOLOGY ACCEPTANCE MODEL

Attributes for Serious Games	**Values for Learning and Education**	**Association with TAM from the learner's viewpoint**
Incremental learning	Learning material is delivered incrementally. Additional new knowledge is delivered and not done all at once. It will have a proper start and end section. Learner feels and learns in a natural way and less complex.	Incremental learning is seen as a normal way of learning. This attribute would not be a factor for the learner to use or reject this technology.
Linearity	Learning will be in sequence. This will suit the sequential learner. However, due to the games flexibility, active learner can skip chapters.	Linear also appears to be a natural flow of learning and there is no strong connection for urging the user to choose a serious game for learning.
Attention span	This concerns with the cognitive processing and short-term memory loads placed upon the learner by the game. These loads need to be carefully calibrated to the target learner Not to be overwhelmed and too long in the learning process.	There is probably a weak link between learner needs and playing the serious games.
Scaffolding	Support and help during learning within the games.	Learner may assume that every game always come with help, support tips or hints in the form of a game manual or online help.
Transfer of learnt skills	Learnt knowledge to apply to other skills in the next level.	Yes, learner would see this as a very useful thing because the knowledge acquired from games can be applied to different areas or other domains.
Interaction	Higher engagement, higher learning.	Learner may think interaction is common in learning since every basic learning transaction should have an interaction (two ways of communication).
Learner control	Active learning, self study and self exploration based on individual pace and experience.	Yes, learner may view this as useful because it gives a degree of freedom for the learner to learn at his own pace and likes the idea of all learning happening under his control.
Practice and drill	Repeating for harder task, better knowledge retention and can have plenty of game activities for drills.	Learner may think that this is common way of learning.
Intermittent feedback	Learner to reflect on what has been achieved so far and motivated for higher score (higher learning). Also using just in time feedback for learning.	Learner thinks that every learning always has feedbacks and this is normal.
Reward	Encourage learner and keep motivated. Negative reward as punishment within the game may also contribute to learning.	Yes, learner may feel this is important to keep him motivated and to keep on going. It would elevate his sense of confidence and self assurance in learning.
Situated and authentic learning	Learning where the learner can relate what is being learnt within the game to the outside world.	Yes, learner feels this is useful and can relate to what is being learnt would make the learning process to become easier.
Accommodating the learner's styles	To suit and to reach out to different learner styles.	This may be a strong factor for learner to use this technology but it is quite difficult to test. The result could be biased if the system happens not to be suited to his learning style but applicable to another group.

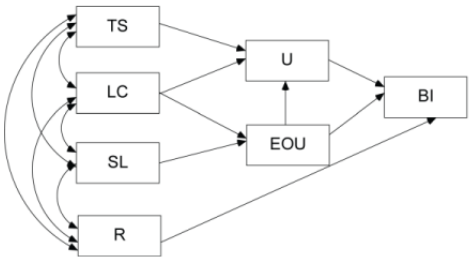

Figure 2 Proposed TAM model for Serious Games

Transfer of Learnt Skills (TS) means applying previously acquired skills to other learning. This can be done within the game by continuing to the next level. Whatever skills have been acquired can then be used in the next level to acquire new skills. The previous knowledge should be revisited and new knowledge should be gradually added to what had been previously learned. New knowledge should be constructed from previous experience.

Learner Control (LC) means that learners like to explore on their own and pick up skills (experience) within the game at their own pace.

Situated and authentic learning (SL) places the learner in an authentic environment, where they would be able to develop mental models of their experience and relate it to real life. Use of a familiar background or common examples in a game's content, and relevant to the learner's experience, should be perceived as easy to use when learning with serious games, because the learner is learning within a familiar territory.

Reward (R) comprises incentives in the game which are used to encourage the learner and to keep their motivation high.

Ease of Use (EOU) refers to a person's perception that using a serious game for learning will require minimal effort. It has been shown that users will interact with the technology if they feel that little effort is needed for using this technology in order to accomplish their tasks.

Usefulness (U) refers to the user's perception that the use of the technology could enhance their performance. The input to Usefulness also comes from ease of use, because the user would be inclined to choose tools that require minimal effort in order to solve the problem. Both perceived usefulness and ease of use are important factors that influence the user to actually use or select this technology (behavioral intention to use).

Behavioral Intention to use (BI) is the intention to perform actual behavior by the learner influenced or caused by both preceding factors of Usefulness and Ease of Use. Learners would intend to use serious games for learning in the future.

IV. THE STUDY METHODOLGY

The study involved three steps; (i) the development of a short serious game tailored to the participants that would be used in the study, (ii) the development and delivery of a questionnaire and (iii) the subsequent analysis.

A. The "Unilink" serious game

It is recognised that many existing or off-the-shelf games could be used to undertake a study into serious games. However, we would not be confident that they would be completely compliant with the framework that we have developed. For this reason we developed the "Unilink" Bus serious game in order to fully meet the requirement of our serious games framework.

The game was developed to permit international students who were unfamiliar with the University of Southampton's bus system and to help them maximise the benefit of this method of transport

The key features of the developed game are to:.

- Recognise the location of the final destination.
- Identify the bus routes.
- Identify the bus number.
- Identify the bus stops and Interchange for bus transfer.
- Recognize where to get off the bus.

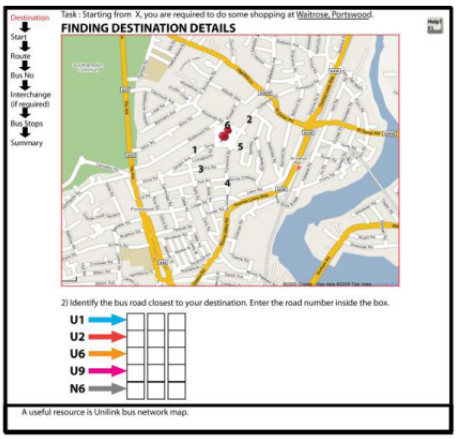

Figure 3 A screen shot from Unilink bus serious game

After the Unilink bus serious game had been initially produced, it was submitted for expert review. There were five panellists that evaluated this game ranging from game interface, gamer interaction, aesthetic design, game functionality and game progression. Then, after the game rectification, the study protocol was submitted for ethical review.

A pilot test was done prior to the actual game survey in order to reveal and correct any problems raised before the actual run.

B. Questionaires

A questionnaire was developed to discover how the participants rated the Transfer of Learnt skills (TS), Learner Control (LC), Situated Learning (SL), Reward (R), Usefulness (U), Ease of Use (EOU) and Behavioral Intention to use (BI) with regard to the Unilink bus serious game. Each of these seven variables were assessed by four individual questions, where each response used a 5-point Likert-type scale, with "fully disagree" at the lowest and "fully agree" at the highest scale. The questions were constructed as follows

- *Transfer of Learnt skills (TS)* is where participants were asked whether they can use and apply the skill learned within the game to the real world (e.g., "I feel that I can use my new skills in identifying Unilink bus routes").
- *Learner Control (LC)* is what the participants feel inside the game, whether they felt in total control of the game activity or allowed to manipulate the game activity (e.g., "This game allows me to search for the answers at my own speed").
- *Situated Learning (SL)* involves the provision of a gaming environment or world where the participants can relate their learning to their needs and interests in the outside world (e.g., "I can learn better if I can relate the experiences within a serious game to my experiences in real life").
- *Reward (R)* is the arrangement in the Unilink bus serious game to encourage the participants and to keep their motivation high (e.g., "I feel encouraged to learn more about the Unilink Bus Game when it displays congratulatory messages").
- *Usefulness (U)* refers to the participants' belief that by using this game, it could help them better in planning to ride the Unilink bus (e.g., "This Unilink Bus Game will help me use the Unilink bus service better").
- *Ease of Use (EOU)* is where participants feel that a minimal effort is required to learn the Unilink Bus serious game (e.g., "I find it easy to use the Unilink Bus Game because I am familiar with the operation of buttons and mouse").
- *Behavioral Intention to use (BI)* is the participants intention to use the Unilink Bus serious game (e.g., "If I am given a serious game of this type, I intend to use it") to help them to perform the actual task.

C. Survey Process

Prior to undertaking the survey a brief presentation was given to the participants informing them about the underlying research and the serious games. Then, students were invited to participate voluntarily with the Unilink bus serious game, which took 20 minutes to complete, followed by a short questionnaire. The survey was undertaken at University of Southampton between June until August 2009.

D. Participants

The game participants were mostly new students at the University of Southampton attending the pre-sessional courses in June 2009. These courses were designed to improve English skills for international students enrolled as undergraduates and postgraduates as part of the university entry requirements.

A total of 56 out of 200 possible participants completed both the game and the questionnaires. The group consisted of three (5.4%) UK students and 53 (94.6%) international students, of which 23 were (41.1%) female and 33 were (58.9%) male.

E. Statistical Analysis

The TAM serious games model in Figure 2 was analyzed with AMOS [22] by testing its relationship using Structural Equation Modeling (SEM). The detailed analysis identified a number of statistically significant paths within the model; as shown in Figure 4.

- R and TS were strongly inter correlated
- LC and SL were strongly inter correlated
- TS to U
- LC to U
- SL to EOU
- EOU to U to BI

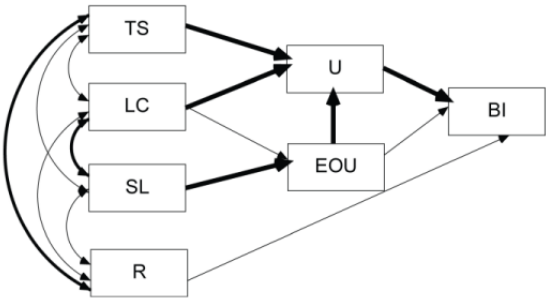

Figure 4: The TAM showing the statistically significant paths.

V. DISCUSSION

The SEM analysis allowed the identification of attributes or combinations of attributes that lead a learner to use this type of game for learning.

A. R and TS are strongly inter correlated

Figure 4 shows that Reward and Transfer of Learnt Skills have a strong correlation link. Transfer of skill seemed to be rewarding, and reward supported Transfer of skills. The SEM results showed that reward was not significantly linked to Behavioral Intention, and so the probable path for the effects of Reward (R) upon Behavioral Intention (BI) was actually "working through" Transfer of skills (TS).

B. LC and SL are strongly intercorrelated

The result shows that learner control and situated learning are strongly correlated. This suggests that learner control supports situated learning, and situated learning is associated with perceived learner control.

C. TS to U

A high rating of Transfer of Learnt Skills (TS) leads to high perceived Usefulness (U). This result suggests learners find this serious game is useful partially because they could apply previous acquired skills to their learning and could add new knowledge to what had been most recently learned.

D. LC to U

A high rating of Learner Control (LC) leads to high perceived Usefulness (U). This result suggests learners find the game useful partially because it allowed self exploration and active learning inside the game.

E. SL to EOU

A high rating of Situated Learning (SL) leads to a high perceived Ease of Use (EOU). This suggests that learners felt that the mental models of their experience lead to minimal effort in the game. The SEM results showed that learner control was not significantly linked to ease of use, contrary to the expectation of the TAM model.

F. EOU to U to BI

The result shows that Learner intention to use the game (BI) is not significantly linked to the game's ease of use (EOU). Instead, the result shows that EOU is significantly linked to Usefulness (U), and that it is Usefulness which is significantly linked to Behavioral intention to Use (BI.

The significant paths to Usefulness (U) were from Transfer of Skills (TS), Learner Control (LC), and Ease of Use (EOU). Usefulness (U) was the only significant link to Behavioral intention to Use (BI), strongly suggesting that learners must perceive that the serious game is useful before they would want or intent to use it.

Finally, all of the TAM components and all of the identified serious game attributes showed significant linkages and inter-correlations, and were all relevant to Behavioral intention to Use.

These findings suggest that serious game design should encompass all these attributes, while development should carefully consider the exact links between game attributes and the resulting Behavioral intention to use.

VI. CONCLUSIONS

In this paper we have demonstrated the use of the Technology Acceptance Model to validate a number of attributes used in the design and development of a serious game. Following identification of the attributes these were mapped on to a modified form of the TAM. In order to evaluate the model a serious game was developed, and together with a supporting questionnaire was administered to over 50 participants.

An analysis of the data using SEM allows us to draw a number of interim conclusions.

Firstly the approach we have proposed is effective and lightweight and had resulted in an acceptable analysis of the TAM for a serious game application.

The results allow us to predict the learner intention to use the serious game. The combination of Transfer of Learnt Skills (TS) to Usefulness (U), Situated Learning (SL) to Ease of Use (EOU), Learner Control (LC) to Usefulness (U) and Ease of Use (EOU) to Usefulness (U) to for Behavioral Intention to use (BI) provide an indication of how to design successful and effective serious games that would ensure learners use them for learning. Educational practitioners also would find this helpful in evaluating games for learning purposes. The results both identified the critical predictors of Behavioral intention to use and validated the serious games framework.

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