

1 Introduction

Computer game-based learning is emerging as a hot topic in education. In recent years, there has been increasing interest, both in the potential of computer games as learning and teaching tools, and in research into their use.

The perceived change in learning needs of the 'Games Generation' (Prensky, 2001) or 'Net Generation' (Oblinger, 2004) coupled with the ongoing growth in use and acceptability of a range of communications technology has precipitated a growing interest in the potential of games and computer games for learning. In a recent survey, 36% of primary school teachers and 27% of secondary school teachers said that they had used games to teach (Sandford et al, 2006).

Of course, using games to teach is not a new idea, with organisations such as the Society for the Advancement of Games and Simulations in Education and Training (SAGSET) dating back more than 35 years (van Ments, 1995). However, the ubiquity of online collaborative communities and use of large-scale virtual worlds, coupled with the ever-growing power of computing technology, have increased the potential of computer-based, immersive, collaborative learning in a way simply not possible before.

The study of educational games as a research discipline is also fast growing in size and acceptability. The 'serious games' movement aims to undertake research in the use of games in education, and a serious games research institute has recently been established at Coventry University. Even so, it has been identified that there is a need for more studies that quantify how games are being used and what is being learned from them (de Freitas, 2006).

Advocates of computer game-based learning argue that computer games have the potential to transform the way in which students learn, and motivate and engage a new generation of learners in a way that traditional education does not (e.g. Prensky, 2001; Gee, 2003). However, a number of negative issues associated with the use of games for learning have also been raised. These include the fact that the use of games can be seen as encouraging sedentary behaviour, may be culturally discriminatory and may lead to aggressive or antisocial behaviours (Sandford & Williamson, 2005); games can also exhibit

gender biases and be impractical in a classroom situation (Becta, 2001a), or may exhibit an incongruity between game outcomes, curriculum and assessment (Sandford et al, 2006).

This thesis examines the evidence for and against the use of games in learning and teaching, and evaluates the potential of collaborative computer game-based learning, looking specifically at its use with students in Higher Education.

1.1 Overview of the research

The use of game-based learning in Higher Education is less common and less well researched than is its use in schools, and often assumptions from the literature on game-based learning with children are used wholesale when considering learners in Higher Education, particularly as regards motivation and the learner experience.

For example, an assumption is commonly made in the literature regarding game-based learning that games are intrinsically motivational for most, if not all, people, and that if this motivation for games can be exploited for education learning will happen almost without the individual realising it. Oblinger (2004) says:

Games also offer advantages in terms of motivation. Oftentimes students are motivated to learn material (e.g., mythology or math) when it is required for successful game play – that same material might otherwise be considered tedious. (Oblinger, p 13.)

Prensky (2001) is a strong proponent of incidental learning with game play:

We would build a fantastic game – one the target market couldn't resist starting or put down once they began. The learning would happen almost without the learners' realising it, in pursuit of beating the game. We would give them "stealth learning". (Prensky, p 24.)

While these suppositions are most frequently employed in the field of child learning, clearly, these ideas cannot be applied to all learners in Higher Education (if, indeed, they can be applied to children) and the belief that learning can be undertaken as an incidental additional effect of game play is wholly inapplicable to adult learners, for whom an understanding of and engagement in the learning process is fundamental (Knowles, 1998).

This research considers the applicability of learning with games, as individual learners progress from learning as children to become adult learners, and the implications this has in terms of motivation for learning and meta-cognition of the learning process. This study investigates the potential of educational computer gaming in Higher Education for increasing motivation, engagement and collaborative learning.

While a number of empirical studies exist that discuss learning with games in Higher Education, these are often descriptions of use (e.g. Becker, 2001; Baker et al, 2003), or the game system design (e.g. Dziabenko et al, 2003) rather than attempts to assess the ways in which the games in question have – or have not – facilitated the process of learning.

At the forefront of this thesis is cognisance of the importance of critically examining the effects on learning of any new educational method rather than simply believing the hype. This work therefore highlights links between theories of learning and the characteristics of games, and undertakes initial investigative work with older learners to consider the acceptability of game-based learning in Higher Education. It considers the types of learning that could be best facilitated by games and the most appropriate genres of game to facilitate these types of learning. A framework for describing the characteristics of game-based activities is presented, and good practice in educational design that can be used to inform the development process of educational computer games is discussed.

Evaluating the educational impact of games is at the core of this research, which particularly focused on understanding and measuring engagement with games. An engagement questionnaire was developed and tested, and used to evaluate differences between the games used in this research.

In addition to examining the theoretical potential of games for learning, this work also applies theory to the design and development of two collaborative online learning applications, each exhibiting certain characteristics of games; these were called the Time Capsule and the Pharaoh's Tomb. The use of these applications in a real-life teaching situation was evaluated and, using a comparative experimental design, their effects upon learning were compared.

In this way, this study aims to combine theoretical analysis and investigative and experimental research to provide an insight into the potential for learning through games in post-school education, and thereby to present a unique insight into the characteristics of games that can lead to more effective learning experiences.

1.2 Theoretical influences

The research described in this thesis is centred on the design and evaluation of computer game-based learning. The theoretical basis for this work is influenced by, and draws upon, three distinct research fields: learning in Higher Education, theories of games for entertainment, and human–computer interaction. In particular, the work is informed by the overlapping areas of game-based learning, design of effective online learning, and computer game design (see Figure 1-1 below).

Investigation of a range of learning theories that pertain to students in Higher Education, discussed in the first section of Chapter 2, provides a pedagogic rationale for the use of games for learning, highlighting links between constructivist theories (including experiential (Kolb, 1984), collaborative (e.g. Vygotsky, 1978; Lave & Wenger, 1991) and problem-based learning (e.g. Boud & Feletti, 1991; Savery & Duffy, 1995) and games used as learning environments.

A study of literature on games, also described in Chapter 2 (see Section 2.2), considers how they can be defined, their functions in society, and motivations for individuals to play games, both for leisure and learning. This has highlighted issues such as how to describe different types of game-based learning, and which games might be most appropriate for learning and teaching. The identification of characteristics of games and other activities that lead to increased motivation and engagement is also discussed (Malone, 1980a; Csikszentmihalyi, 1992).

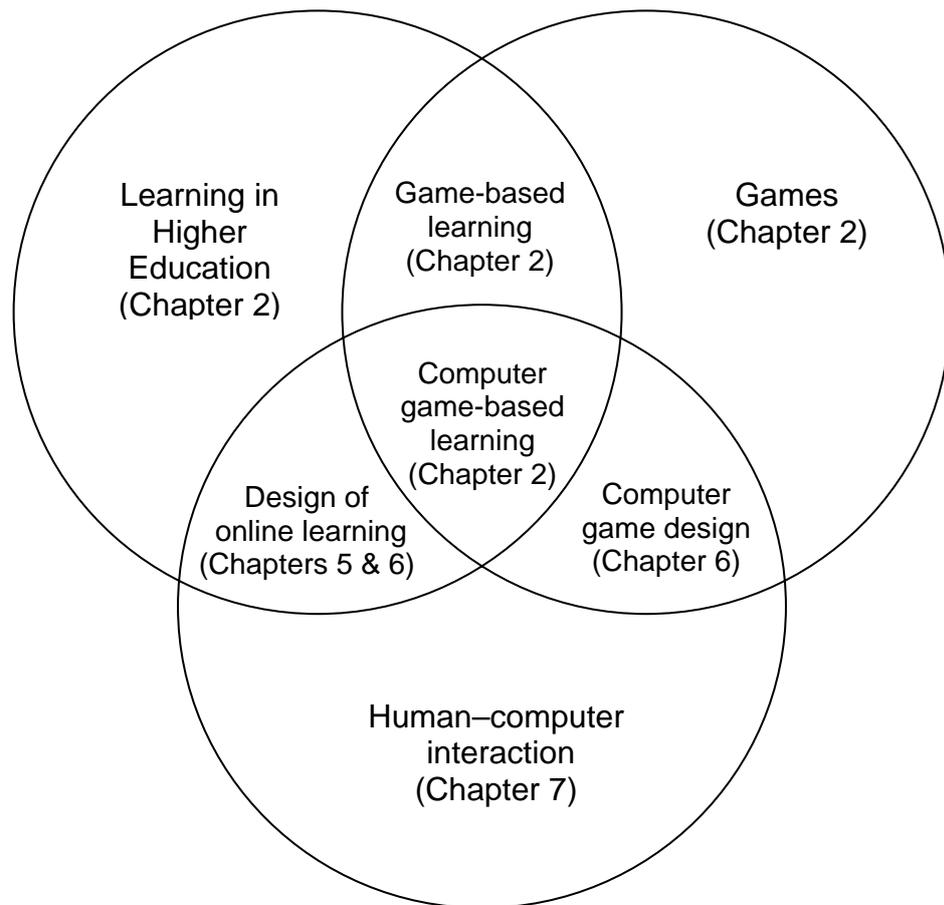


Figure 1-1: This research draws together the areas of games, learning in Higher Education and human-computer interaction

An understanding of research undertaken in the field of (pre-computer) game-based learning is used to underpin theories on computer game-based learning throughout the thesis (see, for example, Sections 2.2.1 and 6.3.2). It provides a further empirical rationale for the potential of games as an effective educational tool and inputs into the discussion on game definitions (e.g. Ellington et al, 1982), as well as highlighting specific insights gained from long experience, such as the importance of debriefing and the game setting within a learning context (Thiagarajan, 1993b).

Theories relating to the design of online learning environments, based around the constructivist perspective (e.g. Grabinger et al, 1997) and use of multiple media for learning (e.g. Mayer, 2001; Paivio, 1991), are discussed in Chapter 5, Section 5.1. These have provided the foundation for the development of

guidelines for the design of online games for learning, which were applied to the two game-based applications created. In Chapter 6 (Sub-section 6.2.1) a discussion on collaborative online learning (Mason, 1994; McConnell, 2000) further supports the design of these learning applications.

Study of the field of human–computer interaction raised issues in the research such as how good practice in interface design and usability could be used to design educational interfaces to meet the varying needs of a wide range of users, with and without previous experience of game playing. In addition, a number of usability evaluation techniques were used to highlight user issues with the applications produced; these are discussed throughout Chapter 7.

Drawing on the field of computer game design (e.g. Crawford, 1984; Oxland, 2004) helped to inform the design of the computer-based educational games, which, while aiming to meet specific learning outcomes, also aimed to be engaging, enjoyable and accepted by the audience.

Finally, at the intersection of these disciplines, and influenced by all of them, is the emerging field of computer game-based learning, in which this research is situated. Another overarching theme that emerges throughout the work, and is related to each of the disciplines described above, is that of collaboration; the growing use and the potential of collaborative games to support and facilitate group learning, and applying lessons learned from the design of collaborative systems and interfaces.

1.2.1 Research questions

The research described in this thesis examines the rationale for accepting computer game-based learning as a valid tool for teaching in Higher Education, and, if games are considered acceptable, considers the most appropriate ways in which they can be designed, developed and integrated into the curriculum.

The overarching question, which is at the core of this research, is:

How can computer games be used most effectively to support learning and teaching in Higher Education?

The field of computer-based learning in Higher Education is of particular interest because there is a rapidly growing interest and body of research in computer

game-based learning, the majority of which has been undertaken with school-age children. There is a clear need for ongoing empirical research to investigate the validity of games in Higher Education, where the rationale of increased motivation that is applied to children learning with games can not be presumed to hold, less so as learners in Higher Education move from undergraduate to postgraduate levels.

The growing use of blended and online distance learning in Higher Education has the advantage of increasing access to education for those who might otherwise not be able to attend; however, there are associated disadvantages of isolation and lack of peer interaction. Collaborative games provide the opportunity to facilitate this interaction in a purposeful and engaging manner, but there are issues of acceptability of this medium to adult students, and best-practice in design, development and implementation.

This research focuses on learners in Higher Education, who may be assumed to exhibit greater independence and self-direction, are likely to have a range of life and work pressures and commitments, come from a variety of backgrounds and possess a range of experiences, with a need to learn in context, understand why something is important to learn, and engage with understanding the process of learning itself (Knowles, 1998). It is, of course, debatable whether the attitudes to learning of students studying at Foundation or First Year undergraduate level are fundamentally different from students at the end of their school careers; and individual students will naturally mature at different rates and approach learning in different ways throughout their academic lives. What is important, however, is to recognise that the motivations and learning aspirations of adult learners as they progress through university are likely to be increasingly different from those of children.

The use of games in Higher Education is the focus of this research for three reasons. First, it is hypothesised that university students, particularly older learners, are much less likely than children to find games for learning acceptable or intrinsically motivating; second, lifelong learning and widening participation is high on the British Higher Education agenda (HEFCE, 2006), and one of the fastest growing segments of the student population is mature

students returning to education (DfES, 2007); third, Higher Education is the area of mainstream education in which the least research has been carried out in relation to computer game-based learning.

In order to consider how computer games might be used most effectively to support learning and teaching in Higher Education, the overarching question was broken down into four research questions:

1. Is there a rationale for using computer game-based learning in Higher Education?
2. How best can computer games be designed to be usable and enhance learning?
3. How can the educational effectiveness of computer game-based learning be measured?
4. How do differences in game design affect the learning experience?

Together, these questions aim to answer the primary question, by first providing a rationale and a breakdown of the types of computer game that might be appropriate when applied to learning (Question 1), investigating good practice in the design of game-based learning (Question 2), and providing empirical evidence of the characteristics of game design that influence educational effectiveness (Question 3 and Question 4). Each of these questions forms a specific area of research in this thesis. The following section examines each question in turn and describes the research methods employed to investigate that question.

1.2.2 Research activities

To investigate the research questions presented above, this study uses both qualitative and quantitative data collection and analysis methods at various stages of the research. A mixed-methods approach is adopted because the research aims to combine the in-depth, detailed analysis of the qualitative approach, with the larger-scale generalisability of the quantitative approach, to provide a rich picture of the nature of the subject under study.

The philosophical stance of this work and detailed rationale for the methods employed is discussed in Chapter 3. The methods used are described in more detail in the following paragraphs and the relationship between the research

questions, areas of work and chapters of this thesis are represented diagrammatically in Figure 1-2 below.

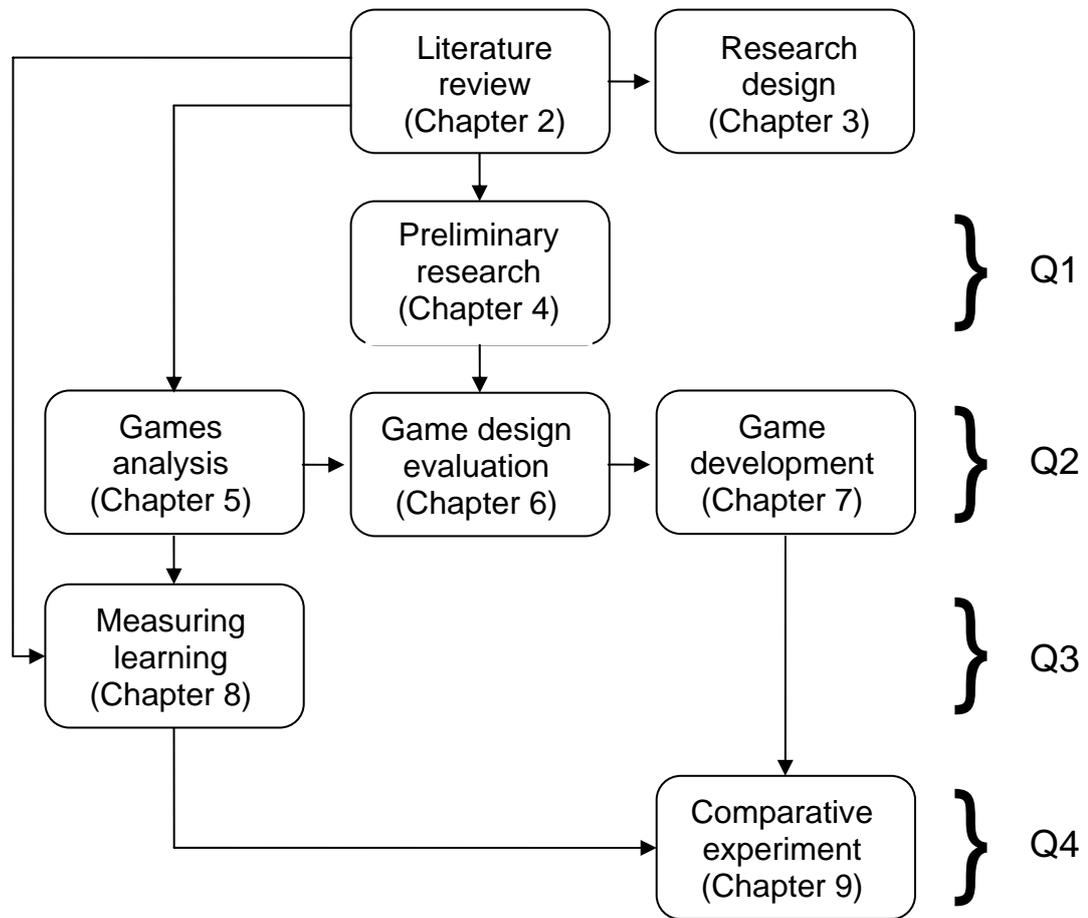


Figure 1-2: The areas of work undertaken in this thesis, the research questions they address, and the chapters in which they are presented

Initially, a literature review was undertaken in the areas of study discussed in Section 1.2; this fed into and informed all subsequent areas of work. In addition, a review of research methods in the field of educational research was undertaken; this underpins the design of the research throughout the study.

Each of the research questions is now addressed in turn, and the research undertaken in an attempt to address the question is described.

Q1: Is there a rationale for using computer game-based learning in Higher Education?

In order to answer this first research question and consider the reasons why computer game-based learning might – or might not – be an appropriate

learning and teaching method in Higher Education, two separate pieces of research were carried out.

A small preliminary study, based on the phenomenographic method, consisting of 12 in-depth interviews, was carried out as an initial exploration of issues highlighted by individuals regarding game playing, for both leisure and study. These interviews examined the perceived characteristics of games, individuals' motivations for playing games, and attitudes towards game-based learning.

Data elicited from these interviews, on motivations for game playing, and attitudes towards game-based learning, were used to create a larger-scale survey, which was used with 200 students of computing. This survey was used to investigate the extent to which the attitudes discovered in the interviews existed in a larger population.

This initial stage of research provided a rationale for further study into the area of game-based learning with students in Higher Education, and provided insights into potential motivational and demotivational factors for older learners, which influenced the design of the experimental games developed.

Q2: How best can computer games be designed to be usable and enhance learning?

In order to address this second research question, and determine best practice for the design and development of educational computer games, a review of existing guidelines was first undertaken, examining previous work in the fields of usability, educational multimedia design and game design.

As well as relying on existing work, an original analysis was carried out of 16 online games, examining their potential educational values, and features of the interface and design that contributed to an engaging and usable game.

These two pieces of work together led to the development of two sets of guidelines for the design of educational computer games, one focusing on the pedagogic design to enhance learning and engagement and the second highlighting points relating to interface design and usability.

These guidelines were then applied to the design and iterative development of two online collaborative educational applications, intended to teach basic group communication and team-work skills: the Time Capsule, a collaborative activity, and the Pharaoh's Tomb, an adventure game.

In the Time Capsule, students have to negotiate and select, as a team, a number of items to be included in a time capsule, with constraints on budget and total number of items. Each team member takes on a character persona with particular preferences and personal goals, and it is only through discussion and collaboration that the group can achieve the overall goal. The Time Capsule was based on an established activity design for teaching these types of group skills and was developed first as a paper-based activity before being translated to an online environment.

The Pharaoh's Tomb is an adventure game in which the team navigate through a virtual tomb, and interact with objects in order to solve problems and achieve the goal of the game. Although both activities have the same learning outcomes, the Pharaoh's Tomb is more 'game-like' than the Time Capsule, in terms of scoring, competition, and provision of an immersive environment. The latter part of this study aimed to investigate whether these differences in the game design led to differences in the learning experience.

Q3: How can the educational effectiveness of computer game-based learning be measured?

This third research question considers ways of measuring the educational effectiveness of game-based activities with a view to comparing different activities. Ways of measuring learning are considered and, for reasons discussed in more detail later (see Chapter 8), it was decided to focus primarily on engagement as an indicator of educational effectiveness.

A self-perception Likert-scale questionnaire was developed and tested in order to be able to quantify levels of engagement students had experienced after undertaking a learning experience and, specifically, to be able to compare levels of engagement between students who had taken part in two different activities. A second questionnaire was created to measure perceived learning

after undertaking an educational activity. Both of these measurement questionnaires were used in the final experiment to investigate the differences in learning effectiveness between the two activities produced.

In addition, the learning potential of both activities was investigated to provide evidence that they do indeed meet the intended learning outcomes. This was done in two ways: first, the paper-based version of the Time Capsule was tested against the online version to try to ensure that it was at least as effective educationally as a conventional way of teaching these skills; second, an analysis was undertaken of the transcripts from the iterative development to provide indications of appropriate learning.

Q4: How do differences in game design affect the learning experience?

To address this final research question, an experiment was undertaken using the activities with a total of 112 students, each using one of the two activities developed – the Time Capsule or the Pharaoh’s Tomb – and completing the questionnaires developed to measure engagement with the activity and self-reported learning.

Two pilot studies were undertaken first, to test the robustness of the two pieces of software and the experimental method in a real-life teaching situation. This was followed by a final large-scale study with 78 participants, in which the differences in engagement and self-reported learning between the two activities were investigated.

In attempting to provide answers for these four research questions, this thesis hopes to provide a range of insights, as well as practical tools, to support the design, development and evaluation of computer game-based learning in Higher Education.

1.3 Contribution to knowledge

This thesis provides significant original contributions to knowledge in two areas. First, it offers insights into the application of game-based learning to Higher Education, providing a pedagogic rationale for its use in certain teaching and

learning situations and an understanding of the characteristics that facilitate motivation and engagement; as well as providing evidence of the effectiveness of different game types to engender engagement. Second, this research has produced practical tools, in terms of criteria, to support the design and development of engaging and usable educational games, as well as a rigorously developed and tested questionnaire to measure post-experiential engagement.

More specifically, this thesis provides insights into the nature of adult motivation to play games, both for recreation and for learning, and provides evidence that there is no link between a motivation to play games for recreation and games for learning. This work also highlights that games are not intrinsically motivating to all students in Higher Education (as is often cited as a rationale for their use) but that there are other, far more compelling, educational reasons for their adoption and use, where appropriate.

The research highlights the importance of collaborative gaming to support collaborative learning processes in the online environment and has shown that educational games can be equally engaging without competition or immersion in virtual worlds.

While providing a rationale for the use of collaborative game-based learning in Higher Education, this thesis also acknowledges that game-based learning is not the educational panacea that it is sometimes considered to be, and that its use must be carefully designed and integrated into the curriculum to be effective.

This thesis also provides a model for the components of engagement and a robust questionnaire for measuring them, and two sets of criteria for the design of effective educational computer games, one focusing on educational design issues and one highlighting interface design considerations.

In all, this thesis hopes to contribute to the growing body of research on collaborative game-based learning by providing an academic foundation for continued investigation in this area as well as an empirical study of the use of game-based learning in a teaching situation.

1.4 Structure of the thesis

This thesis contains ten chapters in total. This section provides an overview of the contents of each chapter and how it fits into the overall research activity as described in the previous section. The relationship between research activity and thesis chapters can also be seen in Figure 1-2.

This initial chapter is the **Introduction** to the thesis, which provides an overview of the influences on the research, describes the research questions explored and the research activities undertaken.

Chapter 2 provides a **Review of literature on learning and games**, which describes the educational theories and perspectives that have influenced this work, drawing on work in the fields of learning and teaching in Higher Education, online learning and computer game-based learning. This chapter provides the background to the thesis and sets the scene in terms of the starting point and influences for the work. It defines the terminology used throughout the thesis, considers what constitutes a game for the purposes of this research, defines genres of computer game, and considers the nature of gaming and engagement, evidence of learning with games and potential weaknesses of game-based learning.

Chapter 3 describes the **Research design** that underpins this thesis, and provides an overview of the range of research methodologies used in this research and how their choice was influenced by the epistemological standpoint of the researcher. The chapter discusses the rationale for the range of methods and techniques employed and the ethical considerations arising from the research design.

Chapter 4 describes the **Background research** that was undertaken first, and reports on the two preliminary studies, exploring perceptions of games, and the nature of game play and motivation for adults. The two studies are described: in-depth interviews and a questionnaire. The results of these are presented and their implications for the design of educational computer games in Higher Education are discussed.

Chapter 5, **Developing design criteria**, first discusses the review that was undertaken of existing guidelines relating to game design, educational online multimedia and usability. The chapter goes on to describe an analysis of a number of existing online games, examining their potential for learning, and highlighting interface and design features that could be used to inform the design of computer game-based learning activities. Two sets of criteria for the design of computer games for learning are presented, one focusing on educational design and one on interface design.

The design guidelines developed are implemented in Chapter 6, **Designing computer game-based learning**, which considers the types of learning that games might be appropriate to teach, and the types of games that may be best suited to this purpose and describes the design process for the two game-based applications developed, the Time Capsule and the Pharaoh's Tomb. This chapter provides an overview of the learning outcomes and discusses the reasons for applying games to this type of learning; it also presents a rationale for the game genre selected. In the final section of this chapter, the design of the applications are evaluated against the learning design criteria developed in Chapter 5.

The process of **Developing computer game-based learning** is described in Chapter 7, which continues from the design process by describing the development methods used to create both of the game-based applications, discussing the iterative methodology and evaluation techniques used. The results from each stage of the evaluations are described and changes to the design of the applications are illustrated. In the final section of this chapter, the final applications are evaluated against the interface design criteria developed in Chapter 5.

Chapter 8, **Evaluating the educational effectiveness of games**, is concerned with exploring ways in which learning from an activity could be measured, and in particular the relationship between learning and engagement. The process of development and testing of a questionnaire to measure engagement with an experience is described, as well as a questionnaire for measuring self-reported learning. In the second half of this chapter, evidence is provided for learning

from both of the online game-based activities, through comparison with traditional paper-based activities and analysis of student transcripts.

The final comparative studies undertaken are described in Chapter 9, **Comparative study**. This chapter describes the three experimental studies (including two pilots) that were undertaken with students using the two game-based learning activities, to try to determine if there was any difference in engagement or perceived learning between students who had used the different applications. The method and results are also described.

Finally, Chapter 10 provides the **Conclusions** of the thesis by evaluating and discussing the findings of the previous chapters, particularly considering the implications for use of computer games in Higher Education. This chapter also provides a reflective critique of the research methodology employed, summarises the contribution to knowledge arising from this work, and considers future directions for this research.

In its entirety, this thesis presents an overview of the field of computer game-based learning and its related disciplines, and describes a range of research activities undertaken with the aim of answering the four specific research questions described in Sub-sections 1.2.1 and 1.2.2 above. The final analysis attempts to answer these questions and address the overarching research question to gain a far greater understanding of how computer games can be used most effectively to support teaching and learning in Higher Education.