An investigation into the potential of collaborative computer game-based learning in Higher Education

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Advocates of game-based learning argue that computer games have the potential to transform university education, motivating and engaging a new generation of learners in a way that traditional education does not. The research described in this thesis, grounded in the fields of education, human-computer interaction and game design, questions this assumption and considers the case for computer game-based learning in Higher Education.

Initial research found that positive motivation for games-based learning is by no means universal in adults, and that a propensity to play games recreationally does not imply an enthusiasm to use games for learning. However, even reluctant gamers were willing to try game-based learning if it was perceived to be an efficient way to learn.

Criteria were developed for the design of effective educational games, based around theories of constructivist learning. These informed the development of two collaborative game-based activities with identical learning outcomes: an adventure game and an online version of a traditional teambuilding exercise.

Questionnaires were developed to measure self-reported learning and engagement and 112 students participated in an experiment to compare educational effectiveness between two groups, one using the adventure game and the other the teambuilding activity. No significant difference was found between the two conditions, with the exception that those students who used the teambuilding game had a significantly greater perception of control than those who used the adventure game.

This study challenges the assumption that games will revolutionise education because they lead to increased motivation and engagement. Instead, it argues that there is a potential for increased engagement through educational games, but this is because they embody the principles of interactive, collaborative and experiential learning.

Overall, this research offers an insight of the nature of adult game playing, practical guidance for the development of educational games, a validated tool for measuring post-experiential engagement, a critical analysis of usability testing techniques for multi-user games, and a genuine rationale for the use of game-based learning.

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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).

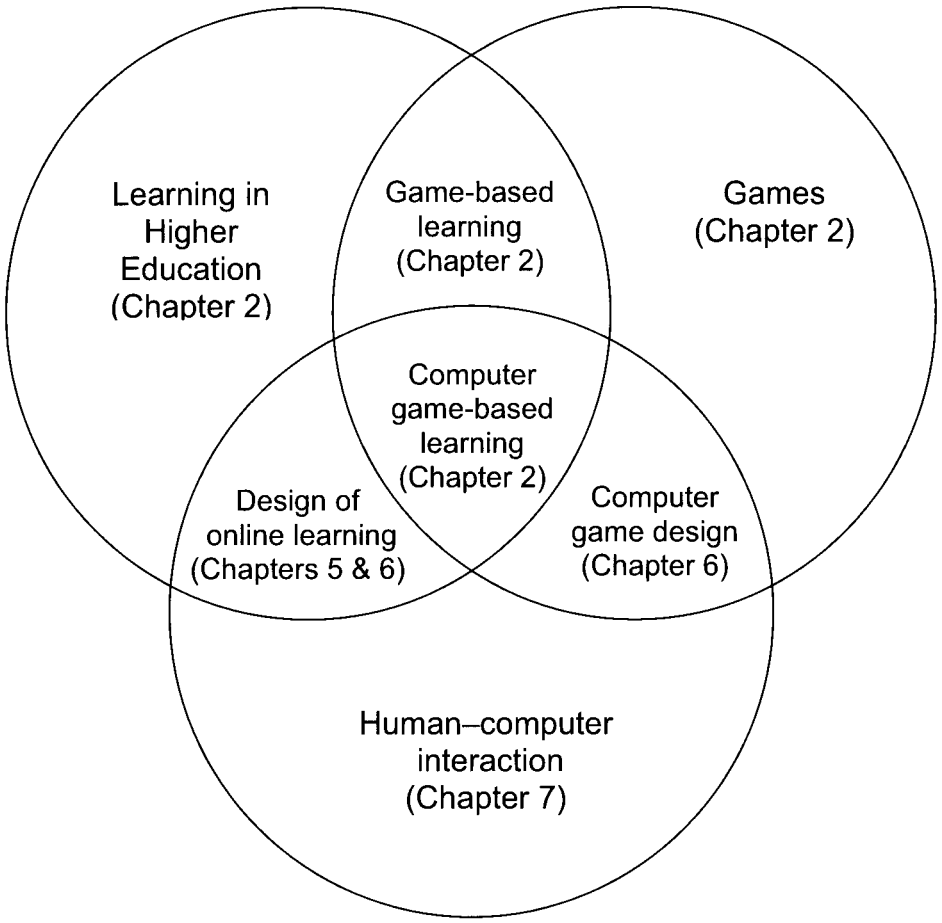

Figure 1-1: This research draws together the areas of games, learning in Higher Education and human–computer interaction

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.

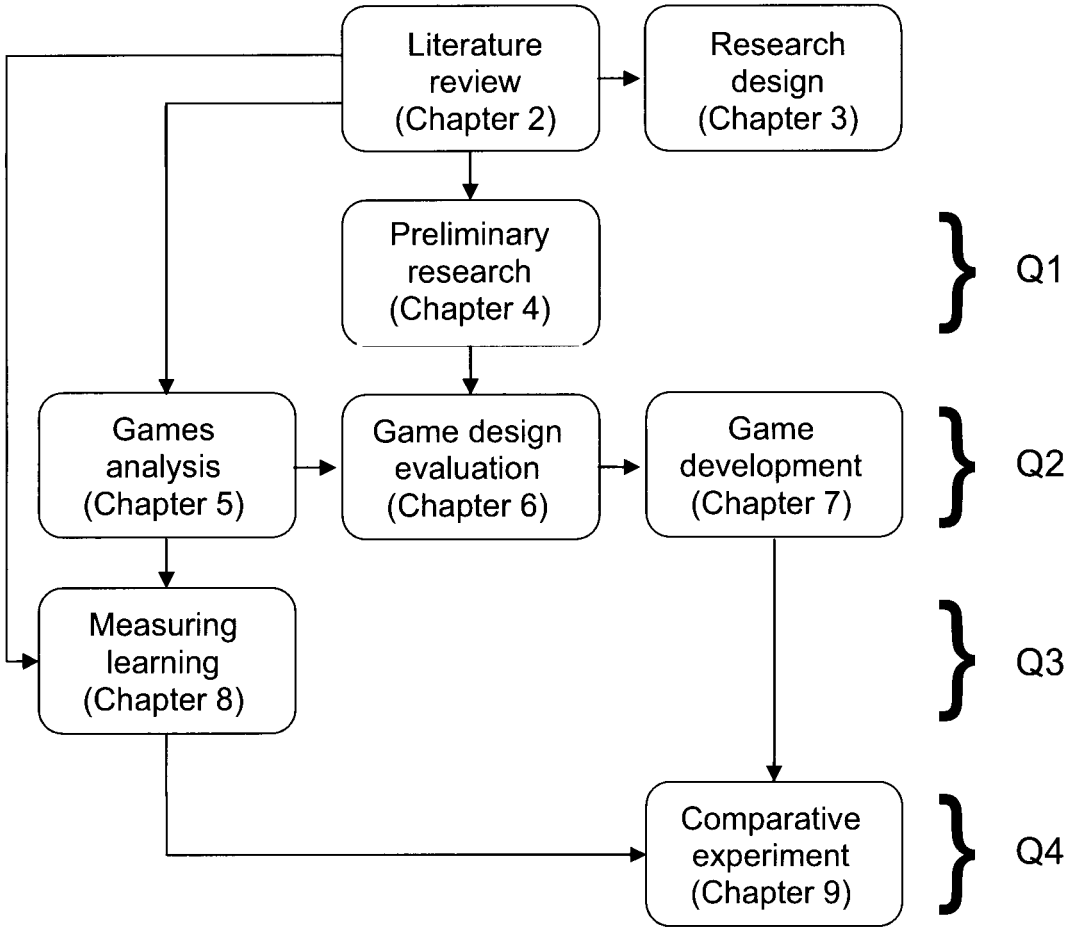

Figure 1-2: The areas of work undertaken in this thesis, the research questions they address, and the chapters in which they are presented

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.

2 Review of literature on learning and games

This chapter provides a review of the research literature in relation to games and learning in Higher Education, which underpins and informs the work discussed in this thesis. This review is broken down into three sections: first, there is a discussion of theories of learning that are pertinent to teaching in Higher Education; second, there is an examination of literature relating to game-playing; and finally, these are drawn together in an exploration of work relating to learning with games.

The inception of educational gaming dates back to the 1950s with the integration of war-gaming, computer science and operations research, coupled with the progressive educational theories that emphasise active, experiential learning and reflection. The first computer games were developed in the late 1960s and it was not long before computer games were also being used and developed for educational purposes (Wolfe & Crookall, 1998). Educational games and gaming simulations have been used for many years in the fields of business, training staff in fiscal and economic skills, and in the military for combat training and war-gaming. The health sector has been using gaming visualisation techniques for several years, for example through the use of virtual patients, and aircraft pilots often use aircraft simulations in the early stages of training (Kirriemuir, 2002).

There are many examples of different and innovative ways in which computer gaming has been used to support learning and teaching in recent years, both with children and in Higher Education. For example, recent research with school children includes the use of bespoke science games (Magnussen, 2005), off-the-shelf historical games (Squire & Barab, 2004), and multi-user gaming environments (Barab et al, 2005). Examples of recent research in Higher Education include the use of games to support the learning and practice of civil engineering concepts (Ebner & Holzinger, 2006), a competitive game to teach programming (Lawrence, 2004), and virtual reality games used with geography students (Virvou & Katsionis, 2006).

Some studies use existing commercial games in a teaching context, for example using the Civilization game to teach history to school students (Squire, 2005), while others involve the creation of a bespoke game, such as the action–adventure game developed to teach basic literacy skills to adults (Kambouri et al, 2006) or a collaborative mathematics game developed for children (Klawe, 1999).

While there is some experimental evidence that computer games increase motivation (e.g. Squire & Barab, 2004; Ebner & Holzinger, 2006) and can be an effective way to enhance learning (e.g. Klawe, 1999; Kambouri et al, 2006; Hämäläinen et al, 2006), much of the research into game-based learning is anecdotal and small-scale (e.g. Becker, 2001) or does not address issues of educational effectiveness (e.g. Dziabenko et al, 2003). There is an identified need among policy makers for more robust empirical work to provide a baseline of evidence on how educational games can be used most effectively to teach (de Freitas, 2007). Mitchell and Savill-Smith (2005) conclude that:

> the literature base is relatively sparse, findings often conflict in their outcomes, there is a lack of studies regarding educational games use by adolescents, some studies have methodological problems, and longitudinal studies are needed. (Mitchell & Savill-Smith, p 61.)

Wolf (2001) suggests that the lack of academic research into games in general could be due to their status as 'games', something seen as more trivial and frivolous, which separates them from traditional media such as books or film, and that they are more difficult to study than traditional media because they are harder to master and because of the time they take to experience.

This chapter considers a range of theoretical literature on learning and gaming, as well as discussing a number of recent empirical studies, their limitations and the evidence they present. First, learning theories as they relate to Higher Education are considered to provide a pedagogic foundation for further consideration of computer game-based learning.

2.1 Learning in Higher Education

This section introduces and examines theories of learning that support the use of game-based learning in Higher Education and that have influenced the research presented in this thesis. The starting point is a discussion of the constructivist perspective on learning and teaching, which is followed by a discussion of collaborative learning, experiential learning, problem-based learning and adult learning.

2.1.1 Constructivism

The way in which learning is perceived has changed significantly over the last century. Until the late 1950s the behaviourist school of thought was predominant, which saw the mind as a 'black box' that could be studied by examining observable changes in behaviour, where learning could be reinforced and the consequences of our actions would affect subsequent behaviour. In the late 1950s, cognitivism became the dominant instructional paradigm, where the focus is on thought processes behind behaviour, looking particularly at the main areas of cognition, sensory receptors, executive control, working memory and long-term memory. More recently, the constructivist paradigm has become the prevailing way in which the theory of learning is described (Cooper, 1993).

Bruner (1966), one of the first theorists to be considered by others to work within the constructivist scope, proposed the idea that learning is active and that learners construct their own knowledge about a subject through active engagement in learning by building on past knowledge and experiences. He theorised that instruction should engender a predisposition to learn, specify the ways in which to structure knowledge so that learning is most effective and specify the most effective sequences in which to present the materials to be learned. In its totality, the constructivist view consists of a number of theories and perspectives; however, Savery and Duffy (1995) provide a summary of three fundamental precepts:

- Situated cognition – individuals' understandings are developed by interactions with their environment; they are formed by a combination of content, context, activity and goal and are individually constructed; they

cannot be shared, but compatibility of understandings can be tested through discussion with others.

- Cognitive puzzlement – cognitive conflict or puzzlement is the stimulus for learning and determines the organisation and nature of what is learned; there is always a goal for learning something and this goal is a primary factor in determining what the learner attends to and what is constructed.
- Social collaboration – knowledge evolves through social negotiation and through the evolution of the viability of individual understandings; the social environment is critical to the development of understanding, and other individuals are a primary mechanism for testing understandings and providing sources of alternative views to challenge thinking.

The constructivist perspective hypothesises that people learn by constructing their own perspectives about the world, by problem-solving and personal discovery. The design of student-centred online learning environments and interactive, exploratory learning objects has been very much influenced by the constructivist perspective (e.g. Grabinger et al, 1997; Land & Hannafin, 2000).

Wilson (1996) defines a constructivist learning environment as:

> a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities. (Wilson, p 5.)

Honebein (1996) presents a number of pedagogic goals of the design of constructivist learning environments. He says that they should support students to take responsibility for their learning, including the topics they pursue, methods of learning and strategies for problem-solving; provide experience of multiple perspectives and viewpoints; encourage ownership and self-awareness of the learning process; make learning realistic and relevant, based on authentic, real-life activities; make learning a social experience, supported by collaboration and interaction; use multiple modes of representation; and use rich media.

These concepts of constructivism and constructivist learning environments are of particular relevance to this study because of the way in which these principles are reflected in certain types of computer game. For example, games can provide the opportunity for learners to explore and navigate immersive virtual worlds using rich media, they can create authentic contexts for practising skills that can be transferred to the real world, and they can present a forum and context for problem-solving. Collaboration and learning from others is fundamental to the constructivist perspective, and multi-user games or collaborative game playing in the same physical space are two ways that facilitate this.

The issues of support for student responsibility for planning and structuring learning, and meta-cognition and engagement in the learning process are not ones that are normally considered within games, even those designed for education. It is therefore important to consider the context in which games for learning are used, their role in the curriculum and the activities that precede and follow any game for learning. Prensky (2001) makes the argument that if games were used for learning then "learning would happen almost without the learners' realizing it, in pursuit of beating the game" (p 26). Without debriefing and reflection, to support the learner to understand the process, context and transferability of learning, the value of learning undertaken in this way is questionable.

In the following sub-sections, four areas of learning theory are discussed, which are related to the use of constructivist learning environments in Higher Education. These are collaborative learning, experiential learning, problem-based learning and adult learning. Each of these areas supports the rationale for the use of games as constructivist learning environments by showing how games can exhibit characteristics of effective learning environments.

2.1.2 Collaborative learning

Central to the notion of constructivist learning is the idea of students working together, sharing and clarifying ideas and opinions, developing communication skills and learning from one another. Working collaboratively enables students to work to their strengths, develop critical thinking skills and creativity, validate

their ideas, and appreciate a range of individual learning styles, skills, preferences and perspectives (McConnell, 2000; Palloff & Pratt, 2003; Palloff & Pratt, 2005).

Vygotsky's (1978) work in the field of social constructivism is particularly concerned with the collaborative aspects of learning, theorising that learning takes place at a social level first and then at an individual level. His theory of Zones of Proximal Development contends that the zone of proximal development is the difference between what a student can learn working alone, and what he or she can achieve when being supported and guided by a teacher or some other expert.

Participating in communities of practice provides a legitimate and ongoing way of learning from others as part of a group through apprenticeship and education in the context of the group norms, processes and identity (Lave & Wenger, 1991). Wenger (2000) describes these communities of practice as "the basic building blocks of a social learning system" (Wenger, p 229).

One of the significant advantages in the growth and ubiquity of personal networked computers is the potential to develop virtual communities of learners. Collaborative online learning communities involve the "bringing together of students via personal computers linked to the Internet, with a focus on them working as a 'learning community', sharing resources, knowledge, experience and responsibility through reciprocal collaborative learning" (McConnell, 2006, p 11).

Multi-user gaming communities provide a similar platform for collaboration and the ability to learn with others. Studies of leisure users of Massively Multi-user Online Role-Playing Games (MMORGs) have found evidence of collaborative learning, development of communities of practice (Steinkuehler, 2004) as well as the potential for learning a range of group skills, including the etiquette of meeting people, group management, co-operation and social interaction (Ducheneaut & Moore, 2005).

2.1.3 Experiential learning

The constructivist perspective also puts forward the idea that students learn better by exploring and experiencing authentic contexts for themselves and discovering their own meaning from the experience. The Experiential Learning Cycle (Kolb, 1984) is shown in Figure 2-1 below. This model emphasises the importance of active learning, with planning, reflecting and theoretical underpinning. According to this cycle, learning takes place as part of a sequence of steps. The student starts by actively undertaking the learning experience (stage 1), which provides a concrete experience; this is followed by personal reflection on the experience (stage 2). The reflection is followed by the application of known theories to the experience, or the derivation of rules from it (stage 3, abstract conceptualisation) and finally the learning is used to inform, modify and plan the next learning activity (stage 4, active experimentation).

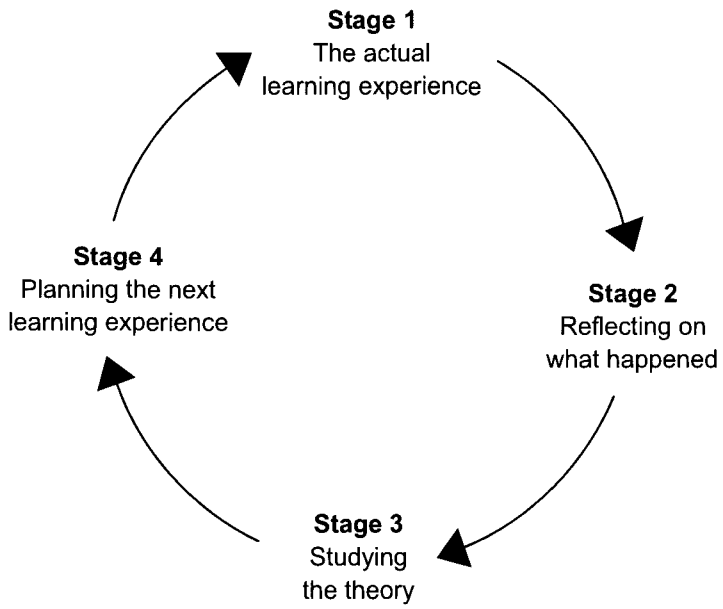

Figure 2-1: The Experiential Learning Cycle (Kolb, 1984)

One of the primary benefits of computer-based learning, which also applies to game-based learning, is the ability of the computer to provide the interaction and feedback that is crucial to the experiential learning cycle. Sims (1997) says that "interaction is intrinsic to successful, effective instructional practice as well as individual discovery." (p 158). Computers can facilitate a whole range of types of interaction from basic items that can be clicked, moving backwards or

forwards through a linear sequence, to the use of hyperlinked environments and virtual interactive worlds (Sims, 1997).

Gee (2003) argues that computer games reflect the experiential learning cycle in that students must examine the virtual environment, reflect on the situation and form a hypothesis about what something in the situation might mean, and re-probe the virtual world to see what effect it has. While it is true that this cycle maps onto learning within the game world, it does not necessarily provide students with scope for the meta-cognitive processes that are required for them to truly engage with and take responsibility for their own learning when applying their learned knowledge and skills to the real world. It is important to recognise that game-based learning is necessarily part of a larger learning process and should be considered in terms of the other activities and reflection that surround the game and not as a stand-alone activity.

2.1.4 Problem-based learning

Problem-based learning as a teaching and learning method is considered here because of the clear parallels between a problem-based approach and the activities that take place in certain types of computer game, such as puzzle or adventure games.

Problem-based learning generally involves small groups of students working with a facilitator to tackle real-life, cross-disciplinary problems. Resources are made available to the students but information on how to tackle the problem is not provided, and work is carried out intensively on one problem at a time. This provides activity-based learning, with students taking more responsibility for their own learning and learning in a real-world context (Boud & Feletti, 1991). The Internet can also be used to facilitate problem-based learning. Jonassen (2002) describes a number of different types of problem that can be addressed in this context, including logic problems, application of algorithms or rules, diagnostic or troubleshooting problems, strategic problems, design problems and dilemmas.

Researchers have highlighted that computer games have the facility to create real-life problem-solving experiences. Kiili (2005) argues that “games provide a

meaningful framework for offering problems to students. In fact, a game itself is a big problem that is composed of smaller causally linked problems." (Kiili, p 17), and in a survey of 25 educational 'experts' using game-based learning, de Freitas (2006) found that "broadly the experts interviewed seemed to advocate the use of simulations and games for problem-based learning." (de Freitas, 2006).

However, it is important to note that problem-based learning is essentially a collaborative method of learning, and to exploit the full potential of this teaching philosophy in a gaming situation, collaborative or multi-player games would be better suited to provide this than games played individually.

2.1.5 Adult learning

The research described in this thesis is concerned with the implementation of games in Higher Education, rather than examining the use of games with school-based learners. Therefore, an understanding of how learners in Higher Education may differ in their approaches to learning is important in the design of any learning experience, games included.

Although 18-year-old first year undergraduates may have more in common with school-based learners, there is a growing representation of mature and adult learners in Higher Education. Adult learners are typically defined as individuals "who have returned to learning after some kind of separation from a formal educational environment such as school, college or university" (Hodson et al, 2001, p 327) and who may typically have more work and personal responsibilities, caring commitments, greater life experiences and a need for greater study guidance.

Adult learning theory, or andragogy (Knowles, 1998), argues that the key characteristics of adult learners, as related to their motivations and learning needs, are that:

1. Adults need to know why they need to know something before they are willing to invest time and energy in learning it.
2. Adults have a deep psychological need to be self-directing and to take responsibility for their own learning.

3. Adults have a wide variety of backgrounds and experience and it can not be assumed that all adult learners come from the same starting point.
4. Adults become ready to learn something when they need to know it to be able to cope effectively with real-life situations.
5. Adults are task-oriented in their learning. They learn things best in the context of using them to do things they want to do.

It is important to note, however, that pressure of life and work commitments and limited time to devote to study is becoming more true of younger students also. Adult learning theory has much in common with the constructivist approach in that it advocates learners taking responsibility for their learning, and learning through experience in an authentic context, so it can be argued it is actually of relevance to all learners to varying degrees.

Rogers (1989) also describes a number of practical factors that contribute to effective learning in adults, again highlighting the importance of the learning being relevant to real life and also the need to enable adult learners to control the pace of their work, breaking down learning into manageable chunks, basing learning on previous experience and making use of the wealth of previous experiences, and creating an awareness of the meta-cognitive processes associated with learning.

Adult learning theory highlights the fact that motivation to learn is paramount and that learning activities must be purposeful. This brings into question the acceptability of game-based learning with adult learners, who may perceive games as frivolous and a waste of time (empirical evidence to support this is discussed in Chapter 4).

In all, the theories discussed in this section – constructivism, collaborative learning, experiential learning, problem-based learning, and adult learning – are closely related in terms of pedagogic stance; that is, empowering learners to take control of developing their own learning, questioning in real-life situations and learning from others. The next section considers the characteristics of games that might form a definition of game-based learning, presents a framework of genres of game from which to consider which are most applicable

to game-based learning in Higher Education, and considers theories relating to gaming and engagement.

2.2 Games

Having considered a number of educational theories that support the potential value of game-based learning, this section examines some of the theoretical constructs associated with the nature of games and gaming in order to provide a basis for considering different game types for their potential educational value. In particular, the characteristics of a game are discussed and a working definition postulated, a taxonomy of game genres is presented as a starting point for considering the types of games that may be appropriate for certain types of learning, and the nature of engagement with games is considered.

Play is a powerful influence on learning that is fundamental to the development of both adults and children (Rieber, 1996), promoting engagement and mastery of developmental tasks (Colarusso, 1993). Koster (2005) says that games are a fundamental part of the evolving human experience and the way in which we learn, providing the opportunity to practise and explore in a safe environment, teaching skills like aiming, timing, hunting, strategy and manipulation of power.

However, there are misconceptions associated with play that might affect the acceptability of game-based learning, particularly for adults in Higher Education. Play is perceived by many as only for young children, as not being a respectable thing to do, and as activity that is easy (Rieber, 1996). There is a potential dichotomy relating to educational games: play is seen as being a source of joy and fun and essentially voluntary (Caillois, 1961), yet when it is used as part of formal education the voluntary aspect may be removed.

This highlights a strong need for game-based learning to be purposeful, and to be perceived as such by the learners, so that games are not perceived as frivolous and learners are willing to undertake them voluntarily (as, in essence, all participation in Higher Education is voluntary) as the most effective way to learn. This is supported by the background research discussed in Chapter 4.

In order to identify the boundaries of this study, the next sub-section of this chapter attempts to clarify exactly what is meant by a game in the context of game-based learning.

2.2.1 Defining a game

The first question considered as part of this research into games and learning was exactly what is meant by the term 'game'. Wittgenstein (1958) argued that it is not possible to come up with a single definition of a game but different types of games are, in fact, related by a number of 'family resemblances', and that an exact definition of a game is not essential to use the term effectively. However, in order to provide a frame of reference for this research, analyse differences between different types of games, and establish what activities are included in the definition of game-based learning, some consideration of this issue is important. This section provides a summary of the characteristics that have been used to define games by researchers and practitioners, and from this, describes a framework for analysing game-based learning activities.

There are many definitions in the gaming literature regarding what makes an activity a game and what the defining characteristics of a game are. A selection of definitions are considered here, first examining three definitions from researchers into non-computer-based educational games, then three from designers of games for entertainment, then finally three from researchers in the field of computer game-based learning.

Definitions from the field of non-computer game-based learning include that of Ellington and colleagues (1982), who define a game as necessarily containing rules and overt competition, either between other players or against the game system. This limitation to overt competition appears to be somewhat restrictive, however, particularly when considering co-operative learning games, and Klabbers (1999) uses a wider definition including competition or challenge and describes games as "an activity or sport involving skill, knowledge or chance, in which you follow fixed rules and try to win against an opponent to solve a puzzle." (Klabbers, 1999, p 18). Greenblat (1987) defines games as simulations that work wholly or partly on the basis of players' decisions, which have roles, goals, activities, constraints and consequences.

Definitions from commercial game designers have a different perspective. Crawford (1984) argues that the elements that define a game are representation (a closed formal system with explicit rules that represents a subjective, fantastic, subset of reality), interaction (social or personal), conflict or challenge, and provision of a safe environment, i.e. one where consequences do not hold in reality. Oxland (2004) says that games need rules and boundaries, feedback, an interface to the game world, context sensitivity (or immersion), goals, quests and challenges, a game environment and balance (or playability). Koster (2005) provides a much less formal definition, saying that games are puzzles to solve, they are exercises for our brains and that it is the act of solving these puzzles that makes games fun.

It is hardly surprising that there is more focus on playability and fun in the definitions created by game designers in the entertainment industry, and it is important not to lose these elements of what makes games engaging when considering how games could be used for learning. This is not an easy task, as Virvou and colleagues (2004) highlight, saying that "educational software games aim at serving two distinct aims, which are often conflicting each other: education and entertainment" (p 692).

More recent definitions by researchers in the field of computer game-based learning have more in common with those of non-computer-based games researchers. Dempsey and colleagues (2002) define a game as an activity involving players (one or more), with goals, constraints, payoffs and consequences, which is rule-guided, artificial in some respects and has an element of competition, while Prensky (2001) describes six structural elements of games; namely rules, goals, outcomes and feedback, competition or challenge, interaction, and representation or story. A wider definition is used by de Freitas (2006) who defines computer-based learning games as:

> applications using the characteristics of video and computer games to create engaging and immersive learning experiences for delivering specified learning goals, outcomes and experiences. (de Freitas, p 9.)

From consideration of these definitions, it was felt to be unhelpful and artificial – if not impossible – to create a distinct and absolute division between what is and

is not a game in a computer-based environment. There is no common definition in the literature and practitioners from different disciplines have varying perspectives. However, it was felt to be useful to highlight characteristics of games that commonly occur in the definitions presented and to use these to create a framework for examining different types of game and support an inclusive definition of 'game', with activities being more or less 'game-like'. The more of these characteristics an activity possesses, the more essentially 'game-like' it can be considered to be. These ten characteristics of game-based activities are defined in Table 2-1.

Characteristic	**Definition**
Competition	Where the goal is to achieve better than other people.
Difficulty	Presentation of tasks that require effort.
Exploration	A context-sensitive virtual environment.
Fantasy	A make-believe environment or story.
Goals	Explicit aims and objectives, with a clear purpose.
Interaction	Feedback from actions and changing state of play.
Outcomes	Measured results from game play (e.g. scoring).
People	Other individuals playing the game at the same time.
Rules	Boundaries of play, limitations or constraints.
Safety	Lack of consequences of the game in the real world.

Table 2-1: Ten characteristics of game-based activities

The characteristics of 'fun' and 'playability' are not included here as characteristics of games because, while they might be something for which game designers strive, they can not be objectively observed as characteristics of games but are dependent on the perception of the individual playing the game.

These ten characteristics are closely aligned to what individuals perceive a game to be (see Table 4-1 in Chapter 4) and are used to consider which activities can be considered as game-based learning throughout this thesis. The more of these characteristics an activity exhibits, the more game-like it is considered to be (for example, the Time Capsule and Pharaoh's Tomb activities are considered in relation to this framework in Table 9-1 in Chapter 9).

There are several types of activity that are associated with games and are often included in discussions of game-based learning. These include simulations, microworlds, role plays, puzzles, toys, and stories. There is disagreement among researchers over whether these activities constitute games or not, but the inclusive definition described above enables any of these activities to be considered under the heading of 'game-based learning', albeit some with more gaming characteristics than others.

Two domains closely associated with games are simulations and microworlds. There are many similarities between simulations and games, and the term 'simulation-game' is often used to describe an object that has characteristics of both. Simulations attempt to model an environment with as much realism as possible, and show genuine cause and effect, and while they can be explored and experimented in, they do not have to have defined goals. Simulations are often used when there is some reason why the actual system cannot be experienced, such as cost, danger, inaccessibility or time (Rieber, 1996). A microworld is an artificial environment, which can be described as "a small, but complete, version of some domain of interest" (Rieber, 1996, p 46). While microworlds are similar to simulations and can be confused with them, they differ in that they first present the learner with the simplest case of the domain (Rieber, 1996).

Another area often associated with games is role play. Role-playing allows people to take part in an experience by acting out the role of a character in a particular situation and experiencing empathy with that character. Role plays often follow a set of rules and involve interaction with others, but do not always have defined goals (Feinstein et al, 2002). While it is possible to have a role play that is a game (role-playing games themselves being a prime example), role plays can have many other uses such as experiential learning, empathy, or relaxation.

Puzzles are another activity that are often likened to games and, in fact, many games have elements of puzzle-solving. Crawford (1984) argues that it is interaction that makes an activity a game rather than a puzzle, in that puzzles do not actively respond to the human's moves. However, he also says that "we

can easily turn many puzzles and athletic challenges into games and vice versa. For example, Chess, a game, has spawned a whole class of puzzles, the end-game problems." (Crawford, 1984, online).

The essential difference between toys and games is that toys do not have goals and set rules of play whereas games usually do. With a toy, the designer has almost no say over the players' final experiences (Crawford, 1984). Stories are another form that share some of their characteristics with games, particularly the element of fantasy. The distinction between games and stories is that stories are essentially linear and non-interactive while games are non-linear and interactive. Rockler (1989) argues that mystery stories are themselves games to some extent, particularly detective fiction, in that they have a set of rules (e.g. readers must be given access to all the clues, the suspects must be known and the murderer among them) and an outcome.

Koster (2005) argues that toys, games, play and sport are the same at the most fundamental level. He says that:

> Playing a goal-oriented game involves simply recognizing a particular sort of pattern; playing make-believe is recognizing another one. Both deservedly belong in the same category of "iconified representations of human experience that we can practice with and learn patterns from" (Koster, p 36).

Adopting an inclusive definition of computer game-based learning enables all of the activities described above to be considered part of the spectrum as they all share characteristics with computer games. This inclusive definition enables this research to focus on an examination of how different game characteristics affect learning rather than a semantic distinction between games and non-games. In the next sub-section the characteristics of different genres of computer game are considered.

2.2.2 Genres of computer game

As well as examining the characteristics of games, this research considers which particular types of games might be more appropriate to teaching particular skills to learners in Higher Education. In order to provide a framework in which to do this, an analysis of genres of computer game was undertaken.

Many researchers have tried to categorise computer games into types or taxonomies, and although there are small differences between them, there is also much similarity in terms of the general categorisation. Oxland (2004) makes the point that:

> Identifying what constitutes a genre has been fraught with ambiguity, mainly due to the creative flux our industry introduced, the overlap of genres and the constant churn of technology and ideas (Oxland, p 24).

Wolf (2001) describes over 40 different genres of game but it was not felt to be helpful here to deal with so many distinctions. The purpose of investigating genre was to determine a manageable number of discrete classifications of game with distinct characteristics, that could be readily understood by participants in research and used to map educational design characteristics onto genres in order to decide on a particular type of game to develop (see Chapter 6).

Genre	Definition	Examples
Adventure	A game involving a series of quests or puzzles, where the protagonist must move through a virtual world performing actions and manipulating objects to achieve the game's aim.	Myst The Hobbit
Platform	A game in which the primary aim is negotiating movement between a series of platforms, avoiding obstacles and enemies and picking up treasure.	Sonic the Hedgehog Super Mario Brothers
Puzzle	A game that primarily involves logic and puzzle-solving.	Lemmings Tetris
Role-play	A game in which the player takes on a fantasy role and takes part in adventures within a fantasy world.	Dragon Quest Neverwinter Nights
Shooter	Played in the first person, a game that involves exploration of virtual worlds, weapons and combat.	Doom Quake
Simulation	A game that models some sort of virtual environment and allows interaction with that environment.	Sim City The Sims
Sports	A game in which the player undertakes a virtual sporting activity.	FIFA Football Alpine skiing
Strategy	A game in which strategic decisions must be made to meet the overall goal.	Chess Dungeon Keeper

Table 2-2: Eight genres of game with definitions and examples

For the purposes of this research, a list of game genres and definitions (see Table 2-2 above) was extracted from the literature (Prensky, 2001; Wolf, 2001; McFarlane et al, 2002; Makar & Winiarczyk, 2004; Oxland, 2004). This list was felt to be representative of the literature, providing distinct classifications, while not including so many sub-classifications as to be unmanageable. Even so, it is worth noting that a game may still fall into more than one category. This taxonomy is used as a basis for considering the types of game that might be most suitable for use in education (see Section 6.2).

2.2.3 Games and engagement

One of the key features of games is their ability to engender engagement, and engagement is also an important factor that contributes to effective learning, so the nature of engagement with games is essential for consideration.

Benyon and colleagues (2005) say that:

> engagement is concerned with all the qualities of an experience that really pull people in – whether this is a sense of immersion that one feels when reading a good book, or a challenge one feels when playing a good game, or the fascinating unfolding of a radio drama (Benyon et al, p 61).

They identify a number of key elements that contribute to engagement in virtual environments: a sense of authenticity and identification, adaptivity of the environment, compelling narrative, immersion and flow (Benyon et al, 2005, based on Shedroff, 2001).

Jones (1998) defines engagement in the context of online learning as "the nexus of intrinsic knowledge and or interest and external stimuli that promote the initial interest in, and continued use of a computer-based learning environment" (Jones, online).

As a way of examining the concept of engagement in more detail, Flow theory (Csikszentmihalyi, 1992) is particularly useful. Csikszentmihalyi's research is based primarily on empirical data, asking people spontaneously about what they were doing and how they were feeling, with a large number of subjects over long periods of time. Flow theory describes the state of optimal experience,

which is supposed to bring happiness, and is described as "the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it" (Csikszentmihalyi, p 4). Being in a state of 'flow' is considered here to be very close to being highly engaged.

Flow theory states that the following elements add to enjoyment, and the more of these elements that are present, the more enjoyable, engaging and immersive an activity is:

- a challenge that requires skills with an attainable goal and known rules;
- complete absorption in the activity;
- clear goals;
- immediate feedback;
- concentration on the task in hand;
- a sense of control, lacking the sense of worry about losing control;
- loss of self-consciousness;
- transformation of time.

Flow theory is not without its opponents. Draper (1999) criticises the theory, saying that flow is not a single concept but is actually broken down into u-flow and c-flow. U-flow is a smooth but unconsciously managed flow of actions (e.g. driving a car) whereas c-flow requires the total attention and consciousness of the individual (e.g. playing a game of chess). He also argues that engagement only occurs where there is a "connection to the person's deepest values and goals" (Draper, 1999, online). Salen and Zimmerman (2004) make the point that flow is intrinsic to the game but is dependent on the state of mind of the player. This is an important issue to consider in the context of the research presented here: the characteristics of a gaming activity are viewed as objectively observable (see Table 2-1) while engagement is viewed as a subjective state observable only to the individual taking part in the activity (a breakdown of characteristics of engagement used for this study can be found in Table 8-1).

Malone (1980a, 1980b) produced some of the original and seminal work in gaming and engagement. He investigated the elements that make computer games engaging and how those features that make games captivating might be used to make game-based learning more interesting and enjoyable. His work was undertaken with children and while he does make the assumption that computer games are intrinsically motivating he also admits that "...it is clear that there are big differences between people in the kinds of games they [children] like. No single instructional game can be expected to appeal to everyone" (Malone, 1980a, p 21).

Malone initially presented three aspects of games that lead to increased engagement: challenge, fantasy, and curiosity. Appropriate challenge can be created by the use of goals, which should be obvious, compelling and adaptable, coupled with an uncertainty of whether these goals can be met. He argues that short-term goals are more motivating than long-term and that fixed goals (e.g. winning a game) are more motivating than emergent goals (e.g. painting a picture). Creating the optimal level of challenge for an individual is seen as key; according to Malone, "an environment is not challenging if either the person is certain to reach the goal or certain not to reach the goal" (Malone, 1980a, p 52).

Fantasy can be intrinsic, where the skill or knowledge to be learned is closely related to the fantasy, or extrinsic, where the skill does not depend on the fantasy. Malone states that intrinsic fantasies are generally more interesting and instructional, and that instructional fantasies serve wish-fulfilment and conflict-resolution functions. Curiosity can be sensory (light, sound, other sensory stimuli) or cognitive, which involves the prospect of modifying high-level cognitive structures, ensuring that understandings are complete and consistent. Feedback should be surprising and constructive. Malone and Lepper (1987) extend Malone's original theory to include the additional factor of control, which is broken down into contingency (where interactions are logical), choice (a large number of options are available) and power (a decision has a powerful effect).

It is worth making a couple of points regarding the value of this work as related to learning in Higher Education today. First, Malone's work was conducted with

children, and although his findings may be replicable with adults, there is no evidence of this, and while some of the factors intuitively make sense when applied to adult motivation (e.g. goals, control) other factors are less compelling (e.g. fantasy). Secondly, Malone's work took place during the 1980s, a period when computer games were new to most children and were to some extent motivating purely for their novelty value; today, games are ubiquitous and people are far more sophisticated in their expectations of games. Even so, Malone's work is still regularly used as a basis for work on game design and engagement (for example, recent references include Sandford & Williamson, 2005; Dickie et al, 2006; Ebner & Holzinger, 2006) and has been endorsed and applied by many other researchers since its inception, so it is viewed here overall as still being valid but to be applied with some caution.

The final section of this chapter examines the research literature on computer game-based learning, focusing in particular on the advantages and potential disadvantages of using games in education.

2.3 Computer game-based learning

In recent years, there has been a growing interest in computer game-based learning. A number of factors have brought this about, including the move from traditional, didactic teaching theories to more learner-centred, active models of learning, coupled with the availability of easy-to-use games creation technologies and the growing body of evidence that games can be an effective tool for learning, as well as motivating and engaging students (Garris et al, 2002).

This section first discusses reasons highlighted in the literature on computer game-based learning for its effectiveness, and then provides some examples of empirical studies showing the use of game-based learning. Finally, this section examines some of the weaknesses and problems associated with the use of computer game-based learning.

2.3.1 Rationale for computer game-based learning

Throughout the literature on game-based learning, in the case of both adults and children, an assumption is commonly made that the rationale for using

games for learning is that games are intrinsically motivating (e.g. Nawrocki & Winner, 1983; Driskell & Dwyer, 1984; Sweeters, 1994; Grice & Strianese, 2000; Alessi & Trollip, 2001; Becker, 2001; McFarlane et al, 2002; Oblinger, 2004).

These assumed motivational factors surrounding games are often used as a rationale for using games for learning, the argument being that if the motivational factors associated with games could be transferred to learning then the learning would be more effective. Dempsey and colleagues (2002) make this assumption and provide examples of suggested uses of existing computer games in educational settings, but do not provide any evidence that motivation to play games for entertainment necessarily leads to motivation to use games for learning.

Reflecting on this assumption, particularly with adult learners in Higher Education, it is evident that not all people are intrinsically motivated to play games, nor indeed are people who are motivated to play games for leisure necessarily motivated to play them to learn (see Chapter 4). However, this assumption is still rife in the literature.

There are several possible explanations for this widely held and little-questioned assumption regarding the motivational aspects of games. Games researchers tend to be highly motivated to play games themselves, and do not consider those individuals for whom game playing is not motivating, or indeed is actually demotivating. It is also self-selecting games enthusiasts who often participate in gaming studies, which only serves to propagate the assumption. In addition, much of the research literature in this area is based around studies carried out with children, a population who are more likely to be motivated to play with games, from which the results are generalised to adults.

Despite the potential motivational aspects of games not providing a compelling rationale for their use educationally, there are other pedagogic reasons for considering computer game-based learning. A more persuasive argument for using games to learn is based around the changing profile of modern learners.

Prensky (2001) describes the definite distinction between 'Games Generation' learners, or 'digital natives' who have grown up with computer games, television, and other media, and use them to learn instinctively; and older learners, for whom interacting with these types of technology has to be done through conscious effort and who exhibit more traditional learning strategies. He argues that the generation of people brought up in a world of computers are cognitively different from previous generations and that this immersion in technology has fundamentally changed the way in which people acquire and assimilate information. He describes ten cognitive changes in people of the Games Generation.

- Games Generation learners are used to processing information at a much faster pace than traditional learners.
- Games Generation learners can process information from several sources at once.
- Games Generation learners will focus on graphics and images before reading the textual information.
- Games Generation learners will not follow a linear path through learning materials, but will take a more random, hypertextual route.
- Games Generation learners will expect to work with others rather than alone; collaboration and teamwork will be the norm.
- Games Generation learners take a much more active role in seeking out information and deciding what to learn.
- Games Generation learners have a much less distinct boundary between what is considered play and what is work. Playing games to learn will not be anathema to them.
- Games Generation learners expect quick rewards and quick feedback and will soon become demotivated if they do not experience quick gains for effort.
- Games Generation learners are more accepting of fantasy concepts than traditional learners.
- Games Generation learners are comfortable with and enthusiastic about new technologies and quickly embrace change and advancement.

While many of these ideas regarding changes in learners may seem instinctively correct, it should be noted that these characteristics are based on experience rather than on empirical studies. It is also important to note that the increasing numbers of mature students in Higher Education means that many learners are simply not part of Prensky's 'games generation'.

Gee (2003) puts forward the argument that video games can be used to learn because they have good learning principles built into them. He argues that playing video games involves learning a new literacy and although games are not necessarily appropriate for teaching content, they do teach people how to interact in a new domain and learn transferable skills. He says that when we learn new domains we learn to experience things in new ways, gain the potential to join new social groups and prepare for future learning in related domains.

Other hypothesised educational benefits of learning with computer games cited in the literature include improvement in practical reasoning skills, motivational levels and retention (Rieber et al, 1998) and the ability of games to push learners forward, adjust to the skill levels of the players, and support alternative learning styles (Jenkins, 2002). Computer games are suited to learning because they enable players to practise the skill of learning and are designed so that players take control of their own learning (Papert, 1998).

There are also a number of researchers who believe that students can learn by developing or creating games, as well as simply playing them. Reiber (1998) argues that learning by building games can be an at least, if not more, effective way to learn than traditional methods, while Shubik says that "possibly at least as important as playing a game is constructing one" (Shubik, 1989, p 186). Gee (2003) argues that active, critical learning should lead to learners becoming designers, either by physically designing extensions to the game or by cognitively extending the game design and using that to inform their play.

The next sub-section examines a number of case studies of game-based learning and discusses the empirical evidence of the learning effectiveness of the games used.

2.3.2 Evidence of learning with games

There is an identified need for a greater number of rigorous studies investigating the use of game-based learning (Mitchell & Savill-Smith, 2005; de Freitas, 2007). In this sub-section, a number of studies that have taken place in recent years are presented and discussed. It examines some of the empirical

evidence that is available as to the educational value of game-based learning. The studies selected here aim to provide a representative sample of the type of research that is being carried out in the area and the issues that commonly arise.

The studies described here also provide an overview of the data collection and analysis methods that are commonly used in the area, and highlight some of the methodological issues. Examples are used from (non-computer) game-based learning, and computer game-based learning in schools, Higher Education and continuing education.

Evidence of learning through non-computer games goes back many more years than does that with computer games. Randel and colleagues (1992) present a meta-analysis of 67 existing studies on educational gaming and simulations from 1963 to 1991, all of which involved school-age children; of these studies, they report 27 to show a significant difference in favour of games (although they say that five of these used questionable controls). Sun (1998) describes research undertaken using a role-playing game to teach the basic principles of operations management. A basic evaluation was carried out with fourth-year and Masters-level students who had used the game, through group discussion at the end of the playing session. The paper describes the evaluations as very positive, saying that the students found the game interesting, they felt involved, they perceived it to be helpful to understanding theory and appreciated the ability to apply theory to practice. Despite the positive evaluation outcomes, the evaluation itself appears to be somewhat ad hoc and lacks rigour; this is typical of much of the research on the use of games that is reported.

More recently, O'Leary and colleagues (2005) undertook a study to compare learning satisfaction and effectiveness between game-based learning and traditional lectures for third-year medical students. They used a pre- and post-test to evaluate learning and a satisfaction survey. The study showed no difference in learning between the two groups but the group using the game rated it higher for satisfaction.

Studies have also been undertaken with school students of a range of ages to examine the effects of game-based learning. Sung and colleagues (2006) undertook an experiment with 59 children aged four and five years to compare the relative effectiveness of two software applications increasing the children's understanding of taxonomy, including classification and identifying characteristics. Three experimental groups were used: one using a game, one alternative software, and a control group with no intervention. A pre- and post-test was used to determine learning. The study showed evidence that the game supported learning of some taxonomic concepts compared to the other software and control group.

Magnussen (2005) describes a study that was undertaken to evaluate the learning potential of a cross-disciplinary science game that simulated a forensic investigation used in schools. This was a small-scale study that used data based on observations from play tests with two classes of children. The analysis showed evidence of learning from the game, in particular collaborative learning, the ability to handle large amounts of data, and the establishment and testing of theories.

In an example of the use of commercial computer games in education, Squire and Barab (2004) used the commercial strategy game Civilisation III to teach history to 18 students in High School. The evaluation was based around a case study design with pre- and post-tests; however, the students simply refused to complete pre-tests so no data on learning are available. In addition, observations, journals, and interviews were used to gather data. This study provides evidence of engagement with the game once students were aware of the purpose of the game and could see the potential for learning through re-enactment of history.

Fewer examples of studies of this type are available from Higher Education than from the school sector. Hämäläinen and colleagues (2006) describe an evaluation of a 3-dimensional virtual game environment for promoting collaboration in students in Higher Education. Twenty-four students played the game, in six groups (each with four players), and a range of data gathering techniques were used including video observation, questionnaires, interview,

screen capture and personal notes. The study found that the game was effective for supporting a range of team skills, and the teams exhibited collaborative behaviours including joint goal orientation, effective negotiation, co-ordination of different perspectives and information sharing.

Also in Higher Education, but in the field of civil engineering, Ebner and Holzinger (2006) evaluated a game for teaching theoretical concepts to Masters-level students. This study uses a pre-test/post-test method to compare learning between a group of students who attended lectures and played the game voluntarily and those who just attended lectures. There was no significant difference in learning between the two groups. However, there are issues of bias with this methodology due to the voluntary nature of participation.

Computer game-based learning studies have also been undertaken in the area of adult and continuing education. Gander (2000) evaluated the use of a computer-based adventure training game for teaching information systems concepts to adult learners. Thirty students took part in the evaluation and were split into three groups, each playing for different lengths of time (30–90 minutes) and undertaking a pre- and post-test as a way a measuring learning. The results of the tests show that learning was certainly happening in the groups that used the games for 60 minutes or more, but since the experiment did not use a control group, it is impossible to determine whether this would be the most effective way to teach this subject.

Kambouri and colleagues (2006) describe the use of a game developed to motivate young adult learners to improve their basic literacy skills and provide a forum in which they could practise the skills developed. This relatively small-scale study involved 13 learners, who undertook pre- and post-session interviews, and completed questionnaires. The results showed that the game had engaged the students and helped them to make significant literacy gains beyond those expected by the educators and game designers.

In all the areas of education discussed here, there is limited empirical evidence to show that game-based learning is any more effective than traditional methods, although there is more evidence that students enjoy games more.

There are a range of practical issues associated with the use of games in learning, particularly formal learning, which might have impact on their educational effectiveness; these limitations are discussed in the following sub-section.

2.3.3 Weaknesses of game-based learning

A major practical issue in the use of computer games for learning is how to design and develop the educational game to be used; whether to use off-the-shelf games software designed for entertainment, or to create bespoke educational games.

The problems associated with the design of bespoke education software often involve the amount of money spent on producing it compared to entertainment software, and how this affects the expectations of learners. Jenkins (2002) argues that most educational software is of poor quality, badly edited and unprofessional. It will never be the case, however, that the amounts of money spent on commercial software will be available for education, and it is more important that resources be used to ensure that educational games are well designed in terms of playability and learning. The growing trend towards modifying existing games software for use in education (de Freitas, 2007) may provide one way to address this issue.

Other criticisms of game-based learning include that transfer of game-based learning to real life may not be clear (e.g. Dempsey et al, 1993–94), that motivation to play a game may actually be detrimental to learning (e.g. Jacques et al, 1995) and that games may be a less efficient manner of learning than traditional methods, not least because of the amount of time that is required to become proficient at the game, time that could be used for learning (e.g. Alessi & Trollip, 2001).

Some of the other disadvantages associated with computer game-based learning include that it is often difficult to pitch games at the right level of interest and challenge for their intended users, they can be gender-specific and often have violent or stereotypical characters, and most educational computer games

are designed as single player whereas collaboration and group work can dramatically enhance learning (Becta, 2001b).

In addition, there is evidence that using game-based learning may discriminate against girls and may lead to aggressive, addictive or anti-social behaviours (Sandford & Williamson, 2005), that they may be impractical to run in a classroom setting because of time constraints and the time taken for teaching staff to learn and support games (Becta, 2001a), there may be a lack of available equipment (de Freitas, 2007) and there are issues with ensuring alignment between games outcomes, learning outcomes and assessment (Sandford et al, 2006). Jones (1997a) argues that, while games and simulations can be powerful learning tools, they can also damage personal relationships and cause emotional hurt and distress.

A number of practical constraints also exist concerning the use of games in teaching, including increased preparation time for academics and teachers (who may be less familiar with the technology than the students), the difficulty of ensuring that the learning outcomes of the game are appropriate for the learning outcomes of the curriculum, a range of technical and administrative issues, inappropriate resources, and a fear of the unknown on the part of teaching staff (Lean et al, 2006).

Despite the disadvantages and practical implementation issues, it is clear that certain types of computer game do have the power to engage certain types of people. If games can be designed to encapsulate the learning principles discussed in Section 2.1 of interactive and collaborative experimentation as well as learning content that is appropriate to the curriculum and assessment, then they can clearly be an appropriate tool for learning. Whether they are the most appropriate and acceptable to learners will depend upon the particular learning context in which they are used.

As de Freitas (2007) says, “the key challenge for effective learning with games is for the learner to be engaged, motivated, supported and interested but also importantly for the learning to be undertaken in relation to clear learning

outcomes as well as being made relevant to real-world contexts of practice." (p 5).

In all, this chapter has provided an overview of and drawn together the research literature in the fields of learning in Higher Education, games, and game-based learning, looking at a number of learning theories and linking them to characteristics of games to support a rationale for games-based learning in Higher Education. This chapter has shown the theoretical potential for computer games to be an effective way to teach, as long as they are underpinned by effective pedagogy.

This link between games and learning is revisited in Chapter 6, where the potential of different game genres to embody the educational principles described in this chapter is discussed.

The following chapter moves on to describe and consider the research design for the work described in this thesis, including the research philosophy, techniques employed and ethical considerations.

3 Research design

This chapter considers issues associated with the design of the research described in this thesis. First, the philosophy of the research is discussed in the context of educational research as a whole; then an overview is presented of the research techniques used; and the chapter finishes by considering the ethical issues associated with this research.

3.1 Research philosophy

Ontological assumptions, regarding the way in which reality is viewed, give rise to epistemological assumptions, about how the view of reality is studied, which influence methodology and, in turn, data collection and analysis methods. Therefore, the choice of research methods in education is more than a technical exercise but is concerned with understanding how the researcher views the world (Cohen et al, 2000). This section, therefore, takes cognisance of the fact that the world view and philosophy of the researcher can influence the approaches taken and conclusions drawn from the research, and provides an overview of the personal philosophy of the researcher and a discussion of the ways in which this might influence the research and measures that have been taken to counter this.

There are two contrasting philosophical approaches to research in the social sciences: positivism and relativism, the positivist approach being closely associated with quantitative research methods while relativistic approaches are associated with qualitative ones (Robson, 2003). The positivist, or scientific, approach to research views the nature of the world as existing regardless of people's perceptions of it, and that experiences can be described in terms of objective facts that are essentially value-free; hypotheses can be tested against these facts, and causal relationships can be demonstrated between events. This perspective takes no account of the fact that social science is involved with the understanding of human phenomena or cognisance of the nature of human perceptions.

Relativist approaches take the view that there are not absolute truths, but people have different ways of perceiving the world and that there is no external reality independent of the beliefs and perceptions of those experiencing it; the complexity of experience and behaviour must be studied to gain true understanding. The extreme relativist perspective "maintains that there is no external reality independent of human consciousness; there are only different sets of meanings and classifications which people attach to the world" (Robson, 1993, p 22).

In effect, positivism and relativism can be seen to represent two extreme world views. Pring (2004) describes a 'false-dualism' that exists in the belief that in rejecting the positivist perspective the relativist perspective must be unequivocally accepted. He argues that:

> How we conceive things is embodied within a language and inherited by those who learn the language. Far from individually constructing the world, we acquire those constructions which (although socially developed) are possible because of certain features of reality which make them possible. It is not that there are multiple realities. Rather are there different ways in which reality is conceived, and those differences may well reflect different practical interests and different traditions. (Pring, p 52.)

The current approaches to research in social science tend to reflect this stance; while accepting that pure positivism is inappropriate for undertaking research with people, extreme relativism is equally unsuitable for envisaging reality. Robson (1993) describes three broad strands of current approaches to social and educational research: post-positive, constructivist and emancipatory. The post-positive view is that a reality does exist but that it can only be imperfectly known because of the limitations and biases of the researcher. Constructivist research (also called 'interpretive' or 'naturalistic') considers that the nature of reality is a social construction and that it is the role of the researcher to make sense of the multiple social constructions. Emancipatory research (e.g. feminist approaches) is critical of post-positive and constructivist approaches because it perceives relatively powerful experts undertaking research with relatively powerless people, and looks for ways to correct this imbalance.

The research described in this thesis is heavily influenced by the constructivist perspective and a belief that knowledge of the world can not be truly objective, but that meaning and understanding are constructed individually and that shared understandings can be reached through discussion with others. The philosophy of research implemented in this work stems from this, with a belief that educational research can never be entirely objective and that the nature of truth is influenced by those who perceive it. The types of data examined in this research reflect this philosophical viewpoint in that they focus on individuals' perceptions of their experiences, their feelings and beliefs.

While this thesis is based on a belief in the subjective, or individually constructed, nature of educational research, an equally strong belief is held that it is the duty of researchers to acknowledge and take account of, within appropriate ethical frameworks, the influence of the beliefs and values of the researcher on the implementation of the research methods and on the interpretation of the results. Although the data examined during this research are almost exclusively qualitative, focusing on the perceptions of participants, both qualitative (e.g. interview) and quantitative (e.g. Lickert questionnaire) data collection and analysis methods are used, with the aim of triangulating the findings of the research.

Above all, this thesis is underpinned by the belief that all research, whether it originates from a quantitative or qualitative tradition, should be carried out with rigour and integrity, acknowledging and understanding both its bias and its limitations. The following section details the research methods used to address each of the research questions described in Chapter 1.

3.2 Research techniques

This section provides an overview of the research techniques used for addressing each of the four research questions, and a rationale for each of the techniques used.

The research draws on both quantitative and qualitative data collection and analysis techniques and these are described in more detail in the sub-sections that follow.

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

The first research question considers the reasons for using computer game-based learning in Higher Education and what the potential benefits might be. Two stages were undertaken to answer this question: first, fact finding about the nature of the domain of computer game-based learning, in-depth and on a small scale, and secondly, testing these findings on a larger scale. The data collection and analysis techniques used to address this question are summarised in Table 3-1 below.

Questions	Data collection	Data analysis
How does the concept of game-based learning in the literature match people's perceptions? What factors motivate people to play games for leisure and learning? Is game-based learning seen as an acceptable way to learn?	Interviews	Thematic analysis Categories of description
How generalisable are these findings to a population? Is there a link between motivation to play games for leisure and motivation to play games to learn?	Survey	Descriptive statistics Chi-squared (X^2) analysis

Table 3-1: Data collection and analysis techniques used to consider the rationale for using computer game-based learning in Higher Education

A series of 12 in-depth interviews with students and ex-students in Higher Education was used as the starting point for this research. It was important to ensure that the concept of game-based learning used in the academic literature matched the perceptions of those people in the population under study, so that the participants and researcher were, in effect, talking a common language. In terms of establishing a rationale for the use of game-based learning, the research explored people's motivations for game-playing both for recreation and leisure and, more fundamentally, to establish whether the use of game-based learning in Higher Education would be seen as an acceptable way to learn. Semi-structured interviews with open-ended questions were used for the first part of this research because the aim was to explore the field of study and the individual perceptions of that domain. The interviews used to initially explore

people's conceptions of game-based learning were based upon the phenomenographic methodology designed to explore individual perceptions of a phenomenon. The interviews were analysed by drawing out themes, and by creating and testing categories of description (Marton, 1981; Marton, 1986). The phenomenographic method was selected because its outputs of categories of description were considered to be an appropriate tool for understanding how different people perceive games and game-playing, which could usefully inform further stages of the research.

In order to test the findings from these interviews on a larger scale and, in particular, consider whether there is any link between motivation to play games for leisure and to learn from games, a larger-scale survey was undertaken with 200 undergraduate and postgraduate students. This survey was used to collect quantitative data on game-playing habits, motivations and preferences, as a practical way of testing the findings from the initial interviews with a larger population. It was analysed using descriptive statistics to present an overview of the data and a X^2 (chi-squared) statistical analysis to examine if there was any relationship between a motivation to play games recreationally and a motivation to learn using games. A X^2 test was appropriate because the data were nominal, that is, the students could be categorised as motivated to learn with games, not motivated either way, or de-motivated (Greene & D'Oliveria, 1993).

More detail about the methods used to conduct these interviews and survey, the results of the analysis and the conclusions drawn can be found in Chapter 4.

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

The second research question examines some of the practical and design issues associated with the development of game-based learning. To answer this question, three areas were addressed: first, the development of criteria to evaluate aspects of game-based learning; second, an analysis of the appropriateness of different game types to game-based learning; and third, a consideration of the usability issues associated with the design of the two game-based applications created as part of this research. A summary of the data collection and analysis methods used is given in Table 3-2 below.

Questions	Data collection	Data analysis
What criteria can be used to evaluate the extent to which an educational computer game embodies sound educational principles? What criteria can be used to evaluate the extent to which an educational game is usable and fit-for-purpose?	Review of secondary sources. Review of existing games.	Synthesis of existing guidelines. Analysis of game design for usability and learning.
What types of game are most appropriate for learning? What activities in Higher Education are most appropriate to be taught with games? Can two specific educational games be designed to include sound educational principles?	Review of literature on games and learning.	Mapping of game characteristics with educational characteristics. Evaluation of game design against learning criteria.
How can the playability, functionality and interface design of two specific computer-based games be improved?	Walkthroughs. Focus groups. Observation.	Categorisation of issues. Evaluation of game against usability criteria.

Table 3-2: Data collection and analysis techniques used to consider how best computer games can be designed to be usable and enhance learning

In order to develop criteria for evaluating the effectiveness of particular computer games for learning, two specific areas were examined: the educational principles embodied within the game and the usability of the game. These criteria were produced by synthesising findings from a review of secondary sources with first-hand data collected from a review of online games. Much has already been written regarding the development of usable and effective educational games, so it was important to review existing research first as a starting point. This was augmented by undertaking a review of online games, for two reasons: first, the development of computer games is a fast-moving field and the games available at any time are likely to be ahead of the published literature; and second, this review provided the opportunity to become immersed in the range of online games available and to generate ideas for the game design and development undertaken. The purpose of developing criteria was to inform and support the game design and development process and enable explicit evaluation during the development process. A full description of the development of evaluative criteria can be found in Chapter 5.

The second area addressed by this research question was which types of game are most suitable for learning and what types of skill or knowledge are most appropriate to be taught using games. The literature review undertaken in Chapter 2 provides a starting point for considering the genres of game that have most potential for learning and the types of skills or knowledge that might most appropriately be taught with games in Higher Education. This provides a rationale for the design of the two game-based learning activities described in Chapter 6, which are then evaluated against the criteria for effective design for learning, as an indicator of their efficacy.

The final aspect of this research question looked at two specific instances of game-based learning (the Time Capsule and Pharaoh's Tomb applications) to determine how game play, the functionality available and the interface design could be improved. A range of data collection methods were used to evaluate the usability of the two activities created because this supported triangulation of the issues collected. Walkthroughs of the applications enabled the participants to talk through their experiences individually, while focus groups gave them the opportunity to discuss their experiences with others and collectively brainstorm and problem-solve solutions, and observations provided indications of behaviour that were sometimes not all that apparent to the participant when immersed in the experience. Findings from the usability studies were categorised and used to address and resolve usability issues. There is an extensive description and discussion of this stage of the research in Chapter 7.

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

This third research question is concerned with ways in which the educational effectiveness of game-based learning could be measured. This involved three separate methods of collecting evidence of learning: the development of a questionnaire to measure engagement; an experiment to compare learning between face-to-face and online versions of the same activity; and an analysis of transcript data to provide evidence of learning. An overview of the data collection and analysis techniques is given in Table 3-3.

Questions	Data collection	Data analysis
How can post-experience engagement be measured with a questionnaire? How can it be ensured that the questionnaire is reliable?	Questionnaire piloting	Kendall's Tau correlation Discrimination power
Is a specific online activity as effective as an equivalent face-to-face one?	Questionnaire	Fisher's exact test
Is there evidence of learning from a specific online activity?	Transcripts	Content analysis

Table 3-3: Data collection and analysis techniques used to consider how the educational effectiveness of computer games might be measured

For reasons discussed in Chapter 8, this research was not primarily concerned with measuring learning as such but with measuring the levels of engagement experienced during an activity. In order to do this, a Likert attitudinal questionnaire was developed to measure engagement. A version of the engagement questionnaire with 42 questions was piloted with 33 participants and was then analysed using a combination of a Kendall's Tau correlation analysis (used to measure correlations between ordinal data) between questions that were supposed to be measuring the same factors, and the discrimination power statistic of each question (Robson, 2002). Those items that were less effective at measuring the intended concepts were removed and a final 18-question questionnaire was developed.

Likert-style questionnaires are commonly used to gather opinion in the field of education, but there are two issues with their design and use. First, it is often the case that questionnaires are developed and used with minimal piloting, statistical analyses, or refinement of questions; second, these type of questionnaires are often analysed inappropriately by assigning a numerical value to each response and using parametric comparative statistics. A major contribution of this work is the production of an attitudinal scale that has been rigorously developed and tested, with an example of analysis using appropriate statistical techniques.

In addition to developing a tool to measure engagement, a self-report learning questionnaire was produced and used to evaluate differences in learning between a face-to-face version of the Time Capsule activity and the online

version. This aimed to provide evidence of the comparative effectiveness of the two activities for learning. Fisher's exact test was used because the data being compared were nominal and could be categorised (i.e. the students were asked to say whether they felt that their learning in an area had increased or whether it had not) but the distribution of expected values meant that a X^2 test was not appropriate in this situation.

Finally, to provide another perspective on the evaluation of learning, as well as evidence for the suitability of the two learning games produced, transcripts from the trials of both the online Time Capsule activity and the Pharaoh's Tomb activity were collected and analysed. This analysis involved scrutinising the content of the transcripts to find evidence of learning, collaboration, and creative problem-solving.

Further detail and descriptions of this section of the research, the methods employed and the results of the analysis can be found in Chapter 8.

3.2.4 How do differences in game design affect the learning experience?

The final part of this research examines the use of two different types of game-based learning activity in a comparative experiment and evaluates the differences in learning and engagement between the two experimental groups. A summary of the data collection methods and data analysis techniques is provided in Table 3-4.

Questions	Data collection	Data analysis
Is there a significant difference in learning between students in each experimental condition?	Self-perception of learning questionnaire	Chi-squared (X^2) analysis
Is there a significant difference in engagement between students in each experimental condition?	Engagement questionnaire	Mann–Whitney test

Table 3-4: Data collection and analysis techniques used to consider how differences in game design can affect the learning experience

Three experimental studies were carried out to address this final research question: two pilot studies (with 15 and 17 participants) and a final study with 79 participants.

In each study the students were split into two groups; approximately half used the Time Capsule activity and half the Pharaoh's Tomb, and at the end of the game they were asked to complete a self-reported learning questionnaire and an engagement questionnaire. The pilot studies aimed to test the software under conditions of many subsequent users and ensure that the games, supporting materials and questionnaires were usable in a teaching situation.

The self-reported learning questionnaire was used as a method of testing what had been learned from completing the activities. For reasons discussed in Chapter 8, this style of questionnaire was used rather than a more usual pre-test/post-test design for measuring learning. Once again, X^2 was used as analysis technique for determining whether there was a significant difference in responses, because the questionnaire asked whether the students perceived they had increased their skills in an area or not (i.e. the students' responses can be categorised).

Engagement with each of the activities was measured with the 18-question Lickert questionnaire that was developed in an earlier stage of the research. The responses to this questionnaire were analysed using the Mann–Whitney test to determine whether there was a significant difference in engagement between the conditions, overall and also in terms of the factors that contribute to engagement. As the responses to the questionnaire were ordinal, the Mann–Whitney test is an appropriate non-parametric statistical test to use when a single variable is being analysed with different participants in two experimental conditions (Greene & D'Oliveria, 1993).

As can be seen from previous sub-sections, a range of different qualitative and quantitative data collection and analysis techniques have been used as part of this research. What the overview in this chapter aims to provide, as well as a summary of methods employed, is evidence of triangulation throughout, where more than one research method has been used to contribute to answering each of the research questions in this thesis, within the practical and ethical limitations of the research. The final section of this chapter considers the ethical issues associated with the research.

3.3 Ethical issues

In this section, the ethical issues that were considered while undertaking this research are discussed, along with the decisions made and the implications of those decisions. The BERA (2004) ethical guidelines for educational research were used as a guiding set of principles that informed this work.

Denscombe (2002) says that it is an important, but easily overlooked, point that any research within a social context should be morally and legally acceptable; that is, it does not break the law and it respects the cultural norms of the society in which it operates. It is affirmed that the research described in this thesis is morally appropriate and does not break the law in any way. It should also be made clear that the researcher is committed to undertaking research with integrity by undertaking and presenting research as faithfully and honestly as possible.

A small amount of funding was received from Manchester Metropolitan University to provide incentives for participants but this was in no way tied to any expectations regarding the research. Other ethical issues are considered under two headings: the rights and interests of the participants; and the issues of informed consent.

3.3.1 Rights and interests of the participants

It is the right of any participant in research to take part knowingly and not to be deceived or have information misrepresented about any aspects of the research, although occasionally a level of deception might be necessary for the research. In the case of four of the participants of one of the usability tests, because there was only one evaluator available, it was necessary for the participants to believe that they were playing the games with two people remotely when in fact there was one person in the next room acting in both of these roles. It was felt that the level of deception was minimal and therefore acceptable in this situation; at the end of each evaluation the participants were debriefed and met the other player. Apart from this one instance, no deception was felt to be appropriate in the case of the research described here, and every effort was made to be as open, honest and transparent as possible.

Research should not discomfort, cause pain or mental stress to the participants (Denscombe, 2002). While it can not be a hundred per cent guaranteed that no participant felt uncomfortable or stressed while undertaking the research, the voluntary nature of participation throughout (see the following sub-section for more detail) and the open way in which the research was conducted and discussed with participants should have helped to put participants at their ease.

The right to privacy of the individuals taking part was also considered, in particular, issues of confidentiality, anonymity and data security. Participants were made aware that all data are treated as confidential and although publications may be generated from this research all results would be presented anonymously and no individual would be able to be identified. All original paper data collection instruments are kept securely and all electronic data, questionnaire results and interview transcripts, are anonymised and stored on a secure computer.

It was also important that at no point was taking part in this research detrimental to participants. This is particularly relevant when alternative experimental conditions were used as a required part of a programme of study, as in the case of the comparative study testing learning between paper-based and online versions and those comparing the Time Capsule and the Pharaoh's Tomb. In all cases there was no reason to believe in advance of the experiment that one experimental condition would benefit the group undertaking that condition more than the other, and it is felt that all groups would have an equivalent educational experience. Where the research took place in scheduled teaching sessions, it was ensured that the learning outcomes of the curriculum matched the learning outcomes of the games used and that there was minimal disruption and class time spent undertaking the research (e.g. completing questionnaires).

3.3.2 Voluntary informed consent

BERA (2004) describe voluntary informed consent as "the condition in which participants in the research understand the process in which they are to be engaged and agree to their participation without any duress, prior to research getting underway" (p 6). In an ideal world, participants would be provided with printed information in advance and be asked to sign a consent form before

undertaking any research; for pragmatic reasons this was not always possible during this research, although it was ensured that all participants were informed about the nature of the research, and made aware of their rights not to participate and to withdraw from the research at any time.

In total, 443 participants took part in various stages of the research. Table 3-5 shows a summary of their involvement, the number who took part in each stage of the research and how they were recruited to take part.

Group	Involvement	Number	Recruitment method
1	Interviews	12	Word of mouth
2	Questionnaires	200	Lecture attendees
3	Usability evaluations	27	Word of mouth
4	Questionnaire pilot	33	Email recruitment
5	F-2-F / online comparison	60	Tutorial attendees
6	Pilot study 1	15	Email recruitment
7	Pilot study 2	17	Tutorial attendees
8	Final study	79	Tutorial attendees

Table 3-5: The groups of participants involved during this research, the nature of their involvement, number and recruitment method

Participants taking part in groups 1 and 3 were recruited by word of mouth and volunteered to take part in the research. All of the participants were informed about the nature of the research and their part in it before they agreed to take part, and because the people involved in these stages of the research spent time in individual contact with the researcher there was ample opportunity for discussion and clarification regarding the research, although they were not provided with written information or asked to sign a consent form.

Students in group 2 were asked to complete a background questionnaire at the end of a lecture. They were given a short talk about the research, provided with the opportunity to ask questions, and asked to complete an anonymous questionnaire. Completing the questionnaire was voluntary and it was not possible to tell which students had or had not completed it, so it is felt to be unlikely they would feel coerced in this situation. While the response rate was

high, it was not absolute so there were some students who chose not to participate.

Participants in group 4, the questionnaire pilot, were recruited by email and undertook the research remotely. The initial email provided written information on the study and those who responded volunteered to take part. A small number of the original participants withdrew from or only partially engaged in this stage of the research, in all cases citing pressure of time. These participants were thanked for their contribution to the research and assured that withdrawal was an acceptable decision for them to make.

Initially, for the first pilot study, group 6, incentives of book tokens were offered to students, which were felt to be appropriate and commensurate with the amount of effort required. These participants were informed by email of the nature of the research and asked to sign a form showing that they consented to taking part in the research. However, the tokens offered did not prove to be enough of an incentive to recruit the requisite numbers of participants so an alternative recruitment strategy was adopted for the other experimental studies.

The students in groups 5, 7 and 8 took part in the research as part of their programme of study, so their engagement in the process was not entirely voluntary. In these cases the learning applications were used as part of normal teaching, as their learning outcomes matched those of the curriculum at that stage. It would not have been appropriate to allow these students not to participate in learning activities that were part of their course, but they were given the option not to participate in the aspects relating to the research (e.g. completing the questionnaires). In all of these cases there were severe time limitations and it was simply not practical to distribute written material and consent forms; however, in each case the students were given a short presentation on the research, provided with the opportunity to ask questions and made aware of their right not to take part in the research.

During these sessions, the researcher was leading the class so would have been perceived in the role of a teacher; it is possible then that some of the students may have felt compelled to complete the questionnaires, despite

reassurances that participation was non-compulsory. This is a difficult ethical issue that occurs when undertaking research in genuine classroom settings. In the case of this research it was felt to be a justifiable risk as the difficulty in recruiting participants voluntarily meant that there was little option but to undertake the experiments during scheduled teaching sessions.

This chapter has considered the philosophical standpoint that underpins the research described in this thesis; it has restated the research questions and described and attempted to justify the data collection and analysis techniques that were used at each stage of the research to answer these questions; finally the chapter presented a range of ethical issues that were considered as part of this research. The next chapter starts to describe in detail the original research carried out by presenting the initial interview and survey data used to address the question of rationale for game-based learning.

4 Background research

To start this investigation into computer game-based learning, a background study was undertaken to enable the researcher to find out more about the area by talking to people first-hand, and to examine variation of opinion and perception as regards game playing. More crucially, this study aimed to provide evidence that computer game-based learning would actually be perceived as an acceptable way to learn by students in Higher Education.

The first part of this study consisted of a series of interviews with students and individuals who had previously studied in Higher Education, which aimed to examine their definitions of games, their motivations for playing games and their attitudes towards game-based learning in education. The interviews were followed up by the use of a survey questionnaire with 200 undergraduate and postgraduate students, with the intention of examining how representative the opinions expressed in the interviews were in a student population.

This chapter describes these two areas of work, first discussing the background interviews, the research methods used and the results, then reporting on the survey that was employed and its findings, and finally discussing the implications of these results for the rest of the research.

4.1 Interviews

A series of interviews were conducted, the main objective of which was to develop a wider understanding of the range of people's attitudes to and perceptions of games and computer gaming. These interviews also aimed to investigate the veracity of the assumption that a majority of people find games intrinsically motivating, which is common in the literature on game-based learning (see, for example, Prensky, 2001; Oblinger, 2004), and sought to discover whether people who were not intrinsically motivated by games were open to the potential of game-based ways of learning and computer-based learning.

Overall, the interviews were designed to attempt to consider how the concept of game-based learning and characteristics of games in the literature match people's perceptions, what factors motivate people to play games for leisure and learning, and whether game-based learning is seen as an acceptable way to learn by people studying at the level of Higher Education.

The method for data collection and analysis of the initial set of interviews was based upon the phenomenographic methodology. Phenomenography is a research approach developed during the early 1970s, with its roots in a series of studies on learning carried out with students at the University of Göteborg in Sweden. It is designed to answer questions about how different people perceive different aspects of reality, particularly in the field of education. Marton (1986) describes phenomenography as "...a research method for mapping the qualitatively different ways in which people experience, conceptualize, perceive, and understand various aspects of, and phenomena in, the world around them". The aim of phenomenography is not to make statements about the world but about people's conceptions of the world. It is interested in investigating how people perceive the world around them and categorising the different conceptions people have about the object of interest, and does not try to characterise reality, but how reality is perceived by an individual (Marton, 1981). This methodology was selected because it provides a structured approach to the analysis of interviews, and focuses on specific outputs, which were considered appropriate for considering the different conceptions that exist regarding game-playing.

The primary outcomes of phenomenographic research are categorisations of description, which look at the range of ways in which people perceive a phenomenon. The primary method of data collection is open-ended interviews, which allow discussion of many possible areas and let the interviewees talk about the subject from their own points of reference. The interviews are then transcribed in full, to provide the source material from which the categories of description are derived. The analysis looks for the most distinctive categories that appear in the data to identify significant differences in the ways that people view some part of the world.

The phenomenon of adult game playing and how it is perceived by different people was thought to be an appropriate topic for the use of phenomenographic methods, but this stage of the research is described as a mini-phenomenography because it was not carried out with the large number of participants normally used for this type of study. It was felt that a small number of participants would be appropriate in this instance to get a feel for the subject, and the initial work is backed up with a quantitative survey with a larger population.

Twelve interviews were conducted, with interviewees selected from colleagues and people known to the researcher, all of whom were either currently studying in Higher Education or who had previously studied to at least first degree level. Twelve was felt to be a sufficient number to draw out themes and opinions without making the amount of interviews unmanageable. There were an equal number of male and female participants, with the ages of the participants falling into all categories from 20–29 to 60+ years, with the greatest number falling into the 30–39 years age bracket.

Half of the individuals who took part in the study considered themselves 'game players' and half saw themselves as 'non-game players' (i.e. people who play games by choice as a matter of course and those who do not). Whether participants considered themselves to be game players or not was, of course, strongly influenced by what an individual perceived a game to be, which was not the same for all participants, but in all cases fell under the broad definition discussed in Chapter 2 (see Table 4-1). Since the purpose of this initial research was to find out what people perceived the characteristics of a game to be as well as their personal motivations, the important fact is not that there were exact numbers of game players and non-game players but that a range of opinion was represented.

Each interview lasted between 30 and 90 minutes and covered the areas of background information, attitudes to games and gaming, other leisure activities, and attitudes to learning. In addition, a crib sheet of games and activities was used as a memory-jogger to get the participants to think about areas that they may have missed during the main interview (see Appendix 1). Although there

were set questions, the aim of the interviews was for the format to be as unstructured and open as possible, so the actual questions and lines of discussion varied from interview to interview as different themes and topics were brought up by the participants.

The interviews were transcribed so that data would not be lost during the analysis, and so that there would be less reliance on the memory and initial interpretations of the individual carrying out the analysis. Example segments from transcribed interviews are available in Appendix 2. The interview transcripts were analysed iteratively, initially examining them to draw out themes and hypothetical categories of description, then re-analysing to test statements in the interviews against the proposed framework, until a coherent set of categories were arrived at that accounted for the perceptions of all individuals interviewed.

4.1.1 The characteristics of games

There is considerable variation in how a 'game' is defined in academic research; therefore an important starting point for this research was to compare the definitions in literature with the definitions derived from the target group, to reach a final definition. Without establishing what a game is for the purposes of this study it would be impossible to distinguish between a game and a non-game.

The analysis of the literature in Chapter 2 discusses a number of characteristics that are common in definitions of a game. These are challenge, difficulty, fantasy, goals, exploration, interaction, outcomes, people, rules, and safety. The interview transcripts were analysed to identify elements of the definitions used by the interviewees that matched the characteristics described in Chapter 2. For example, participant H said:

> [a game is] something you do to amuse yourself, and other people... you get bits and pieces and things, and you try and win...

In this example, amusement is mapped to fun, other people are directly referred to, and reference to the concept of winning is seen to imply that an element of competition is necessary. Table 4-1 below shows this mapping of

characteristics of games (taken from Table 2-1 in Chapter 2) against the definitions offered by the interviewees.

Characteristics	Interviewees											
	A	B	C	D	E	F	G	H	I	J	K	L
Competition			x	x	x	x		x		x	x	
Difficulty	x		x	x			x		x	x		
Exploration							x					
Fantasy												
Goals		x								x		
Interaction							x				x	
Outcomes		x							x			x
People		x	x	x		x		x	x		x	x
Rules											x	
Safety		x									x	

Table 4-1: Game characteristics mapped against the perceptions of 12 interviewees (A–L)

It can be seen from this table that the characteristics most commonly cited were competition, a level of difficulty or challenge, and other people. The other characteristic that was most commonly mentioned (by half of the participants), but which was not included in the initial framework of characteristics, was 'fun'. The only characteristic not mentioned by any of the interviewees is 'fantasy', the concept of having a make-believe element. However, it is not altogether surprising that this characteristic was overlooked by the group, as it is a characteristic that may more commonly be associated with children's games than with adults. Each of the other characteristics was mentioned at least once, providing evidence that these are all factors that people in the group under study associate with games. The combinations of characteristics that were considered to define a game, however, were extremely varied, even in this small sample, which supports the use of an inclusive definition of games in the context of game-based learning.

It appears that there are two ways of looking at the definition of a game: as something intrinsic to the game itself (i.e. this activity is a game) or as a perception of the person engaged in that activity (i.e. this activity is a game for

that person, at that time). If the concept of 'fun' is used to define a game, the second view must necessarily be used, as fun is an individual perception. As interviewee A says:

> … it's difficult to say what's enjoyable 'cause it's different for different people … some people enjoy card games on their own, other people find that deathly dull. So it really depends on the context of the person.

For example, many people would agree that Chess is a game, but for someone with no interest in Chess it may hold no fun. If the second stance is taken, it is questionable then whether Chess can be defined as a game, and in effect, it becomes impossible to actually define any activity as a game. For this reason, this research takes the view that the state of being a 'game' is intrinsic to the game itself and, although fun might be the sole purpose of many games, it is not used as a defining characteristic here. For the people interviewed there seems to be a definite association of games with recreation and not with work or learning, which may influence their willingness to consider computer-based educational games as a valid way to learn. While these interviews were undertaken with a small sample of participants, it certainly provides further evidence that adults may not be as predisposed to find games motivating for learning as is assumed in the literature.

4.1.2 Games and motivation

From the interviews, it was clear, and perhaps unsurprising, that the participants who considered themselves to be game players had different motivations for playing games than those who did not. Among the game players, three distinct motivations for playing games emerged, which led to three categories of description. All of the people who considered themselves game players appeared to fall predominantly into one of these categories, although they are not mutually exclusive: Cerebral Gamers, Social Gamers, and Physical Gamers.

The people who did not consider themselves to be game players, did not, however, never play games. There appeared to be two circumstances in which they would play games: boredom and social facilitation.

Cerebral Gamers play predominantly for the intellectual challenge. They like to solve puzzles and problem-solving games and may also be interested in crosswords and quizzes. For example:

> 'I enjoy games with problem-solving in them mainly, quests, finding things, solving mysteries.' (Participant I)

Social Gamers play primarily for the social interaction and being with other people. They will tend to play team games, board games, and multi-player computer games. For example:

> '…I would play with my friends whereas I wouldn't play with other people' (Participant A)

Physical Gamers play primarily for the exercise and physical exertion enjoyed when playing. They tend to be involved mainly in sporting games. For example:

> '…it's good exercise and at the same time you're getting something out of it' (Participant B)

Other reasons for playing games that were mentioned in the interviews, such as a need to win, relaxation, and escapism, are not included in this framework because they were not the primary motivation for game playing, but seem to be secondary motivations that are present across all three of the game player categories.

The participants in the study who perceived themselves as non-gamers tended to only play games in two situations: where the game is used as a social facilitator, perhaps in an awkward gathering or as a way of getting to know people, or when they are looking for an activity to counter boredom, usually for short periods of time. The game players were also motivated to play games for these reasons but they were not their primary motivations.

Motivating and demotivating factors

Six factors emerged during the course of the interviews that appeared to be motivating (two factors) or demotivating (four factors) for games and activities in general, for both game players and non-game players alike.

The two motivating factors were:

- being able to see swift and steady improvement; and
- a perception of being good at an activity.

The ability to undertake an activity and see continual and ongoing improvement was seen as an important motivational factor for adults, which is consistent with some of the key research on what makes games motivating for children (Malone, 1980a).

> '[It is good when you can] keep getting your score higher and getting up the levels…' (Participant L)

> 'I do like the challenge of being able to eventually play something that previously I couldn't.' (Participant E)

As well as a perception of improvement, a perception of being good at something was seen as motivating. This may be associated with a feeling of being in control of the activity (Malone & Lepper, 1987) and providing opportunities for success (Dempsey et al, 2002).

> 'I'm good at it … so I like that 'cause I can do it.' (Participant B)

> '[I played the game] because I was good at it.' (Participant J)

The four factors that were considered by all to be demotivating were:

- difficulties in getting started;
- getting stuck during the activity;
- lack of trust in the environment; and
- intrinsic boredom with the subject matter or game itself.

A key theme was the importance of being able to start an activity quickly without having to spend too long learning the rules, etiquette and parameters. An activity that is difficult to get into, without proper helpful instructions appears to

be very demotivating. When people undertake an activity for the first time they are more likely to be bad at it, which is demotivating in itself; it is of increased importance that they can get started quickly and see a swift initial improvement. This supports the assertion of Dempsey and colleagues (2002) that clear, concise instructions and early opportunities for success are important.

> 'I've never got round to actually playing it 'cause it takes a long time to get into and it's probably a bit dull to start off with.' (Participant A)

> 'I don't like the ones where I can't start, I like to at least have some chance of getting somewhere in the game.' (Participant I)

The issue of getting stuck for a long time at a certain point, for instance plateauing in skill level or being unable to solve a puzzle, and not being able to progress, were seen as very demotivating factors, particularly for this group of adult learners who place an extremely high value on their time and do not want to waste it going around in circles.

> 'I kept getting chucked back to the beginning and I'd have to go through the whole lot again.' (Participant H)

> 'I felt I reached a plateau at a very early point and never seemed to get very much better...' (Participant E)

Another demotivating factor, which was mentioned by several of the participants, occurred when an individual felt that he or she had lost trust in the environment of the activity or game itself, that it was perceived to be unfair, or incorrect.

> '[Regarding online gambling] I think it'd be fixed for a start.' (Participant A)

> 'I'm not convinced that the answers in Trivial Pursuit are entirely correct.' (Participant C)

A final demotivating factor, and perhaps one that cannot be addressed or countered by any amount of intrinsic motivating factors is a deep-rooted boredom or lack of interest in the underlying subject of any game or activity.

> 'I find racing games on computer really, really boring ... partly 'cause I'm really bad at them partly because they're just so pointless ... it's like having to watch sports on telly, they're so boring they make you queasy.' (Participant G)

> '...a lot of it's about statistics and about, like organising all these things, like how much food the city gets, I don't really care.' (Participant A)

In addition to highlighting a number of factors that appeared to be universally motivating or demotivating, a whole range of additional factors were discussed that appeared to motivate some participants but demotivate others. These are not discussed in any depth here but are mentioned as an outcome of the study and also as a framework for possible further research into the nature of individual preferences regarding gaming motivation.

There were 15 factors that emerged during the interviews, each of which can be thought of as a continuum (see Table 4-2). For a factor to be considered in this analysis it had to have been mentioned by two or more of the interviewees (who could exhibit opinions at any point on the continuum).

Continua	**Description**
Active – passive	The level of involvement in the activity.
Cerebral – non-cerebral	The extent to which an activity is intellectually challenging.
Chance – skill	The degree of random input into the activity.
Competitive – non-competitive	The degree of competition / importance of winning.
Definite end – open end	Whether the activity has a fixed end point.
Easy – difficult	The preferred level of challenge.
Frivolous – serious	The preferred level of playfulness within the activity.
Physical – sedentary	The amount of physical exertion required.
Quick – lengthy	The amount of time an activity takes to complete.
Realistic – fantastic	The amount of realism in an activity.
Relaxing – stimulating	The level of excitement engendered.
Simple – complex	The complexity of the rules of engagement in the activity.
Solitary – social	Whether the activity is undertaken alone or in a group.
Speed-dependent – non-speed-dependent	The degree to which speed of action is important to the activity.
Team – individual	Whether the activity is undertaken collaboratively or as an individual.

Table 4-2: Continua of motivational preferences

It is hypothesised that each individual will have a preference for games at different points along the continua. Some preferences will be static or move little for an individual, and others will be more fluid depending on the particular circumstances and context of the game playing (e.g. mood, purpose, other players, etc.).

While these continua are not used further in this study, they are added here out of interest to highlight the possible range of factors that may influence motivation to take part in games for different individuals, and to highlight a finding from the research on which future studies could be based. Clearly, the factors here are drawn from a small sample and may not be generalisable or mutually exclusive, but they provide an interesting starting point for future research.

4.1.3 Games for learning

It was considered important at this stage of the research to provide some justification – if such evidence existed – for researching further into adult learners and gaming, given that this research does not want to start from the point often used in the literature that games are good for learning because they are intrinsically motivating.

The perceptions of game-based learning were, perhaps surprisingly, positive, even from those who considered themselves non-game players, with all participants saying that they would consider the idea of a game to learn if it was the most effective way to learn something. Many participants added to this saying that they would consider any method if it was the most effective way to learn something.

Even more surprisingly perhaps, only two people out of the twelve said that the fact that they were using a game would be intrinsically motivating. The rest of the respondents were more cautious and the overwhelming opinion was that a game would be considered and, while it might not motivate in itself, it would certainly not put people off if it were seen to be an effective way to learn. Educational games for this group of learners would need to be well designed, have very specific and clearly communicated learning outcomes, and obvious

benefits over other methods of learning. This backs up the theory of adult learners needing to know why they are being taught the way they are and to be self-directing (Knowles, 1998).

4.2 Background Questionnaire

The second part of the study took the results from the 12 in-depth interviews and examined a larger population to see if they still held true. The population used for this study was a group of third-year undergraduate, and Masters-level postgraduate computing students. This group were selected for two reasons: first, the purely pragmatic reason that this was a large group of students that could be easily accessed; and second, it was hypothesised that out of any population of students in Higher Education it was computing students that were most likely to engage with game-based learning. Findings from this group can not be generalised to other groups of students, but if it could not be shown that game-based learning was perceived as an acceptable and appropriate way to learn by this group, then it is very unlikely that results would be more positive in other discipline areas, and there would be very little justification for accepting that this was an appropriate way to teach in Higher Education.

A short questionnaire of 11 questions (see Appendix 3) was designed to examine their gaming preferences, motivations and attitudes towards the use of games in education. This questionnaire was pre-tested with a small number of individuals to ensure question clarity and unambiguity, and revised before being used with the final group of students.

Four classes of students were given the questionnaire, all of whom were taking a Group Project unit: one group consisted of students who had entered the university directly into the third year, and were typically older and had accessed university through a non-traditional route (n=83); two groups were studying at postgraduate level (n=45); and one group were traditional third-year undergraduates (n=72).

The students were asked to complete the questionnaire at the end of a lecture. They were first given a short talk about the nature of the research, provided with the opportunity to ask question, and advised that completion of the

questionnaire was entirely voluntary. The questionnaire was administered on paper and collected during the same session, and it appeared that there was a nearly 100% response rate (although without attendance data it is impossible to be accurate).

The majority of people who completed the questionnaire were young men aged between 20 and 29, which is representative of the total population of the programme. This group might be considered to be more likely to engage with games and educational games (Entertainment Software Association, 2007). Table 4-3 shows the breakdown of ages across the three types of students (direct entry (DE), postgraduate (PG), undergraduate (UG)) and Table 4-4 shows the gender split.

		AGE					
		Under 20	20–29	30–39	40–49	50–59	Total
LEVEL	DE	3	56	18	5	1	83
	PG	1	31	8	4	1	45
	UG	4	62	5	0	1	72
Total		8	149	31	9	3	200

Table 4-3: Breakdown of respondents by age

		SEX		
		Male	Female	Total
LEVEL	DE	68	14	82
	PG	34	8	42
	UG	64	7	71
	Missing			(5)
Total		166	29	200

Table 4-4: Breakdown of respondents by sex

The vast majority (98.5%) of the population had played a computer game at some point previously, while 48.5% still played regularly and 38.5% occasionally. 78% said that they play other types of non-computer game and only 7% play no type of game at all now. This provides strong evidence that this is a group that engages with games in their leisure time and, if the assumptions in the gaming literature are to be believed, would be expected to be motivated by educational games.

4.2.1 Preferred types of game

There was a wide range of types of games played within this group. Figure 4-1 shows the percentage of the students in each group (direct entrants, postgraduates and undergraduates) who reported playing that type of game, as well as the percentage of the group as a whole (total). The graph is ordered by highest overall percentage from left to right.

It is interesting to note that while the two most favoured types overall are first-person shooters and multi-player games, there is much variation in the percentage of players between the groups. In particular, the percentage of postgraduate students who played multi-player games is much smaller than in either the direct entrant or undergraduate students. Also worth noting is that a much greater proportion of the postgraduate students play puzzle games than in the other groups.

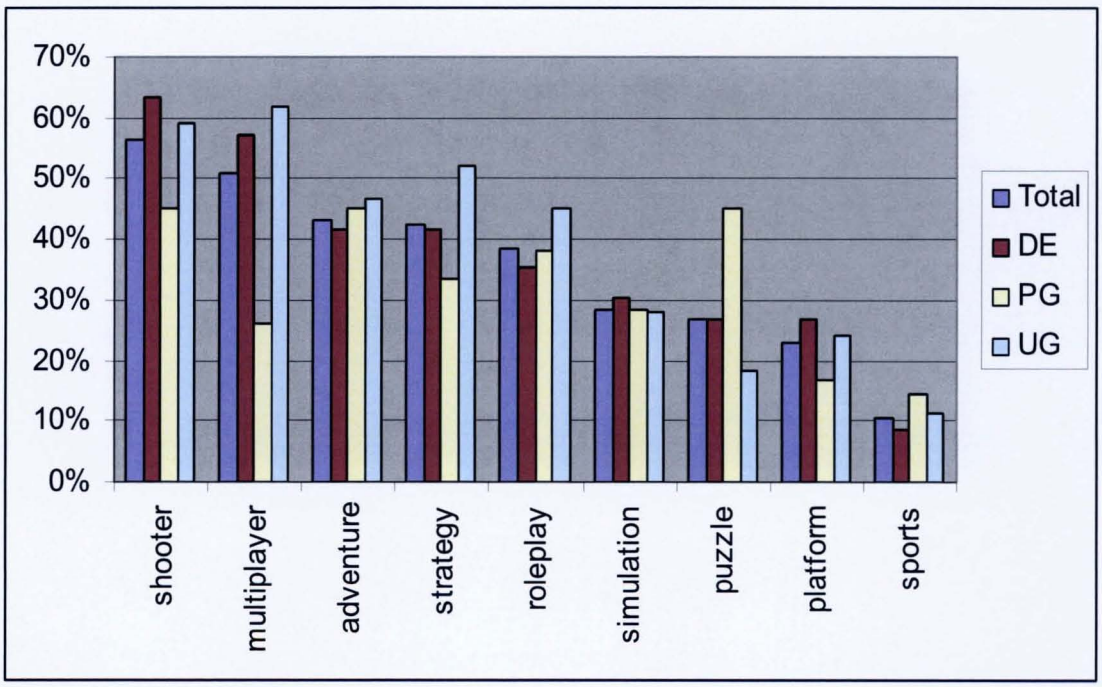

Figure 4-1: Preferred types of game, showing the total percentage and percentage breakdown by direct entrants, postgraduates and undergraduates

So, while the group under study may show a greater propensity to play games, the types of games favoured by students at different levels of study may differ. It is important to note that it cannot be assumed that even when students are motivated to play games, they will be motivated to play the same types of games that might be appropriate for learning, and that there is no guarantee

that the games that the students chose to play in their leisure time are those that they might be most motivated to use for learning.

4.2.2 Motivations for playing games

The students who completed the questionnaire were asked about their motivations for playing games and computer games, based on the types of gaming motivation described in Section 4.1.2. Table 4-5 shows a breakdown of the motivations to play computer games and non-computer games (note that motivations are not mutually exclusive) as a percentage of those students who said that they played that type of game.

	Computer gamers (*n*=174)	Non-computer gamers (*n*=156)
Playing with others	59.8%	66.0%
Mental challenge	58.0%	43.0%
Physical challenge	7.5%	34.0%
Boredom	52.9%	38.0%
Ease social situations	6.3%	16.0%

Table 4-5: Comparison of motivations to play computer games and non-computer games

It can be seen that playing with others and mental challenge are the two most common motivational factors for recreational game playing. This provides some evidence to support the idea of development of a game for learning that involves mental challenge and playing with other people.

There were a small number of additional motivating factors for playing games, offered by the respondents. These included relaxation, escapism, addiction and aesthetics, but these were only mentioned a few times within the population so they are not considered as primary motivations here.

4.2.3 Motivation to learn using games

In order to consider whether game-based learning would be seen as an acceptable, or even motivational, way to learn in this population, the students were asked if they would be positively motivated to learn something with a game, whether they would not be motivated either way, or whether they would find a game demotivating. Table 4-6 shows the breakdown of responses.

		Frequency	Per cent (%)	Valid per cent (%)
Valid	Positively motivating	125	62.5	63.1
	Not motivating either way	56	28.0	28.3
	De-motivating	17	8.5	8.6
	Total	198	99.0	100.0
Missing		2	1.0	
Total		200	100.0	

Table 4-6: Motivation to use games for learning

It is interesting to note that even in a group of predominantly male, predominantly young computing students, who you might expect to be more motivated than other groups to learn with computer games, fewer than two-thirds of the students actually said that using a game to learn would be positively motivating.

It is also an implicit assumption in much of the gaming literature that those people who are motivated to play games in their leisure time will also be motivated to use them to learn. In order to test this assumption, a statistical analysis was carried out to see if there was any link between motivation to play games recreationally and motivation to play games to learn.

Since nominal categories were used (e.g. game player/non-game player), a X^2 (Chi-squared) test was used to examine whether the students who were motivated to play games and computer games in their leisure time were more likely to also be motivated to learn with games. Contingency tables for this analysis are shown in Appendix 4.

When the numbers of students who play computer games recreationally were analysed in relation to the numbers of students who would be motivated to play games to learn, no significant relationship was found (X^2=6.482, *df*=4, *p*=0.166). This was also the case when the numbers of game players were analysed in relation to the numbers motivated to play games to learn (X^2=0.657, *df*=2, *p*=0.720). Therefore, there was no evidence from this survey that there is any relationship between a motivation to play games or computer games for leisure and a motivation to use them for learning.

4.3 Implications

The research described in this chapter has shown that individuals have a wide range of personal definitions of games, largely matching those identified in the literature. This supports the use of the open and inclusive definition of games described in Chapter 2 and used throughout this thesis.

The research described in this chapter also identified primary reasons that people play games; the two most common being for cerebral challenge or social reasons. Since educational games are likely to be collaborative and mentally challenging, it is reassuring that this matches the preference of game players. It is clear from the evidence presented in this chapter that it cannot be assumed that all adults will be motivated by games, or that they will all be motivated by the same types of games, or even that individuals who are motivated to play games in their leisure time will be motivated to learn using them. Of a group who might be considered to be those adults most likely to find educational games motivational, it was discovered that fewer than two-thirds of the group would find them motivational.

In contrast, however, despite it being clear that games were not motivational for all, there is evidence from the interviews conducted that they would still be seen as an acceptable and appropriate way to learn in Higher Education, if they were perceived as being the best and most effective way to learn.

In terms of the rationale for using games, the research described here has shown that simply to rely on the fact that games are motivational is not in itself a sufficient rationale for using a game. Nevertheless, this is not to say that games should not be used in teaching, only that the sole reason for using them should not be because they are perceived to be motivational. The rationale for using games to teach must be that they can embody sound educational principles and have the potential to create experiential and collaborative, immersive and engaging, problem-based learning environments that appropriately map the curriculum. If the game is perceived as being the most effective way to learn something then students will be motivated to use it to learn, not simply because it is a game.

The following chapter starts to investigate the potential of different types of computer game for learning. Through a review of guidelines and an analysis of existing online games, it examines the characteristics of computer game design and interface design that increase usability and support learning, to create two sets of criteria to examine the usefulness of particular games for learning in Higher Education.

5 Developing design criteria

So far, this thesis has examined the literature on games and learning and described a background study that was undertaken to examine the acceptability of this type of learning for students in Higher Education. This has provided a rationale for the use of computer game-based learning, but highlighted the importance of the games used being appropriate and seen as the most effective way to learn. This chapter examines the factors that can influence how pedagogically effective and usable a game-based learning application might be.

One of the aims of the overall research was to design, develop and compare two game-based learning applications, one that is essentially a computerised version of an existing classroom activity and one that is much more game-like, involving navigation of a virtual world and manipulation of objects within that world. As a starting point for designing these activities, it was important to recognise what constitutes good design, both in terms of educational effectiveness and also usability of the application. This chapter aims to present two sets of criteria that can be used to support the creation and evaluation of educational computer games.

First, existing design guidelines in related areas were reviewed and synthesised; these included the design of learning environments, multimedia learning design and game design. Secondly, an evaluation of a number of Internet games was carried out to examine their educational potential and interface characteristics. Finally, these two pieces of work were drawn together to produce two sets of criteria for the design of effective educational games, one focusing on learning design the other on the usability of the interface. The next section describes the evaluation of design guidelines that was undertaken.

5.1 Evaluation of design guidelines

This section presents a review of existing guidelines in three areas related to effective educational online game design: the design of learning environments; the design and use of educational multimedia; and the design of engaging computer-based activities. A short literature review of the guidelines produced in each of these areas is included in the following sub-sections.

5.1.1 Guidelines for designing constructivist learning environments

The currently dominant constructivist learning paradigm (as described in Chapter 2) holds that "learning is a process of people actively constructing knowledge" (Alessi & Trollip, 2001, p 32); certain games can be viewed as constructivist learning environments in that they provide opportunities for collaborative problem-solving in authentic contexts. If educational games are to be effective for supporting learning then it is important that they are underpinned by the principles of constructivist learning environments.

Alessi and Trollip (2001) present 14 principles that, they say, facilitate the production of knowledge from a constructivist view, while Savery and Duffy (1995) present eight instructional principles that in their view derive from constructivism. Hannafin and Land (1997) put forward 11 assumptions about student learning and provide examples of how these can be practically taken account of in constructivist environments, and Jonassen (1999) presents a framework for designing constructivist learning environments. The principles presented in these publications have been drawn together and are presented in the paragraphs that follow.

Active learning and critical thinking. Constructivist learning environments should support active and student-centred learning, by being designed to support and challenge the learner's thinking, encouraging the testing of ideas against alternative views and in alternative contexts. Provision of multiple examples and interpretations to provide multiple perspectives should enable learner construction of information or projects and support learners to accept and reflect on the complexity of the real world.

Learner control and reflection. The emphasis within the environment should be on learning rather than teaching, and the actions and thinking of learners rather than teachers. Students should be given greater ownership of learning activities and the processes used to develop a solution as well as the end products. Learner choice, negotiation of goals, learning strategies and personal evaluation should be emphasised. Personal autonomy and reflection on the learning process should be encouraged on the part of the learners.

Authentic and collaborative learning. Learning activities should be collaborative or co-operative, purposeful, personally relevant to the learners and authentic, so that the learning from the activity is transferable to the real-life context. Activities within the learning environment should be designed to reflect the complexity of the environment in which they should be able to function at the end of learning, and learning activities should be anchored to a larger task or problem.

Supported learning. It is important that the process of learning in constructivist learning environments is supported throughout. Learners should be supported in developing ownership of the overall problem or task, and taking greater control of their learning over time through the use of scaffolding. Opportunities and support should be provided for learner reflection on both the content learned and the learning process, as well as by providing appropriate tools for learners to seek their own knowledge and the use of discovery or guided discovery approaches.

These principles of constructivist learning environments are incorporated in the criteria for developing effective computer-based learning activities in Section 5.3. The following sub-section provides an overview of the literature on multimedia learning and examines how it could support the design and development of educational computer games.

5.1.2 Guidelines for designing educational multimedia

In addition to a consideration of constructivist learning environments in the previous sub-section, an examination of the potential of multimedia to support learning is carried out in this sub-section. The majority of modern computer games make use of a range of media (e.g. audio, video, graphics, animation, virtual worlds), so it is therefore important to investigate the theories associated with multimedia learning in order to assess their application to computer game-based learning.

First, this sub-section describes some of the theoretical approaches that support the use of multiple media in learning, before examining a number of

sets of guidelines that are available in the literature and presenting a summary of factors that improve the educational potential of multimedia.

Dual coding theory (Paivio, 1991) hypothesises that there are two cognitive subsystems, one specialising in non-verbal information and the other dealing with language. Therefore presenting information simultaneously in verbal and non-verbal media should improve learning. Dual coding theory, although widely accepted, is still somewhat controversial and researchers (e.g. Clark & Craig, 1992) have argued that there is not enough evidence to support it.

Mayer (2001) provides evidence to support dual coding theory, brings together the work of himself and others in designing effective educational multimedia and describes a number of principles that are pertinent to its design and, by extension, the design of educational games that use multiple media. Mayer presents a range of multimedia effects, providing evidence that combining the use of words and pictures leads to better learning than using words alone and that the effects are increased when the words and pictures are closely proximal; that extraneous material is best excluded; that animation and narration support learning more than animation and on-screen text; and that design effects are stronger for high-spatial learners than for low-spatial learners, and for low-knowledge learners than for high-knowledge learners. This last finding was echoed by Najjar (1998), who also found evidence that educational multimedia is more effective with learners with low prior knowledge and low aptitude, that educational multimedia is more effective when learners are intrinsically motivated, and that multimedia improves learning more effectively as learners get older.

The theory of external cognition (Scaife & Rogers, 1996) highlights the importance of constructing external representations (e.g. diagrams, highlighting, notes) as an integral part of learning. They argue that the use of these additional external representations can reduce cognitive effort and ease problem-solving. This theory provides evidence of the theoretical educational benefits of interactive multimedia that supports the re-structuring, annotation and alternative representation of material to aid learning. In terms of multimedia

games, this type of external representation could include the use of overviews, notebooks, and maps.

Laurillard (1995) classifies educational multimedia into four types: narrative, discursive, interactive and adaptive; and argues that narrative is least good, and adaptive multimedia is best for supporting learning. Narrative multimedia presents information, and learning is supported through acquisition (e.g. print, video); discursive multimedia supports discussion and negotiation (e.g. tutorials, videoconferencing); interactive multimedia supports learning through discovery and trial-and-error (e.g. simulations); while adaptive multimedia supports learning through a process of guided discovery where the system supports and directs the learning process rather than leading it. It is clear that well-designed computer games have the potential to support discursive, interactive and adaptive learning models.

There is clear evidence for the use of multimedia to support learning, and several sets of guidelines also exist to support the design of effective educational multimedia.

Cates (1992) provides 15 principles for designing more effective multimedia products, while Park and Hannafin (1993) provide 20. Stemler (1997), Najjar (1998), and Lee and Boling (1999) all provide practical considerations of the educational characteristics of multimedia in terms of the user interface and multimedia elements used. The principles described in the following paragraphs are synthesised from they key factors drawn out of these sets of guidelines.

Presentation of information. To ensure effective presentation of information, use the medium that best communicates the information and adds value, use multimedia as a way of focusing and directing attention, and chunk information to aid readability. Use multiple media simultaneously, but aim to avoid information overload, and provide alternative ways of presenting and delivering information.

Visual design. To create an effective visual design keep the screen design clear, aesthetically pleasing, uncluttered and do not use multimedia in a decorative or gratuitous way. Ensure that navigation is obvious and consistent

throughout and that screen design and icon use are consistent. Create opportunities for the user to customise the look and feel of the application.

Support learning. In order to facilitate learning it must be ensured that the multimedia activity matches the intended teaching situation in terms of curriculum, practice and time and that the multimedia learning component is integrated with external tasks to encourage reflection and active processing of information. The interface should be meaningfully interactive and should provide indications of progress, and prompt, appropriate feedback. The application should encourage the development of meta-cognitive skills and provide opportunities for reflection, as well as catering for different levels of prior knowledge and providing structural aids to relate old and new knowledge.

As well as considering the fact that games generally are multimedia environments, it is important not to forget the basic usability principles that apply to the interface design of any computer-based application. Dix and colleagues (1997) describe three usability principles: learnability, the ease with which novice users of a system can use it; flexibility, provision of a range of ways for the user and system to interact; and robustness, the level of support required for successful goal achievement. Benyon and colleagues (2005) present ten usability principles, covering the areas of access, ease of learning and remembering, ease of use, safety and accommodating differences between people and respecting those differences.

The educational multimedia design principles and the usability principles described in this section are drawn together in Section 5.3, where two sets of criteria for evaluating the effectiveness of educational games are described. In the following sub-section guidelines for increasing engagement with educational activities are discussed.

5.1.3 Guidelines for designing engaging learning activities

This sub-section complements the guidelines discussed in the previous sub-section, by examining guidelines that exist for designing learning activities to be engaging.

Malone (1980a; 1980b) carried out some of the earliest work to examine factors that make games engaging. Despite being more than 25 years old, his work is still regularly cited today in papers on game design and engagement (e.g. Sandford & Williamson, 2005; Dickie 2006; Ebner & Holzinger, 2006). Malone argued that there were three factors that made games engaging: appropriate challenge; curiosity in the environment; and immersion in a fantasy. The additional factor of control over the environment was added after subsequent research (Malone & Lepper, 1987). Malone's findings were reported from work with children rather than adults but it still makes intuitive sense that an appropriate challenge that arouses curiosity while providing control over the environment could enhance engagement with adults; the idea of immersion in fantasy is perhaps less compelling.

Jones (1997) also puts forward a number of features of games that he argues lead to increased engagement, which could be applied to computer-based learning environments. He accepts that games do not engage all people, and focuses on the engagement factors in games for people who are engaged by games. The factors that he mentions that create engagement are: (a) production value – the design and look of the educational tool are very important, being fit for purpose but not gratuitous; (b) providing a mix of strategy and 'twitch' (i.e. thinking skills and motor skills), quick movement with immediate feedback coupled with strategy for a greater feeling of accomplishment and satisfaction; (c) 'thinking around corners', where answers are found through research and problem-solving; (d) the environment providing a safe place to learn from mistakes; and (e) immersion in new worlds through believable characters and circumstances, an illusion of reality, and controls that make sense relative to the reality. While it could be argued that many of these factors makes sense in an educational context, particularly as regards research and problem-solving, again it would be more difficult to argue that the use of 'twitch' or motor skills was appropriate to learning in Higher Education.

Lepper and Malone (1987) suggest a number of general principles for increasing the engagement and therefore effectiveness of learning. Their work was carried out with children so is not deemed to be wholly applicable to adults; only the aspects that are considered to be appropriate to adult learning are

included in the following discussion. Lepper (1998) also highlights a number of design principles for promoting intrinsic motivation for instruction and engagement with learning, while in a more recent study by Becta (2001a), a number of factors are described for increasing engagement with learning and for achieving sustained motivation. The principles discussed in these papers have been drawn together and are summarised in the paragraphs below.

Challenge. Learning environments should provide a range of challenges, increasing in difficulty. These challenges should be varied and have appropriate goals in that they are achievable and yet not easy or straightforward to achieve. The challenges should support research and problem-solving, and the motivational goals of completing the challenges must support the learning goals of the challenge (i.e. in order to complete a challenge it is necessary that the requisite learning takes place).

Stimulation. Engagement can be increased by stimulating curiosity by the provision of partial, incomplete or inconsistent information that encourages the learner to make sense of the situation, or by the use of multimedia effects to stimulate sensory curiosity. Applications that can stimulate and induce positive changes to the affective state of the learner are more likely to support learning.

Interaction. Active participation in a learning experience is more likely to engage the learners than passive involvement. Providing control over the learning environment, both in terms of what is being learned and the interface of the learning environment is important, as is regular, prompt and appropriate feedback showing the effects of actions and how near the learner is to the goal.

Contextualisation. To increase engagement, the learning activity must be seen as personally relevant to the user with a clear application of the learning to reality and a range of interaction controls that make sense in relation to reality.

The factors presented here are brought together with the principles highlighted in the previous two sub-sections, and the factors determined in the following section, in Section 5.3 to present two sets of criteria. The next section supplements the principles discovered from the literature by first-hand

evaluation and examines a number of games for their potential as learning environments, and the interface factors that enhance learning or engagement.

5.2 Review of existing games

In order to achieve a better first-hand understanding of the types of popular computer games available and to gain insights into the educational potential of different gaming types, an evaluation was carried out of existing computer games. This review aimed to gain an overview of the types of popular game available; examine the characteristics of these games that contributed positively or negatively to engagement; consider the potential of these entertainment games for education; and emphasise influences for the game-based learning activities to be produced as part of this research.

This review was intended to examine a relatively large number of games quickly to gain an overview of the potential and generate ideas, rather than study a small number of games in depth. Commercial games can be expensive, and are often time-consuming to install and sometimes require several hours of play to simply work through the tutorial, so for the purposes of this study it was decided to focus on freely available web-based games because they are generally quick to learn and to play and because there are a large number available with a wide variation of genre, interface, design and goals. Since this review aimed to examine some of the most popular games available at the time (2004), the Channel 4 Games web site (see http://www.channel4.com/games) was used as a starting point. This web site provides links to many hundreds of games in a variety of genres, which are rated and ranked by the user population.

A large number of web-based games were examined and 16 were selected for further evaluation, based on a number of criteria. The games selected had to be available free on the web, robust, with no obvious errors and continuously available over a period of time, of a type considered appropriate for educational potential (in general, the games selected focused on adventure, role-play, simulations and puzzles), and not solely designed for children.

In addition, for a game to be selected for inclusion in this review it had to manifest one or more characteristics that were considered to be worthy of

further investigation in terms of educational value or interface design. The web addresses of the games used are available in Appendix 5. Each game was played by the researcher for a minimum of 20–30 minutes before noting areas in which the game has educational potential, elements of the game and interface design that were positively or negatively motivational and ideas from the interface that were seen to be useful or innovative and could be implemented in the game-based applications developed as part of this research. Although the views expressed here are clearly the opinions of a single individual, this part of the research was intended to complement the literature reviews already carried out rather than to be used discretely.

Avatar High is a virtual high school simulation game in which the player has to juggle school and friendships. It has educational potential for teaching interpersonal interactions as well as organisational skills by juggling a number of variables simultaneously. It contains a large degree of interactivity, with multiple possible paths through the game, and the graphics are of a high quality. However, it is difficult to get started, the goals are not clear and there is distracting background music.

Bookworm is a word-builder puzzle game, which could be used to teach writing skills such as spelling or vocabulary. It has a simple premise and game design with increasing difficulty and additional features to keep the player engaged. Sound and animation are used but in a limited and appropriate way. Context-sensitive help is provided and there are alternative methods of interaction available. On the negative side, the game is very repetitive and could get boring quickly and may have limited scope.

Bootlegger is a trading simulation that has potential application in teaching basic economics, cause and effect, or the assimilation and use of multiple sources of information. The game makes use of a simple underlying model and it encourages exploration of this model through use of an innovative theme and the addition of occasional events to add interest. However, the usability of the interface is poor, the functionality is not clear and the help is not easy to find and use. The game is also not sufficiently challenging as there is no clear goal and winning or losing is based on a few actions early on in the game.

The Crimson Room is an adventure in which the player must solve puzzles to escape from a series of locked rooms, using the mouse to interact with objects (known as a point-and-click adventure). The potential educational value lies in the areas of lateral thinking and problem-solving. The game has a confusing start but in this case it sets the scene and encourages exploration. The mystery theme is compelling and the game uses simple, but effective, graphics. However, the lack of instructions could be off-putting to a novice, some of the puzzles are obscure, it is easy to miss objects, not straightforward to see what objects can be interacted with, and easy to get stuck and frustrated.

Grow is a puzzle game that encourages learning by trial and error, experimentation and evaluation. It is a very simple game, yet engaging, unique and original, with many correct solutions. However, the goals of the game are not clear (although discovering them is part of the game) and once the game has been solved it is not really repeatable.

Hamlet is a text-based adventure game based around the Shakespeare play. Educationally, it could be used to enable immersion in the plot of Hamlet. The game has a simple interface, but assumes previous knowledge of text adventures, although hints are provided. Because there are no graphics in the game it relies on the story and the game design for engagement. On the negative side, game commands need to be memorised and typing can become slow and repetitive. It is difficult to visualise the game without graphics.

iSketch is a multi-player computer-based version of the popular game Pictionary in which players have to guess what objects other players are drawing. Its educational applications could include teamwork and co-operation, vocabulary, and teaching appropriate behaviour in a social environment. The game involves playing with real people worldwide in a self-regulating community in which everyone gets a chance to participate and there is no need to divulge personal information. There are many options on types of game and levels of difficulty as well as provision of a practice area.

Laser beams is a logic puzzle that involves moving objects to direct lasers. It has applications in logic and problem-solving as well as applying learned rules

to novel situations. The game provides a large selection of puzzles of increasing difficulty but that can be completed in any order; each puzzle has an explicit goal. The first few levels of the game take the role of a tutorial. However, the puzzles do quickly start to become repetitive.

Law and Order II is a mystery adventure game that involves playing the part of a New York crime scene investigator to solve a murder. Educational applications could include teaching of crime scene procedure or problem-solving. The game provides a clear interface, rich in functionality, with use of high-quality audio, video, graphics and other multimedia elements. A negative point is that it is difficult to slow down or speed up the game, which is at times frustrating.

Lemonade is a simple business simulation about running a lemonade stall; it could be used to teach basic economic principles. The game is based on a simple model and enables players to evaluate different strategies (e.g. cost over quality). However, this site contains distracting banner advertising and colour combinations that are hard on the eye.

Mini golf is a multi-player crazy golf simulation. It has educational potential in terms of the simple physics of objects or social interaction. The game is simple to start, but difficult to master, with improvement as the player becomes more skilled. There is ongoing performance feedback as well as a score and there is a best-score board to gauge performance against all players. However, the game is limited to two players, the chat can be distracting to the game and it is frustrating when a single poor hole can affect the entire game.

The Mystery of Time and Space is a point-and-click adventure game, with the potential to teach lateral thinking or problem-solving. It uses simple, but effective graphics, provides the ability to save the game, provides immediate feedback to actions (both on rollover and click) and enables players to chat with other people playing the game. However, the help menu is difficult to find and navigate, some puzzles are difficult and not always logical, and it is possible to achieve things through trial and error without understanding why.

Runescape is a multi-user role-playing game with the potential to teach collaboration, negotiation and other interpersonal skills. It has high levels of interactivity and possible paths of action in a vast virtual world, and is rich in functionality. Characters in the game can be personalised to a high degree but players have to sign up and create usernames. While there is a lot of functionality, the game environment and interface are complex and learning times high.

Samorost is a point-and-click adventure, with potential for teaching problem-solving, which is most notable for its beautiful and unique graphics, originality and intriguing nature. On the negative side, puzzles can not always be solved logically but can be solved through random clicking, there is a lack of feedback and the goals are not clear.

Typer Shark is a typing tutor, designed to teach keyboard skills. It provides clear, attainable, ongoing goals with increasing difficulty. There are statistics at the end of each round and bonuses and regular feedback on accuracy. However, the game is highly repetitive (although that is the nature of the skill being taught) and soon becomes boring. The time constraints add pressure to the game.

Whizzball is a puzzle environment in which a range of objects are used to move a ball across a board. It has potential for teaching creativity and problem-solving. As well as playing existing puzzles it provides the ability to create new ones and share them with a community, where they are rated by other members of the community. In this way the game caters for a whole range of ability. A negative point is that the player cannot develop outside of the system, for example by creating new tools rather than manipulating ones that exist.

Table 5-1 below shows the best characteristics that were seen in each game, which were input into the design criteria developed in the following section and influenced the design of the two game-based learning applications discussed in Chapter 6.

Game	Best characteristics
Avatar High	High level of interactivity. Use of avatars.
Bookworm	Ongoing context-sensitive help. Increasing difficulty and gradual addition of new features. Different ways to interact with the environment.
Bootlegger	Based around a strong and compelling theme.
The Crimson Room	Simple but effective graphics. Encouragement of exploration. Interaction with objects.
Grow	Explorative and provides mystery. Many possible solutions.
Hamlet	Provision of hints and clues. Strong plot and storyline.
iSketch	Player regulation of the environment. Provision of a practice area. Equal opportunity for all in the team to participate anonymously.
Laser beams	Control over order in which game can be completed. Clear goals at each stage of the game. Integrated tutorial area.
Law and Order II	As high quality multimedia as possible. Rich range of functionality. User control of speed.
Lemonade	Simple but compelling basic game design.
Mini golf	Competition with others. Ongoing feedback regarding performance. Easy to start, with increasing difficulty. Steady improvement.
The Mystery of Time and Space	Support from player group. Save game function. Immediate and intrinsic feedback to actions performed on objects.
Runescape	Many possible paths of action. Large world to be explored. Ability to collaborate or compete with others. Personalisation of characters.
Samorost	Mysterious and original. Stimulates curiosity.
Typer Shark	Increasing difficulty. Performance indicators built in to the game. Regular feedback on performance.
Whizzball	Possibility for extending game by creating new levels. Sharing levels with online community.

Table 5-1: Best characteristics from the 16 games reviewed

The examination of these games revealed a number of design principles that supported game play, interface design, engagement, and the potential for learning. These factors are discussed in the following paragraphs.

Game design. Features of game design that were seen as supporting playability and providing the best environment for learning were provision of a multi-player puzzle adventure game with a large world to be explored and a high level of interactivity with characters and objects, based around a theme

with a strong plot and storyline, with multiple possible ways to complete the game, not just a single solution. The game should also have a mystery and explorative element, aiming to make it surprising, original and motivating, and involve elements of competition and collaboration. In terms of support for learning the game, it should provide a training environment where users can learn the game while starting to play but with no consequences, and ongoing context-sensitive help, hints and clues.

Engagement. There are a number of factors that increased engagement, including clear goals at each stage of the game, group and individual, and sub-goals as well as main goals, and performance indicators built into the game and regular feedback on performance provided. The game should be easy to start but with increasing difficulty and addition of new features; players should quickly be able to achieve initial goals and see improvement in performance. The ability to save games should be provided so that progress is not lost. In addition, the use of avatars enables the players to personalise their characters without the need to give away lots of personal information.

Interface design. In terms of the design of the interface, there are a number of lessons that can be learned from this game review. The interface should provide a rich range of functionality and provision of different ways to interact with the environment with player control over which objects or people to interact with and ways in which the game can be completed. It should be apparent what functionality objects posses and provide immediate feedback on actions performed. Graphics should be simple but effective with as high quality multimedia as possible where appropriate (within the limitations of the development and runtime environments).

Educational design. Features that were identified that increased the educational potential of the games examined were the ability of the game to foster learning through problem-solving, decision-making and group interaction, where the game is designed to encourage players to solve problems and work through the game as a group, using online communication media. The environment should also aim to encourage exploration and discovery, possibly with interaction with external web sites. All players should have the opportunity

to interact with the environment and learn to the same potential degree, and social norms and acceptable behavioural standards should be primarily self-regulated.

In the following section these principles are drawn together with the guidelines presented in the previous section to present two sets of criteria for the educational design and interface design of effective game-based learning applications.

5.3 Criteria for designing educational computer games

In this final section of this chapter, the guidelines discussed in Section 5.1 are combined with the factors highlighted in Section 5.2 to produce two sets of objective criteria for the design of game-based learning applications: the first addressing the aspects of the educational design that increase effectiveness for learning, and the second dealing with those elements of the interface design that influence the effectiveness of the application for learning.

Games that are effective for learning are those that apply sound pedagogic principles that are appropriate for the subject being taught. Games that involve problem-solving and constructing an individual understanding, active exploration, collaboration with others and authentic activities supporting the development of skills and knowledge that can be transferred to other situations are those most likely to be effective in an educational context. A variety of game genres, including adventure games, role plays, puzzle or simulation games, commonly have these characteristics.

The first set of criteria consists of six areas that can be used to evaluate the educational design of a game-based learning application. These areas are: the ability of the application to support active learning, the degree to which it is designed to engender engagement, the appropriateness of the application for the learning outcomes to be taught, the degree to which it supports reflection, the extent to which it provides an equitable experience for all participants, and the availability of ongoing support. These criteria are shown in Table 5-2 below.

Criteria	Elements that support fulfilment of the criteria
Supports active learning	Encourages exploration, problem-solving, enquiry. Opportunities for collaboration. Opportunities to test ideas and gain feedback. Opportunities for practice and consolidation. Game goals align with learning goals.
Engenders engagement	Clear and achievable goals throughout. Large world to be explored. High level of interactivity. Multiple possible ways to complete. Stimulates curiosity. Appropriate challenge. Provides control over the learning environment.
Appropriateness	Fits with curriculum and assessment. Appropriate for subject matter. Matches time available. Personally relevant for students.
Supports reflection	Opportunities for reflection. Debriefing on learning. Highlights process of learning.
Provides equitable experience	Accounts for differing prior knowledge. Allows for customisation. Provides equal opportunities to participate.
Provides ongoing support	Orientation and overview. Quick initial success. Gradual introduction of complexity. Hints and clues.

Table 5-2: Criteria for the effective educational design of game-based learning applications, and elements that support fulfilment of each criterion

As well as defining a set of criteria to support educational design, a second set was developed focusing on the interface design of game-based learning applications. This second set of six criteria examines whether the user interface, elements used and interaction models facilitate learning: flexible ways for the user to interact with the environment, support for the development of a collaborative player community, transparent navigation features, features that support the user control of the environment, robustness of design, and appropriate visual design. These criteria are shown in Table 5-3 below.

Criteria	Elements that support fulfilment of the criteria
Flexible interaction	Interaction is purposeful. Feedback is timely and meaningful. Controls are logical and consistent. Performance indicators are built in. Range of interaction methods available.
Support for player community	Self-regulation functionality. Use of avatars. Integrated communication tools.
Transparent navigation	Navigation clear and consistent. Alternative methods of navigation. Help functionality obvious. Overview of position in environment.
User control	Pace and level adjustable. Customisation options. Tasks can be undertaken in any sequence. Instructions obvious and clear. Appropriate and obvious functionality.
Robustness	Recovery from errors. Responsive to input. Context-sensitive help and hints. Ability to save.
Appropriate visual design	Simple, uncluttered and aesthetically pleasing. Information in accessible chunks. Consistent placement between screens. Graphics and multimedia purposeful. Text legible. Pleasing colour scheme.

Table 5-3: Criteria for the effective interface design of game-based learning applications, and elements that support fulfilment of each criterion

This chapter has used both secondary and primary research to develop and present these two sets of criteria to evaluate the elements of educational and interface design that influence the appropriateness of a computer game-based activity for learning. Initially, a review was provided pulling together research on the design of learning environments, principles of multimedia for learning and design of engaging learning activities. Secondly, a first-hand evaluation of 16 online games is described and features in their design discussed.

The following chapter describes the use of the first set of criteria as a basis for designing two game-based learning applications. The second set of criteria was used to evaluate the interfaces of the applications produced, and this is described in Chapter 7.

6 Designing computer game-based learning

One of the main aims of the research described in this thesis was to compare the educational effectiveness of different types of game-based learning. In order to do this, it was important to develop different applications that could be compared, but which were designed with the same learning outcomes and, as far as possible, were designed to implement best practice in educational design. This chapter describes the next stage of this research, which involved applying the literature on games and learning discussed in Chapter 2 and the principles of design for educational game-based learning developed in Chapter 5 to the design and development of two game-based learning applications with different game characteristics (see Table 2-1 in Chapter 2) but with the same intended learning outcomes. The applications developed were the Time Capsule, an online version of a face-to-face group skills activity, and the Pharaoh's Tomb, a collaborative adventure game.

The first section of this chapter examines the genres of game that are most suitable for learning, and the types of skills and subject areas that are potentially more appropriate to be learned with computer game-based applications. From this analysis, it was decided to focus on the creation of collaborative game-based activities to teach and practise the development of basic team working skills, such as negotiation and communication. The second section of this chapter examines issues relating to the design of collaborative online activities, and examines some of the literature on game design.

The third section describes the design of the two game-based applications, the Time Capsule and the Pharaoh's Tomb, presents their learning outcomes, and describes an overview of each of these applications. The final section discusses the extent to which the two designs match the criteria for effective educational design produced in Chapter 5.

6.1 Selecting a game genre and subject area

This research aimed to evaluate the difference in educational effectiveness between two different types of game-based applications, one which was considered to be highly 'game-like' and exhibited all the characteristics of

games, and one that, while having the same learning outcomes, was based on more established ways of teaching the same curriculum. In order to find two applications that differed in design and functionality but had the same learning outcomes and were equivalent in terms of interface characteristics it was decided to create these applications from scratch rather than use pre-existing applications. This also provided the flexibility for the iterative design and development of the applications, their functionality and their interfaces.

The decision to create the applications from scratch meant that there were fewer constraints in terms of the design of the applications, but greater practical constraints in terms of the development time and expertise available. It was important to consider what types of game would be most suitable for learning in Higher Education, and examine what types of skills might be most appropriately learned with games. It was then possible to make a decision about the type of game-based learning applications that were appropriate and could realistically be developed within the scope of the project.

6.1.1 Appropriate games for learning

Chapter 2 provides an overview of a number of learning theories that relate to game-based learning. From these learning theories, five areas were drawn out that represent the characteristics of what, from a constructivist perspective, makes a high-quality effective learning experience. Table 6-1 below shows how these factors map onto the game genres reviewed in Chapter 2. It is worth noting that while these are generalisations based on genre, which may not hold true for specific games, this table does highlight the fact that certain genres of game may be more appropriate for learning than others, and that this is something that should be considered when designing any educational game.

From Table 6-1, it is clear that a number of types of computer game exhibit a whole range of educational characteristics; in particular, adventure games, role plays, simulations and, to a lesser extent, puzzles and strategy games. However, to ensure that any game environment is collaborative, it is important that the game supports collaboration; for example, a multi-player adventure game would, by its very nature, provide the five educational characteristics described. This assertion is backed up in the gaming literature (see for

example, Owens, 1983; Cavallari et al, 1992; Ju & Wagner, 1997). Role-playing games and simulations also offer a great deal of potential in relation to matching characteristics of educational paradigms. Platform games, shooters and sports games appear to offer the least value in an educational context.

Educational Characteristics	**Game genres**							
	Adventure	Platform	Puzzle	Role-play	Shooter	Simulation	Sports	Strategy
Provides context	✓✓✓	✓✓	✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓
Puzzlement	✓✓✓	✓	✓✓✓	✓✓	✓	✓✓	✓	✓✓
Collaborative	✓	✓	✓	✓✓	✓✓	✓	✓	✓
Experiential	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓✓	✓✓✓	✓✓
Problem-based	✓✓✓	✓	✓✓	✓✓✓	✓✓	✓✓✓	✓	✓✓

✓ Possible in this genre ✓✓ Common in this genre ✓✓✓ Always in this genre

Table 6-1: A summary of educational characteristics associated with different game genres

For this research it was decided to create and compare two examples of game-based learning: the first a straightforward computer-based version of a face-to-face activity; and for the second, a multi-player adventure game format was chosen. An adventure game format was chosen because of the close links between adventure games and constructivist learning environments.

Adventure games are set in a virtual, fantasy world of connected locations, containing objects that must be found, manipulated or combined to solve problems. They have an "objective which is more complex than simply catching, shooting, capturing, or escaping, although completion of the objective may involve several or all of these. Objectives usually must be completed in several steps, for example, finding keys and unlocking doors to other areas to retrieve objects needed elsewhere in the game" (Wolf, 2001, p 118). Adventure games involve problem- or puzzle-solving as well as lateral thinking and will usually

have a single solution (although there may be multiple ways of reaching that solution). They can be graphical or text-based, comical or serious, fantastic or realistic, and are usually single-player in design. Many adventure games require mental effort alone, although some have elements of dexterity or timing.

Some examples of the adventure game genre include the first text adventure *Colossal Cave Adventure* (Crowther, 1976) and other early examples such as *The Hobbit* (Mitchell, 1982); the *Secret of Monkey Island* (Gilbert, 1990) and *Gabriel Knight: sins of the fathers* (Jensen, 1993), both of which have generated series that have progressed from 2D graphics to sophisticated 3D worlds; the graphically sophisticated *Myst* (Miller & Miller, 1993) and more recently games that spin off from television series and books, such as *Crime Scene Investigation* (Ubisoft, 2003) and *Harry Potter and the Prisoner of Askaban* (Electronic Arts, 2004).

Adventure games have the potential to facilitate knowledge-construction and problem-solving, as they are primarily based around problem-solving and lateral thinking, and encourage exploration and experiential learning through interactions with objects and people. While there is often a high degree of fantasy, much of the activity is still readily transferable to real-life situations. While adventure games are typically single-player, they are commonly played in pairs, and large online communities have built up around solving particular adventure games. To gain a real-time collaborative element it was felt to be important that the adventure game developed for this research facilitated synchronous multi-user interaction.

Multi-player games typically have specific goals, which can be more easily achieved through collaboration and teamwork, and extensive inbuilt support through in-game help facilities, communities of users, and superusers. The most long-standing type of multi-player game is the *MUD* (originally Multi-User Dungeon and now more usually Multi-User Domain) in which hundreds of players can play simultaneously in a fantasy world, interacting with one another and the environment to solve quests and gain levels using a mixture of puzzle-solving and combat. The original MUDs were text-based only but now three-dimensional virtual worlds in which the player controls an avatar (a character

representing him- or herself) are becoming more common. As well as MUDs, networked first-person shoot-em-ups, such as *Doom* (Romero, 1993), have been common for some time; however, since they all involve violence as an integral aspect, they would be completely inappropriate for education.

Having selected a game genre for development, it was important to ensure that the subject matter and learning outcomes for the game-based activities to be created were appropriate for game-based learning. The next sub-section examines the potential suitable curriculum areas for game-based learning.

6.1.2 Suitable learning outcomes for game-based learning

In this section, the range of skills and subject areas that games could potentially be used to teach are discussed and considered, and a rationale is presented for the selection of the learning outcomes for the games produced as part of this research. Gagné and colleagues (1992) describe five categories of learning, which are shown with examples in Table 6-2 below. These categories show a range of skills that could potentially be taught using computer games.

Category	Examples of performance
Intellectual skill	Demonstrating objective case of pronoun following a preposition.
Cognitive strategy	Rearranging a verbally stated problem by working backward.
Verbal information	Recounting the events of an automobile accident.
Motor skill	Printing the letter 'E'.
Attitude	Choosing to read science fiction.

Table 6-2: Categories of learning (Gagné, 1992)

Computer game-based learning could be used to support the development of all of these capabilities except motor skills, which may be less appropriate to learn with computers, simply because the range of input devices available at present limits the types of motor skills that can be used (although some input devices such as dance mats or drum kits may be used to support acquisition of specific motor skills). Prensky (2001) presents a number of types of learning and relates these to possible game styles; an abridged version is shown in Table 6-3 below.

"Content"	Example	Learning activities	Possible game styles
Facts	Laws	Memorisation Association	Game show competitions Flashcard-type games
Skills	Interviewing	Imitation Coaching Practice	Role-play games Adventure games
Judgment	Ethics	Reviewing cases Asking questions	Role-play games Adventure games
Behaviour	Self-control	Imitation Coaching Practice	Role-play games Multi-player games
Theories	How people learn	Logic Experimentation	Simulation games
Reasoning	Quality analysis	Problem-solving	Puzzles
Process	Auditing	System analysis and deconstruction	Strategy games Simulation games
Procedures	Assembly	Imitation Practice	Timed games Reflex games
Creativity	Product design	Play	Puzzles Invention games
Language	Foreign language	Practice Immersion	Role-play games Flashcard games
Systems	Health care	Understanding principles	Simulation games
Observation	Morale	Observing Feedback	Concentration games Adventure games
Communication	Appropriate language	Imitation Practice	Role-play games Multi-player games

Table 6-3: Types of learning (adapted from Prensky, 2001, p 156)

While Prensky's analysis is at times simplistic and lacking in evidential basis, Table 6-3 does show that games can potentially support a range of different types of learning. This research is based around the constructivist philosophy of learning, which focuses on supporting learners to develop and test their own

understandings of the world, rather than on memorisation of facts. Therefore, it was felt to be more appropriate to focus on learning outcomes that involve development of skills, opinions, attitudes and behaviours, and focus on aspects such as problem-solving, creativity, reasoning, and collaborative skills; showing the application of intellectual skills and cognitive strategies rather than memorisation of facts.

The research design of this project involved the creation of two game-based applications, one based directly on a face-to-face activity but moved into the online environment, and one that is clearly designed as a game and exhibits all of the characteristics of games (see Table 2-1). The previous sub-section considered the types of games that match elements of the constructivist paradigm, and from this analysis it was decided to focus, for the game development, on creation of a multi-player adventure game. This is a genre that has the potential to be active, collaborative, experiential problem-based learning environments.

It was decided to select learning outcomes for the two applications (identical for both) that focused on the development of basic group skills – communication, negotiation and problem-solving. It was felt that the higher-level cognitive skills of application, analysis, synthesis and evaluation (Bloom, 1964) would provide a better match to the types of activity carried out in a multi-user adventure game, and be more meaningful, than using this game format to teach factual information or the acquisition of knowledge. The learning outcomes for the activities focused on understanding the characteristics of an effective group, bring able to communicate and work with others, and being able to problem-solve and reach decisions as a team. It is also important in any educational game that the learning outcomes are closely aligned with the gaming outcomes, so that while students are engaged with the game they are also engaged with the learning.

In addition to being seen to be an appropriate topic and set of skills to teach with collaborative games, this subject area had the advantages that the researcher had experience teaching the subject matter and the learning outcomes are highly transferable across a range of disciplines. It was decided

to create the two games to support students to know what a group is and to be aware of the elements that make a group effective; to appreciate the benefits of working as a group, and be able to communicate and collaborate successfully with others; and to be able to work together successfully to solve problems and reach effective decisions.

As the applications necessarily involve communication and collaborative learning to meet their learning outcomes, it was important to consider some of the issues associated with collaborative learning online; this is done in the following section. This section also examines some of the literature on game design, which supported the design process.

6.2 Designing collaborative games

This section discusses some of the issues that emerge when considering the design process for collaborative computer games. First, issues associated with collaborative online learning are raised, and secondly, the design process for educational games is examined, including ways in which the game design can influence what is learned from games and how games can be designed to be easy to learn themselves.

6.2.1 Collaborative learning online

The Time Capsule and Pharaoh's Tomb applications were both designed to be collaborative (or co-operative, which is used interchangeably here) multi-user online game-based activities. In this section, a range of issues associated with collaborative online learning are considered, and the way in which these have influenced the design of these activities is discussed.

Johnson & Johnson (2003) describe co-operative learning as "the instructional use of small groups so that students work together to maximize their own and each other's learning." (p 488). They say that co-operative learning should ideally be structured so that positive interdependence exists but where there is individual accountability.

Working collaboratively can bring a number of benefits to students, including the ability to work to their strengths, complementing one another, the development of critical thinking skills, the ability to create shared knowledge and meaning,

time taken for reflection and transformative learning by tapping into and developing a range of learning styles, skills and preferences (Palloff & Pratt, 2003). Collaboration assists with deeper levels of knowledge generation, promotes creativity, initiative and critical thinking, and enables learners to create shared learning goals and build the foundations of a learning community. It also addresses all learning styles and preferences, and issues of culture by the application of individual perspectives (Palloff & Pratt, 2005). McConnell (2000) gives an overview of socially orientated theories of learning that provides a rationale for the benefits of co-operative learning. These are: social constructivism, where knowledge is viewed as an individual construction, arrived at through negotiation with others (e.g. Savery & Duffy, 1995); Soviet social-cultural theory, in particular Vygotsky's zone of proximal development, which says that the learning potential working alone is never as great as the potential working collaboratively (e.g. Vygotsky, 1978); and situated cognition, where learning is seen as part of a community of practice and the individual learns by taking part in a cognitive apprenticeship within that community (e.g. Brown et al, 1989).

Online collaborative groups are growing more common in education, particularly with the use of asynchronous discussion tools. These differ from face-to-face groups in that people are geographically dispersed; meetings are continuous in nature and can span much longer time frames; interactions are not immediate; people can contribute at times to suit themselves, at any time of the day or night and from any place; communication usually happens in a slower, more sporadic fashion; there is a permanent record of the group's work; social presence is different from face-to-face meetings; and opportunities to work co-operatively are enhanced (McConnell, 2000, pp 64–65). Romiszowski and Mason (1996, p 439) describe one of the key benefits of computer-mediated communication as "the capability of supporting complex processes of interaction between the participants". The relative anonymity of online communication also provides a more egalitarian platform for students who might be less forthcoming in face-to-face situations (e.g. Mason, 1994; McConnell, 2000). Problems associated with online asynchronous groups include information overload and the difficulties of managing large amounts of messages in different threads. Synchronous online

groups, using real-time messaging, audio and video systems have much more in common with face-to-face groups in terms of temporal factors and social norms.

McConnell (2000) describes a number of important elements for the design of effective online co-operative learning groups.

- The educational process and learning community should be open, learners should be able to make decisions about their own learning within the community, and differences of opinion and diverse viewpoints are seen as an advantage as they engender discussion.

- Students should take greater control and responsibility over their own learning as well as responsibility for supporting others; learners become much more aware of the process of learning.

- The group work should have a real purpose, an authentic task; problem-based learning is very appropriate for this type of task and a high degree of positive interdependence is required.

- An environment should be provided that supports interaction between members, and the group size should be selected to foster interaction (four or five being best).

- Collaborative assessment that supports the group process and consolidates mutual goals should be used, and learners should be involved in assessment; the learning is personal to the learner, and peer and tutor assessment are both appropriate because they have both played a role in the individual's learning.

- The learning process should be regularly reflected on and evaluated.

The ways in which people behave and interact in online groups can differ from face-to-face behaviours. These include a lack of social and interpersonal feedback and unpredictable style of messages causing difficulties (Kiesler et al, 1988) and the "absence of low level social cues and emotions such as body language may influence student learning and interaction" (Vonderwell, 2003, p

79). There is evidence that humour and fun can be key elements in relationship-forming and group dynamics online (Wilson & Whitelock, 1997); however, this can be very culturally specific and so may offend or alienate group members.

Fostering collaboration in an online course is far less straightforward than when students are face-to-face. Rangoonaden and Bordeleau (2000) describe a number of potential problems with online collaboration, including: technical problems; delays across time zones and difficulties in flow of communication with asynchronous discussion; autonomous students prefer individual work whereas collaborative tasks place restraints on their work schedule; diversity in written language, exacerbated by the text-based medium; and course design and assessment that does not reflect the value of collaborative work.

The issues described in this sub-section informed the design of the collaborative games in a number of ways; in particular the decision to develop synchronous activities, and the environment in which it was planned that the games would be used initially. There were three reasons for the decision to create the game-based applications as synchronous applications. First, one of the games was based on a synchronous face-to-face activity and using a synchronous mode made a direct translation of the activity to the online environment possible; secondly, it would be more difficult to carry out user testing asynchronously; and thirdly it was felt that a synchronous game would be more effective for teaching the types of group skills intended, because it more closely simulates face-to-face group interaction. That is not to say that the content could not be taught using an asynchronous mode but that the synchronous mode, if available, would make this easier; of course, this may not always be practical in real – particularly online and distributed – teaching situations. It was also planned to test the games initially in classroom situations (with students still communicating online) rather than at a distance, so that on-the-spot help and support were available to solve any technical issues or problems students were having interacting within the environment.

In the next sub-section, a framework for game design is presented, factors associated with the design of educational games are considered, and issues

associated with learning to play a game (as opposed to learning from a game) are discussed.

6.2.2 Game design for learning

This sub-section considers some of the issues associated with game design in general and with the design of educational games in particular. In addition, issues associated with learning to play the game itself are examined.

Oxland (2004) describes the elements that should go into a design document for an entertainment game that provide a quick overview of a game. These include the game objectives, a summary, character mechanics (motivation, movement, inventory), user interface functionality, game structure (rules, scoring, difficulty, saving/loading, chance conditions, feedback), environment, and multi-player interaction. These elements are used to provide an overview of the design of the activities in Section 6.3.

A single factor that is regarded by many as key to learning from games is the debriefing and post-game discussion (Bredemeir & Greenblat, 1981; Thiagarajan, 1993b). In fact, Thiagarajan and Jasinski, more recently, go as far as to say:

> The game is an excuse for the debrief ... debriefing provides the opportunity for reflection to take place which hopefully will facilitate the transfer of learning from the game to the work context. (Thiagarajan & Jasinski, 2004, online).

Debriefing is an aspect that is frequently not given due consideration in relation to educational computer games, so it is important that the wider context of a game as part of a learning activity is considered. Biggs (1993) describes additional supplementary activities that can be used to improve the effectiveness of games for developing transferable skills, including report writing, presentations, posters, negotiation role play, and ethical dilemmas. Cavallari and colleagues (1992) state that games (in this case adventure games) are best used when integrated into a theme or unit of work, in a cross-curricular manner, and that additional resources (e.g. maps, reference cards, audio cassettes) can enhance the learning experience. Although this work was carried out looking at adventure games, their conclusions make sense when

looking at other gaming types as well. Thus, when designing an educational game, the context in which it is to be used and additional supplementary resources should not be forgotten. Other additional factors that add to the learning with games include the role of the teacher (or computer as teacher) in framing the activity and ensuring that learning outcomes are met, which is seen as crucial for classroom-based learning; and, when existing games are used, working with sections of the game, which may be more effective than working with the whole (Becta, 2001b).

Gredler (1996) notes a number of factors that differentiate educational games from games in general; she argues that educational games should not sanction strategies that involve questionable ethics; chance or random factors should not contribute to winning; winning should depend solely on the application of subject knowledge and/or problem-solving skills. She also highlights that problems can occur when the consequences for giving wrong answers are more interesting than those for right answers (e.g. the game of Hangman).

As well as the learning gained from playing games, it is also important to acknowledge that there is the additional cognitive overhead of learning to play the game itself and, in the case of computer-based games, learning to manipulate and interact with the interface. Computer games are also notable for some of the techniques that they use to allow players to start playing quickly and facilitate the transformation from novice to expert. Houser and DeLoach (1996, 1998) highlight instructional features of games, which, they argue, could be incorporated into all types of software to improve the way in which it is learned. These include: the use of an attract mode with graphics or video that display when the game is not being played to get the attention of potential users and demonstrate what can be accomplished; clearly stated goals; concise instructions provided at intervals throughout the game when required by the user; transparency of controls and functionality, with only controls that are currently available being able to be accessed; performance coaching with necessary information and motivational aids provided when required; the use of 'training wheels' that let users be successful from the beginning as they gain experience; and the provision of consistent feedback through audio and visual cues and continuous scoring.

Hong and Liu (2002) found that the main difference between novice and expert lies in depth of thinking: novices used superficial thinking and concentrated less on problem-solving performance; experts were more analytical, while novices used more trial-and-error. Effectively designed computer games seem to help bridge the gap between novice and expert by helping novices gain experience efficiently. Thiagarajan (1993a) describes three levels of mastery: acquisition where the skill is new and awkward; application where the skill can be transferred to new contexts; and automisation, where the skill can be applied without having to think about it. Table 6-4 summarises how simulation games can be designed for learners at increasing levels of mastery.

	Level of mastery	
Factors	**Acquisition**	**Improving fluency**
Presentation	Walkthrough of the game followed by immediate replay in a similar context.	Rapid drill and practice. Leave the learners to their own devices.
Complexity	Reduce the number of variables.	Increase variables, relevant and irrelevant.
Fidelity	Simplify reality.	Reflect reality closely.
Timing	Slow and deliberate, no time pressure.	Real-world time constraints or faster.
Guidance	Hints, clues and prompts.	Only reference materials provided in the real world.
Motivators	External motivators.	Avoid external motivators.
Divergence	Minimise variation between each problem situation.	Make problems divergent from one another.
Sequencing	Keep the transition between different rounds gradual.	Present problem situations in random order.
Decision-making	Walk through decision-making activities.	Real-world decision-making
Feedback	Provide remedial information.	Feedback in terms of the natural consequences.

Table 6-4: Factors that can be implemented in games to support learners at different levels of skill mastery (from Thiagarajan, 1993a)

Other factors that help novice users learn games and become experts, which are used in the design of computer games, include encouragement of exploratory learning, animated demonstrations, matching the user interface to

the user's skill level, tailoring of colour, help explanations, and the use of default values (McGrenere, 1996).

When designing the two game-based applications (Time Capsule and Pharaoh's Tomb) it was important to consider the additional activities that should take place before and after the game; that is, how the game is framed within the teaching context, to ensure time for reflection and learning from the game. In addition, it was important to consider how the games could be designed to ensure that they were simple to learn and easy to play. The next section describes the design of these two computer game-based learning applications in more detail.

6.3 The Time Capsule and the Pharaoh's Tomb

It was decided to design and develop two different online collaborative applications to teach basic group skills, each with the same learning outcomes (see Sub-section 6.1.2). First, a face-to-face activity called the Time Capsule, was designed, which was heavily influenced by existing activities that are used to teach these skills; then from this, an online version of the activity was designed. While not exhibiting all of the characteristics of games (see Table 2-1), this activity is still classed within the wider definition of 'game-based' learning. Secondly, an online adventure game called the Pharaoh's Tomb was designed.

The purpose of designing two separate activities was to try to evaluate whether there was any educational benefit from using a much more game-like activity that provided an environment to explore and was competitive, as opposed to an application that was a direct translation of a face-to-face activity into the online environment. Before the design process is discussed in detail, the learning material that was developed to support the applications is described. Both applications were based around the same learning material, learning outcomes and de-briefing material.

6.3.1 Learning outcomes and content

The learning content to support the activities is based heavily on the work of Johnson and Johnson (2003), who describe a number of reasons why the study

of small groups is of importance. As humans, we are social creatures and it is in our nature to belong to groups, so membership of groups is an integral part of our lives. Groups are central to our family lives, work lives, education and psychological health. Effective groups have positive social interdependence, where achievement relies on the group working together rather than a single individual, but also individual accountability and personal responsibility, which involve individuals doing their own tasks and helping others do theirs.

Positive social interdependence can be facilitated in a number of ways, for example group members should only be able reach their goals if all other members of the group reach their goals, each group member can have only some of the resources needed to complete the tasks, each group members can be assigned a complementary role and responsibility or members can be bound together by the physical environment (Johnson & Johnson, 2003). The aim has been to design the games described here in such a way that all team members are required to participate and the team goal cannot be met unless all group members work towards it.

Johnson and Johnson (1989) found that groups performing co-operatively performed better on average than those operating competitively, and that co-operation resulted in a greater willingness to take on and persist at difficult tasks, and think creatively, and a greater likelihood of creating positive relationships between diverse individuals within the group. Despite arguing that co-operation is preferable to competition or individualistic efforts in many learning and work groups, they also describe a number of situations when competition can be used effectively, for example when competition takes place within a broader context of positive interdependence and it is between groups, not within groups.

One of the basic tasks of any group is making decisions. Therefore, this area is an important one in terms of multi-player game design, evaluation and provision of learning objectives for the game to be developed. A number of studies have provided evidence that group decisions are more effective than individual decisions. Johnson and Johnson (2003) suggest a number of reasons for this including the fact that there is a process gain, with the group interaction leading

to more ideas and insights; incorrect solutions are more likely to be recognised and rejected; groups have a more accurate memory of facts and events, a higher motivation to achieve and the confidence to make riskier decisions; and involvement in the decision-making process leads to both greater commitment to implement a decision and the changes in behaviour and attitude required to implement it.

Based on this work, the intended learning outcomes for the activities were designed such that by the end of the teaching session, the learners should:

- know what a group is and to be aware of the elements that make a group effective;
- appreciate the benefits of working as a group, and be able to communicate and collaborate successfully with others;
- be able to successfully work together to problem-solve and reach effective decisions.

The Time Capsule and the Pharaoh's Tomb both provide an environment for group discussion, negotiation, problem-solving and decision-making, where all members of the group have to work together to achieve the overall aim. The learning materials developed to support the activities are shown in Appendix 6. All of the activities were designed to fit into a one-hour teaching session; this was the most realistic in terms of actual classroom time that would be devoted to these learning outcomes and this type of activity, and also in terms of what was a reasonable application to develop in the timescale of this research project. The games were originally designed for students to work in groups of three to five, but the practical limitations of the development environment meant that they ended up being limited to groups of three.

6.3.2 Design of the Time Capsule

The design of the Time Capsule online collaborative activity was based on a commonly used type of face-to-face activity for addressing the learning outcomes presented in the previous section. The activity was based on a common scenario-based activity for teaching introductory group skills where students take on the roles of characters in a scenario and have to select, as a

group, a limited number of objects or people. Two of the most famous activities of this type are the hot air balloon and desert island scenarios. In the hot air balloon scenario each member of the team plays the role of a different character trapped in a hot air balloon that is about to crash into a cliff; the group has to agree which person (or people) should be removed from the balloon to save the remaining characters. In the desert island scenario the group is stranded on a dessert island and have to select (or rate) potentially useful items from a list, which is then compared to the predefined 'most useful' list. In both of these cases it is the discussion that takes place during the scenario that forms the basis for a wider discussion about team working and group processes and behaviours.

This type of activity was selected because, as well as being an accepted and commonly used way to meet the intended learning outcomes, it provides an example of a traditional teaching activity that exhibits many characteristics of games, for example it is a difficult activity, with a fantasy element, with clear goals and rules, taking place with other people with a lack of consequences outside of the world of the scenario. A new activity was designed, based on this format, rather than using an existing activity, because it was better if it could be guaranteed that the students using the activity had not used it before, as this could then lead to bias. It was also felt that discussion of objects rather than people was less controversial, particularly in an online environment where there are fewer social cues, and that an activity was needed that did not have a predefined correct answer but that the goal was to reach agreement.

In the Time Capsule activity there are four character roles, three essential, one optional (to allow all players in a class to take part) and each has a briefing sheet containing character information (see Appendix 7). The goal of the group is then to select six items from a total of 30 (see Appendix 8), that cost less than the budget and are agreed by all players (see Appendix 9 for the instructions) in the time allowed (45 minutes). The object list and character profiles are designed in such a way that discussion and compromise is necessary before a decision can be made that will be acceptable to all participants. The activity finishes with a debriefing in groups that examines the outcomes, the group

processes during the activity and the communication that took place in the group (see Appendix 10).

In order to consider how the time capsule activity could be translated into an online version, the framework suggested by Oxland (2004) for providing a design overview was used (see Table 6-5).

Objectives	To select items for a time capsule on which all team members agree.
Summary	Three (or four) local dignitaries have been selected to decide which items should be included in a time capsule. Each character would like certain items to be included and will not agree to the inclusion of other items. A compromise must be reached in which all characters agree.
Character	Each player takes on the role of one of the following characters: • Professor Hilary Dustbuster, local historian; • Felix Grubb, businessman; • Dr Catherine Makewell, local GP; • Titus Bobbins, Lord Mayor (optional). There is no virtual space for the players to navigate. Characters will not have individual inventories but will be able to select from all the objects available. Objects that are currently selected will be highlighted in some way to all players.
User interface	The user interface will enable players to: • view their character information; • see the other characters who are taking part; • select and de-select an object; • provide functionality for reaching agreement; • see the number of items selected and total cost so far; • talk to other players; • see the time remaining to reach a decision.
Game structure	There are a total of 30 items available, from which the characters have to select six. Each item has a price; the total price must not exceed £1000. The game must be completed within a time limit. The game is not scored.
Environment	There is not a virtual environment as such but the interface will allow players to see what items are available and which are selected at any one time.
Multi-player interaction	Players will be able to talk to one another through a synchronous chat facility. Players will be able to see when another player has selected or de-selected an item.

Table 6-5: Overview of the design of the Time Capsule

The learning materials and debriefing activities for the online version of the Time Capsule were the same as for the face-to-face version. A decision was made to keep the instructions and debriefing activities separate and face-to-face in order to reduce the development load. The extent to which this activity design meets the criteria for the effective educational design of game-based learning is considered in the final section of this chapter.

6.3.3 Design of the Pharaoh's Tomb

The second game-based application designed was a multi-player adventure game, which aimed to meet the same learning outcomes as described previously. The aim of the Pharaoh's Tomb is that it would be as 'game-like' as possible, providing a virtual world for the players to explore, navigate around and interact in, with ongoing measured outcomes through scoring, which would also provide a basis for inter-group competition.

As well as having the same intended learning outcomes, this second game used the same learning materials (Appendix 6) and debriefing exercise (Appendix 10). The same game design framework (Oxland, 2004) is used as previously to provide an overview of the design of the Pharaoh's Tomb (see Table 6-6). A more detailed breakdown of the design of the problems is available in Appendix 11.

Objectives	To return a cursed ankh to the Pharaoh's tomb and to all escape.
Summary	The game is set in an Egyptian tomb. The team has to return a sacred Ankh to the Pharaoh in order to lift a curse. The Pharaoh's Tomb consists of a number of rooms, each containing puzzles that the group must solve as a team. This is generally done by picking up, using and combining objects. The puzzles and tasks are designed so that the players need to work together to achieve the goal of the game.
Character	Each player plays a different character in the game, identified by a username, which can be the player's real name or not. Each character has access to a personal inventory but, in order to help ensure collaboration, each person is limited to carrying a single object at a time and each character starts with a different object. Players can move forward and turn around.

User interface	The user interface will enable players to: • view their location and objects in that location; • see a map of all visited locations; • move to other locations; • see the locations of other players; • see objects currently held in the inventory; • pick up objects and put them in the inventory; • put down objects from the inventory; • make objects interact with one another; • see the names of others who are taking part; • see and review information on the current puzzle; • receive hints on the current puzzle; • talk to other players; • see the current score; • see the time remaining.
Game structure	Each player may only carry one object at a time. Feedback will be provided when a player tries an action and is successful. The game must be completed within a time limit. Hints will be provided. Points will be scored for solving puzzles and deducted for using hints.
Environment	The environment is an Egyptian tomb that can be navigated. The tomb contains fixed objects and objects that can be picked up and put down and placed in the inventory. Objects will interact with other objects and can also be combined to form new objects.
Multi-player interaction	Players will be able to talk to one another through a synchronous chat facility. Players can see where others players are located. Objects can be passed between players.

Table 6-6: Overview of the design of the Pharaoh's Tomb

The following chapter contains a description of how the design of both the Pharaoh's Tomb and the Time Capsule was implemented. In the final section of this chapter, the design criteria developed previously are applied to the designs of the two game-based learning applications described in this chapter.

6.4 Applying the educational design criteria

The educational design guidelines described in Section 5.3 highlighted six key criteria that may affect learning: active learning, engagement, appropriateness,

reflection, equity and ongoing support. Both activities are considered below in relation to these educational design criteria.

Supports active learning

In considering the applications in terms of their design for active learning, both provide explicit goals (and the Pharaoh's Tomb has a number of sub-goals) and opportunities for collaboration throughout. The design of both applications is based around exploration and problem-solving, be it exploring a virtual world and solving physical problems or exploring a range of options available and problem-solving through negotiation. Pharaoh's Tomb enables players to test ideas and gain intrinsic feedback on the success of the idea by seeing if it has worked or not, while the Time Capsule lets people test ideas by discussing them with one another and provides feedback that way. Both applications are designed to provide opportunities to practise and consolidate team-working skills, and both are designed in such a way that the gaming outcomes are closely aligned to the learning outcomes, that is, achieving the goals of the game supports rather than detracts from achieving the intended learning outcomes.

Engenders engagement

In terms of supporting engagement, the Pharaoh's Tomb provides a virtual world that can be navigated or explored, with a high level of interactivity between objects.

There are limited multiple paths through the game (e.g. the order in which puzzles are solved) but this is within the overall structure of the way that the game must be completed. An improvement to the game, if it were to be extended, would be to add more objects and provide alternative solutions to puzzles.

The Time Capsule does not require a virtual world to be explored or need such a high level of interactivity, but there are still a large number of objects to examine with properties to investigate. There are many possible ways in which to complete the Time Capsule activity.

Appropriateness

In terms of their appropriateness and fit with curriculum, both activities were designed to take one hour in total, including setting up and debriefing, so as to easily fit into a slot in a teaching timetable. The learning outcomes, which are the same for both, relate to basic team skills, which are transferable across a range of disciplines. A major limitation of both applications was the limitation on group size (three for the Pharaoh's Tomb and three or four as an option for the Time Capsule). This limitation on numbers is a difficult constraint to manage in a real teaching environment but the option is always available for more players to take part if they work in pairs on the same computer.

Supports reflection

The applications are designed for use as part of a teaching session and explicitly allow time for debriefing and reflection at the end. This provides students with the opportunity to talk about their experiences, clear the air about anything that might have happened during the activity, and relate the learning from the session to what they have been doing.

Provides equitable experience

The design of both applications has taken account of the need to make the learning experience equitable for all students. An issue related to this is the lack of ability to customise the applications or make them accessible for students with disabilities; this was not done for these trials because of the additional development and testing time it would have taken and because, in some cases, developing fully accessible software in Adobe Flash is not possible. The workaround proposed for use in the classroom was to pair up people to work with other students when there was an accessibility issue. Issues of language or vocabulary were dealt with by encouraging students to use browser-based applications, such as translators or dictionaries, to support the game.

Neither game may be an equitable experience for students without previous experience of synchronous chat, and the Pharaoh's Tomb, in particular, may be more difficult for students without previous experience of games to get started with or to navigate around. However, the design of both activities aims to ensure that the stronger players will support the weaker ones in order to

achieve the goals of the game, which should help to create a more equitable experience and, again, the option is available for students to work in pairs on the same computer.

Provides ongoing support

Both applications were designed to be as easy to learn as possible, although students with prior experience of this type of adventure game were clearly at an advantage when playing the Pharaoh's Tomb. To support students learning how to use the applications, both provided an instruction sheet to orientate users to the interface and provide an overview of the purpose of the activity (see Appendix 12 and Appendix 13). The Pharaoh's Tomb starts with an easy problem to orientate players to the game and allow them to achieve initial success before gradually increasing the complexity of puzzles; hints are also available at all stages.

The previous discussion demonstrates that both the Time Capsule and the Pharaoh's Tomb applications meet most of the criteria for the design of effective educational games. Issues for further work include the accessibility and customisability of the software and extension for different time periods and number of users.

This chapter has presented a rationale for the types of game that are most appropriate for learning and also for the types of learning outcomes that are most appropriate to be taught with games. Also discussed are issues associated with the design of collaborative activities and educational games; and the designs of two collaborative game-based learning applications for teaching group skills are presented, one based on a face-to-face team-building activity and one with many more game-like features, an adventure game in a virtual environment. Finally, these game designs were evaluated against the criteria for effective game design described in Chapter 5.

The next chapter builds on these designs and describes the iterative development process and cycles of evaluation that took place to develop working prototypes for both of the these game-based applications, which could then be tested and evaluated in real teaching situations.

7 Developing computer game-based learning

This chapter describes the development process for the two examples of game-based learning activities that were presented in Chapter 6: the Time Capsule and the Pharaoh's Tomb. The Pharaoh's Tomb application was developed first because it was more complex in terms of both interface design and programming, with more functionality and potential usability issues. The aim was to carry out the majority of testing on this application and to re-use an adapted and cut-down version of the interface for the Time Capsule, which would aim to achieve, as far as possible, parity in graphic look and feel.

First, this chapter provides an overview of the interface design considerations and a description of the initial design in relation to the functionality requirements described in the previous chapter. A brief overview of the iterative prototyping development method is provided, and there is a discussion of the range of evaluation techniques that were used, their results, and the modifications that were made to the interface because of this. The next section of the chapter goes on to describe how the final interface for the Pharaoh's Tomb was modified and tested for the Time Capsule. Finally, both of the applications are evaluated in relation to the interface design criteria developed in Chapter 5.

The programming and interface design of the two applications was undertaken by the researcher, which enabled a high degree of flexibility in the design of the interface and making subsequent modifications. It was decided to undertake development using Adobe Flash in conjunction with the ElectroServer multi-user server and API. Adobe Flash (formerly Macromedia) is a multimedia authoring system for rapid development and deployment of multimedia applications and games. Graphics and sound can be easily integrated and although there is an initial software cost, applications are free to deploy. Flash does not have multi-user capabilities but a number of multi-user programming interfaces exist that can be integrated easily. An example is the ElectroServer, which is a robust commercial package that supports multi-user interactions and communication and is free for up to 20 concurrent users. This choice of development environment had the main advantages of being relatively inexpensive, familiar to the researcher, and accessible to end users through the commonly used

Shockwave plug-in, while still providing the ability to undertake rapid development cycles and easily integrate graphics.

7.1 Development of the Pharaoh's Tomb

This section provides an overview of the initial interface of the Pharaoh's Tomb in relation to the functional requirements described in Chapter 6 and summarised in Table 7-1 below, and examines some of the issues that had to be considered when developing the initial prototype. The latter part of this section describes the iterative development methodology employed.

Area	Functionality
Navigation and movement	View current location. View map of visited locations. Move between locations. See locations of other players.
Interaction with objects	View objects in current location. See object currently in inventory. Pick up objects from the environment. Place objects in the environment. Make objects interact with each other.
Interaction with other players	See the players that are taking part. Talk to other players.
Status information	See and review information on the current puzzle. Receive hints on the current puzzle. See the current score. See the time remaining.

Table 7-1: Functional requirements of the Pharaoh's Tomb

It was important to use graphics that were appropriate, that were suitable for the style of game and of a quality high enough not to be distracting. In terms of graphic type, there were essentially three options: three-dimensional, two-dimensional and text-based (with or without still graphics). Once Adobe Flash was determined as the development environment, the choice of graphics became clearer. As Flash is essentially a multimedia development environment rather than a game development environment, the graphics would have to be developed and integrated from scratch (i.e. there are no pre-existing graphics libraries for places, people or objects). Flash also does not offer three-

dimensional rendering so it was decided to go for the best possible graphics within the constraints of time and capacity; this was a three-dimensional first-person view using still images rather than dynamic rendering.

An initial decision was made, in order to keep the human–computer interface simple and reduce production time, that the game navigation and interaction should be entirely mouse-driven, while player communication would be driven by the keyboard via a chat facility. For ease of development, a decision was made that the game would be limited to a specific number of players, and three was selected because this was large enough to facilitate the interaction required to meet the learning outcomes, while still being small enough to ensure that the game could be designed so that all players necessarily had to participate to achieve the goal of the game.

Initially, the game was designed around an 8×8 grid so that there were 64 game squares in total. Players could move between squares and change their orientations within a square, making 256 views in total. The initial game grid can be seen in Appendix 14. The first interface for the Pharaoh's Tomb is shown in Figure 7-1 below. The right-hand side is dedicated to player interaction, seeing who is playing and providing a chat facility. The main window in the centre provides a view of the virtual world, and below that (containing a whip in this picture) is the individual's inventory.

This first prototype implemented only basic functionality with the ability to move around, pick up and interact with objects but without much of the supporting functionality such as instructions, help, maps, navigation aids or chat functionality. The aim was first to test the playability of the game in a controlled environment and test the basic concept, navigation and interaction before investing large amounts of time.

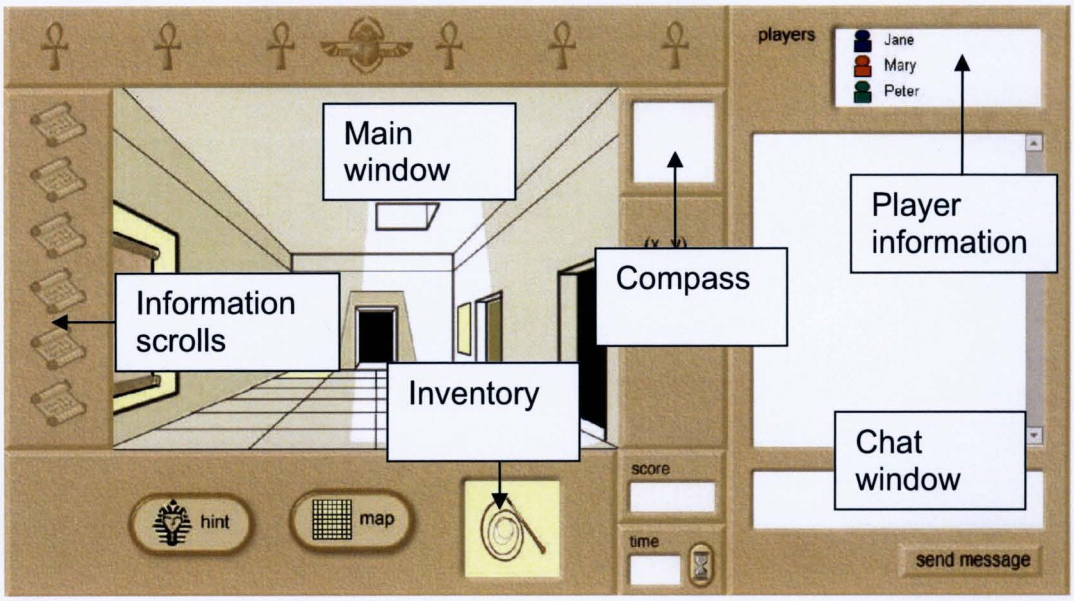

Figure 7-1: Initial interface for the Pharaoh's Tomb

The navigation functionality required that players could see a representation of their present location and objects in that location, which are shown in the main window of the interface. Players move between locations using the mouse, either moving forward or rotating left or right; when the mouse moves to the left, right or centre of the screen the cursor changes into a movement cursor (see Figure 7-2 and Figure 7-3).

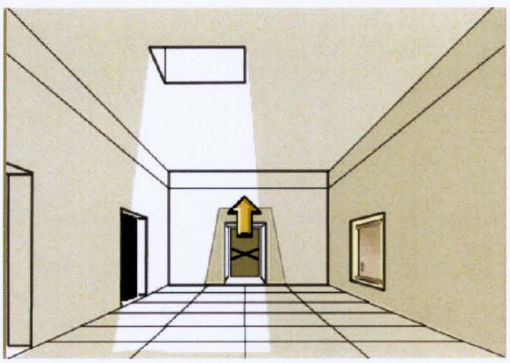

Figure 7-2: Forward navigation in the Pharaoh's Tomb

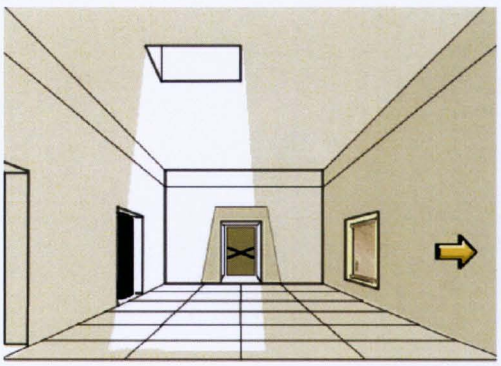

Figure 7-3: Right navigation in the Pharaoh's Tomb

The map was not functional in the first prototype, but in later versions, selecting the Map button displays a two-dimensional grid with markers showing the position of the player as well as the positions of the other players. Only rooms that have been visited by a player are visible on his or her map. Although not available in the first prototype, in later versions a compass is also provided to show the direction in which the player is currently facing.

In order to interact with other players, players need to be able to see who the other players are, be able to see where they are presently located and be able to talk to them. In the Pharaoh's Tomb, the players' names are displayed and each is represented by a different icon. The use of visual avatars was considered, which would allow players to see where the other players were in the main window view of the environment, and to interact with them directly. However, despite these benefits, it was decided not to use avatars because the graphical complexity involved in developing, representing and allowing for customisation of avatars, and the levels of customisation required, were not possible in the timescale of this research. Instead, players can see the position of other players by their positions on the map, represented by their icons. A synchronous chat facility is used to enable players to talk to one another.

Interaction with objects and the environment is facilitated through the use of hotspots, which are virtual areas in the environment where objects can be placed and from where they can be picked up. The concept of hotspots is important as the players need a mechanism to pass items between one another, which would have been straightforward with avatars but these were not being implemented. There are a number of hotspots in different rooms throughout the game environment and these are the only areas in which the players can put down objects.

Each player also has a separate inventory that can hold up to one object at a time. Players manipulate objects by clicking and dragging them towards other objects in the game environment, hotspots or their inventory. When an object is movable a hand cursor appears when the mouse is over it. To make an object interact with another object, one needs to be dragged over the other. Figure 7-4 shows a bucket being moved from a yellow hotspot into the inventory (which currently contains the ankh).

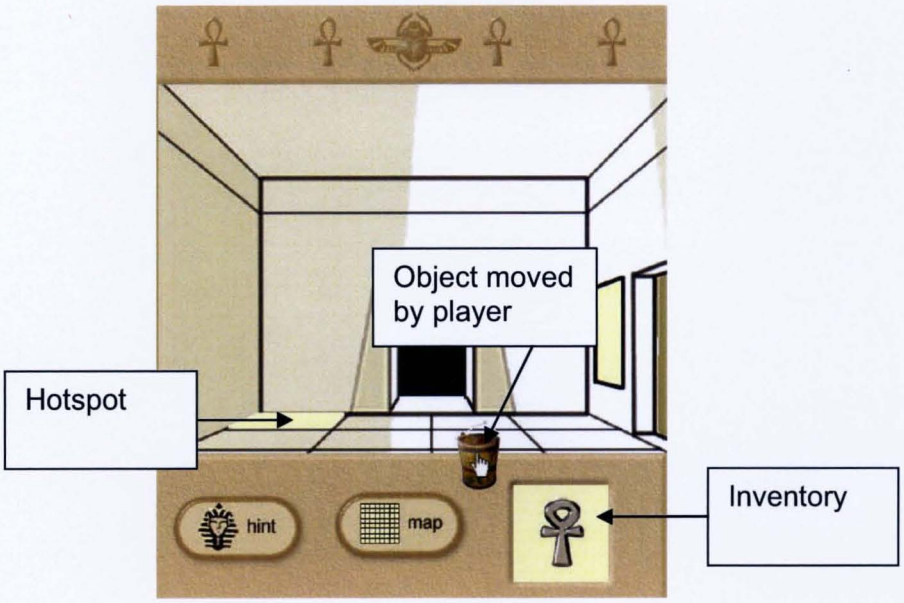

Figure 7-4: Moving a bucket to the inventory

Instructions are provided in each room in the form of a scroll on the wall that can be read by clicking. Once a scroll has been viewed, a scroll icon will highlight on the left of the interface and can be subsequently referred to. There is also a button that will provide hints to the puzzles. Status information is provided in the form of a current score, with points given for solving puzzles and points removed for using hints, and a countdown of the time remaining in which to complete the game.

For the development of the Pharaoh's Tomb it was decided to use an iterative prototyping methodology. Dix and colleagues (1997) describe iterative prototyping as the development of rapid prototypes where each prototype is not discarded but is the basis for the next iteration of development. A decision was made to use iterative prototyping because it allowed the researcher to undertake a number of different types of evaluation and development within a relatively short timescale. The development environment chosen, Adobe Flash, is an appropriate one for this type of methodology as it allows mock-ups to be developed quickly and changes to be made in a relatively straightforward manner.

However, it is also worth noting that although iterative prototyping allows for rapid development, identification of problems early on, with a cycle of testing and modification, there are potential problems with this methodology. These

include the fact that a personal investment in features means that they may be more difficult to discard, and bad initial decisions are kept throughout the iterative process, and that it is important to focus on the underlying reasons for a usability problem, rather than the symptom (Dix, 1997). There were three stages in the iterative design for the development of the Pharaoh's Tomb, examining game-play, functionality and interface usability; these are described in more detail in the following section.

7.2 Evaluation of the Pharaoh's Tomb

This section describes the prototyping and evaluation stages of the Pharaoh's Tomb game. In each of the following sub-sections, a stage of the evaluation is examined, results are discussed and changes made are described. There were three stages in the evaluation of the game interface, the first aiming to use a basic prototype to test game play, the second using a fully functional prototype to test functionality and the third aiming to test the usability and interaction design. The methods used for each of these three stages of evaluation are summarised in Table 7-2 below. The participants during this stage of the evaluation were recruited from the colleagues and friends of the researcher. All were current or ex-students of Higher Education and ranged in age from 20s to 60s; nine of the participants were female, eleven male.

Stage	Purpose	Method	Number of participants
1	Game play	Think-aloud walkthrough Debriefing focus group	6
2	Functionality	Observation Debriefing focus group Transcript analysis	10
3	Interface usability	Think-aloud Wizard-of-Oz walkthroughs	4

Table 7-2: Evaluation phases for the Pharaoh's Tomb

Stage 1 evaluated game play, examining whether the puzzles were logical, solvable, of an appropriate difficulty for the time allowed, and what instructions and hints would be required. Think-aloud guided group walkthroughs were used to evaluate the first prototype, which had only basic functionality. Additional

supporting materials were provided in the form of paper-based instructions and maps. Stage 2 used a fully functioning prototype to test whether the functionality provided in terms of navigation, interaction, communication, and instruction was appropriate and sufficient. These evaluations used observation of the game play, debriefing focus groups with the participants after the game and analysis of the communication transcripts to highlight further issues. The final stage of the evaluations, stage 3, focused on usability and interface design and used individual walkthroughs with a single person taking on the role of each of the other players (a Wizard-of-Oz evaluation), to highlight and discuss remaining interface usability issues.

Stages 1 and 2 of testing required that the evaluation take place with multiple people at the same time and some issues arose associated with the simultaneous participation of multiple users. A major problem throughout this study was the recruitment of participants and this was a particular issue for testing the Pharaoh's Tomb game, which required three players to take part at the same time. This meant that if only two participants attended an evaluation session they could not use the game. It would also not be viable to recruit four players for each session to have one in reserve, as that person would be unable to take part if the other three players turned up. To address this problem, a friend of the researcher was recruited as a stand-in who could take on a nominal third role, undertaking the minimal amount of activity required by that character so as to enable the game to be completed, but leaving the remaining players to solve the problems unaided. The results of this additional player are not included as part of the analysis.

A second issue was that in an ideal situation with multiple participants there would also be multiple observers so that each observer could provide a more detailed picture of the interaction of a participant without fear of missing something. It was not feasible to recruit additional observers for each session, but this was addressed by situating the players close to each other but facing away from each other. The observer was then positioned behind all three participants and could quickly move between one screen and another. Any points highlighted during the observation, questions or clarification could be addressed in the short debriefing session after the game play.

7.2.1 Evaluation 1: Game play

The first set of evaluations was carried out with a basic prototype, which enabled players to move about, pick up and interact with objects and complete the game but the functionality that provided support and status information (such as the time, map, hints) and the chat facility were not operational.

Six evaluators took part in this initial evaluation, working in two groups of three. The focus was on examining whether the game design was playable, feasible and what instructions were required. For each evaluation, the group was introduced to each puzzle in the game verbally by the researcher and allowed to explore the environment to attempt to solve it. Players were seated next to each other and allowed to talk to one another and ask for clues, but they were also asked to think aloud and articulate what they were thinking about the game and each particular puzzle.

Players' comments, as well as observations of interactions in the gaming environment, were noted by the researcher throughout the game play and used as a basis for further discussion during a debriefing at the end of the game session. Programming bugs were also noted by the researcher. A game evaluation note sheet, which was used for each stage of the evaluation, is shown in Appendix 15.

During Stage 1 a number of intermittent bugs in the environment came to light, particularly in relation to the multi-player/object interaction, which caused objects to disappear when two people tried to manipulate the same object at the same time. These bugs had not come to light in previous bug-testing as all testing had been carried out by a single person using multiple copies of the game on a single computer. There was no way to emulate the circumstance of two individuals trying to pick up an object at once. From this point onwards, bug testing was carried out on two computers and using two testers when possible.

The three main objectives of the stage 1 testing were to examine whether the game was achievable within the timeframe, whether each individual puzzle worked and whether the game hung together as a worthwhile experience. In general, the game appeared to function well as a playable game, and although

there were minor bugs throughout the game play, the responses from the players were positive overall. All objects were recognisable and the majority of puzzles were achievable, with the exception of the riddle in the riddle room. The riddle used in the game is based on the Riddle of the Sphinx: 'What has four legs in the morning, two legs in the afternoon, and three legs in the evening?' The answer to this riddle is a person during the stages of his or her life (i.e. crawling as a baby, walking as an adult, and using a stick in old age). An existing riddle was chosen to make it easier for the players, so that players might have heard it before as an alternative to solving from first principles. Before solving the riddle, the team have to work together to decode it from a symbol chart, which is in the next room, so players cannot view the riddle and the chart at the same time (see Figure 7-5 and Figure 7-6).

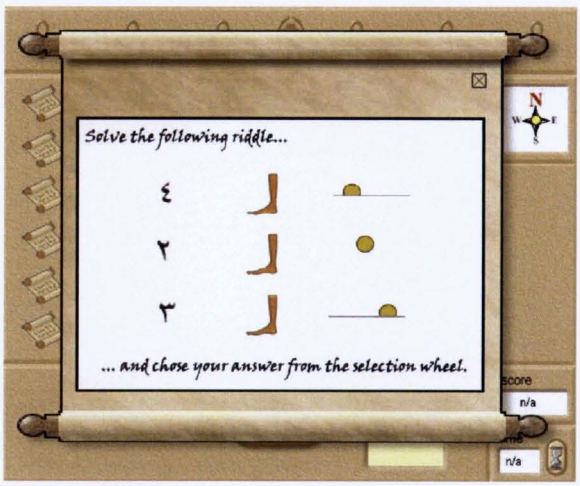

Figure 7-5: The Pharaoh's Tomb riddle presented in code form

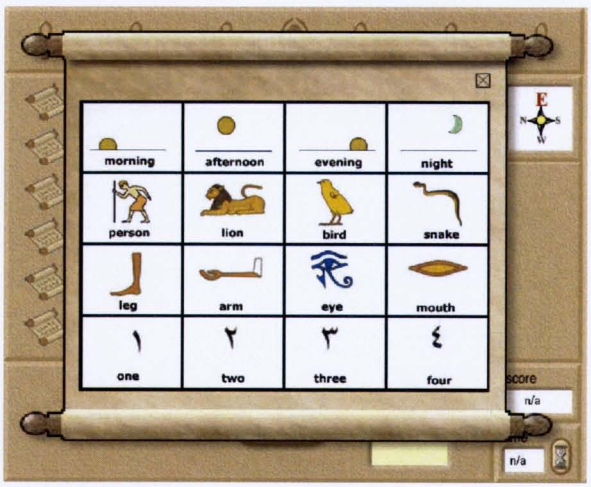

Figure 7-6: The graphical key to the Pharaoh's Tomb riddle code

From the first evaluation it appeared that the riddle was too difficult for many players, although some managed to solve it straight away. In the first prototypes there was no way of progressing if the team could not solve the riddle so, if the researcher were not there to help them, this would have stopped the team continuing and completing the game.

The game took much longer than the planned time in both of the tests. In particular, one puzzle involving placing the ankh in a hole in each room, in addition to completing the puzzle in that room, the players found pointless and it did not seem to add value to the game.

A second puzzle worth mentioning involved opening a combination lock with the combination that was provided on a piece of paper (when turned upside down). This minor puzzle seemed to be disproportionately difficult compared to the other puzzles in the game. Navigation proved to be difficult for many players who found it hard to get their bearings in a large environment with many similar graphics. In particular, rooms that were larger than 1×2 squares (e.g. 2×2 or 2×3) seemed to be particularly difficult to visualise as a complete three-dimensional room and navigate.

Issue	**Solution**
Participants not knowing what an ankh is	Ensure that picture of ankh is included on instruction sheet.
The rotate left and right icons were confusing, being misinterpreted as move left and right.	Replace straight arrows with curved arrows.
Navigation was difficult and participants kept getting lost.	Reduce number of playing rooms from 64 (8×8 grid) to 25 (5×5 grid).
Time spent playing was too long and some of the puzzles seemed to add little.	Remove ankh hole puzzles and paper and combination lock puzzle.
Riddle was too difficult for some.	Allow alternative solution to riddle through trial and error, which reduces score, and provide riddle hints.

Table 7-3: Usability issues arising from Evaluation 1

While the map was not functional in this prototype, players were provided with a paper copy and shown where they were on the map when they requested. The players did not appear to have any trouble interacting with the objects once the inventory had been explained to them. All objects appeared to be recognisable and their function obvious. Table 7-3 (above) shows the key issues that were highlighted in this evaluation, and solutions that were proposed to resolve them.

The prototype was further developed based on the feedback from this set of evaluations and reduced to a much smaller playing area (the new map can be seen in Appendix 16).

7.2.2 Evaluation 2: Functionality

The second set of evaluations used a fully functioning prototype, which had been modified to incorporate the changes and amendments suggested from the first set of evaluations. Ten people took part in the evaluations, which consisted of four trials of the game (in two cases a participant failed to show up for the trial and a stand-in was used).

The aim of this set of trials was to test the range of functionality available, as well as to gain further feedback on the game play and on the usability of the game interface. In each trial, players were asked to communicate with the other players using only the chat facility but they could ask questions or make comments to the researcher who was observing the session. At the end of the session there was an opportunity for each group to debrief and again for the researcher to clarify points and ask additional questions. In addition, the transcripts from the chat facility in each game session were reviewed to highlight any additional issues.

Issues were still apparent with the navigation functionality in the second prototype and many of the players had problems initially navigating the game environment, particularly because they could not view the map at the same time as seeing where they were and because they did not automatically notice the compass. While the majority of participants were able to navigate around the environment once they had been oriented to the navigation controls, one person, who had never played this type of game before, struggled with it

throughout. In the second prototype, the map could be viewed by clicking on the Map button, which would show the map over the viewing area (see Figure 7-7).

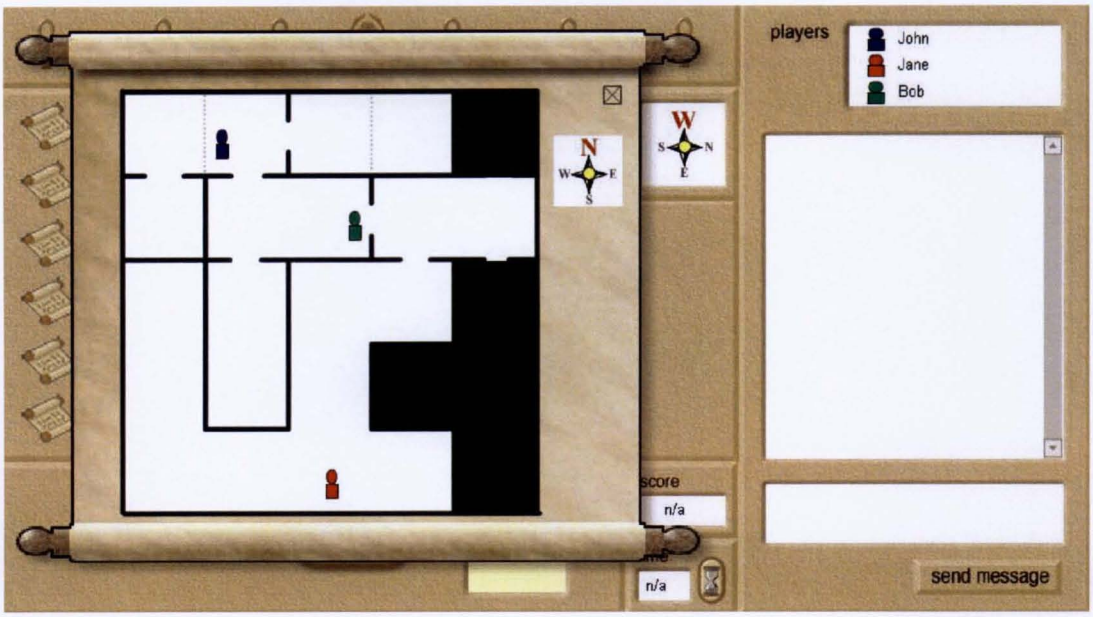

Figure 7-7: Using the map in the Pharaoh's Tomb

Although navigation was clearly easier than in the first trial where the map was paper-based, having to switch between views compounded the navigation problems and made it difficult for players to relate the environment they could see to their positions on the map. The players were each represented by an icon of a different colour on the map, but these proved to be too similar and confusing (also an issue for anyone with colour-blindness). Players who were having navigational problems tended not to make full use of the supporting navigation tools such as the compass and map, but this improved when these tools were pointed out to them. In terms of the game design, it appeared to be easy for one player to be left behind, generally owing to navigational problems, while the other two players worked together to solve the puzzles. A number of changes to the navigation features and game design were suggested, in particular briefing to ensure that the navigation features were noticed, and help to ensure that the navigation of the environment was not detracting from the intended learning outcomes of the game.

Players in this evaluation also had problems understanding how the inventory, which was part of the interface, worked in relation to the actual game world (i.e. that items can be drag-and-dropped between the two). However, this appeared

to be straightforward once they were shown what to do, rather than just reading an instruction. There were also some issues which arose relating to the multi-user nature of object interaction; for example, if one user picked up an object it would appear to another to vanish.

Players were also not accessing the instruction scrolls when they entered each room as they were told to do in the instructions and therefore not reading instructions on what to do in each part of the game. This was particularly problematic in the labyrinth and riddle room, where the instructions were outside the room but the player is locked in on entry, and at the end of the game when an individual leaving the game with the gold would make it impossible for the rest of the team to complete the game.

The issues highlighted in this set of evaluations, and potential solutions, are summarised in Table 7-4 below.

Issue	**Solution**
Navigation difficult	Integrate map into interface. Make icons more distinguishable. Make compass more prominent. Colour map and rooms to match. More characteristic detail added to rooms.
Understanding the inventory	Clearer specific instructions. Naming the inventory.
Not reading scrolls	Show scroll automatically upon entering appropriate area. Warning on exiting the game.
Not working as a full team	Greater emphasis on teamwork in introduction. Scoring structure modified to reward teamwork.

Table 7-4: Usability issues arising from Evaluation 2

At this stage, the interface was re-worked to take account of the issues highlighted above, particularly with regard to the navigation issues. The original and revised interfaces are shown in Figure 7-8.

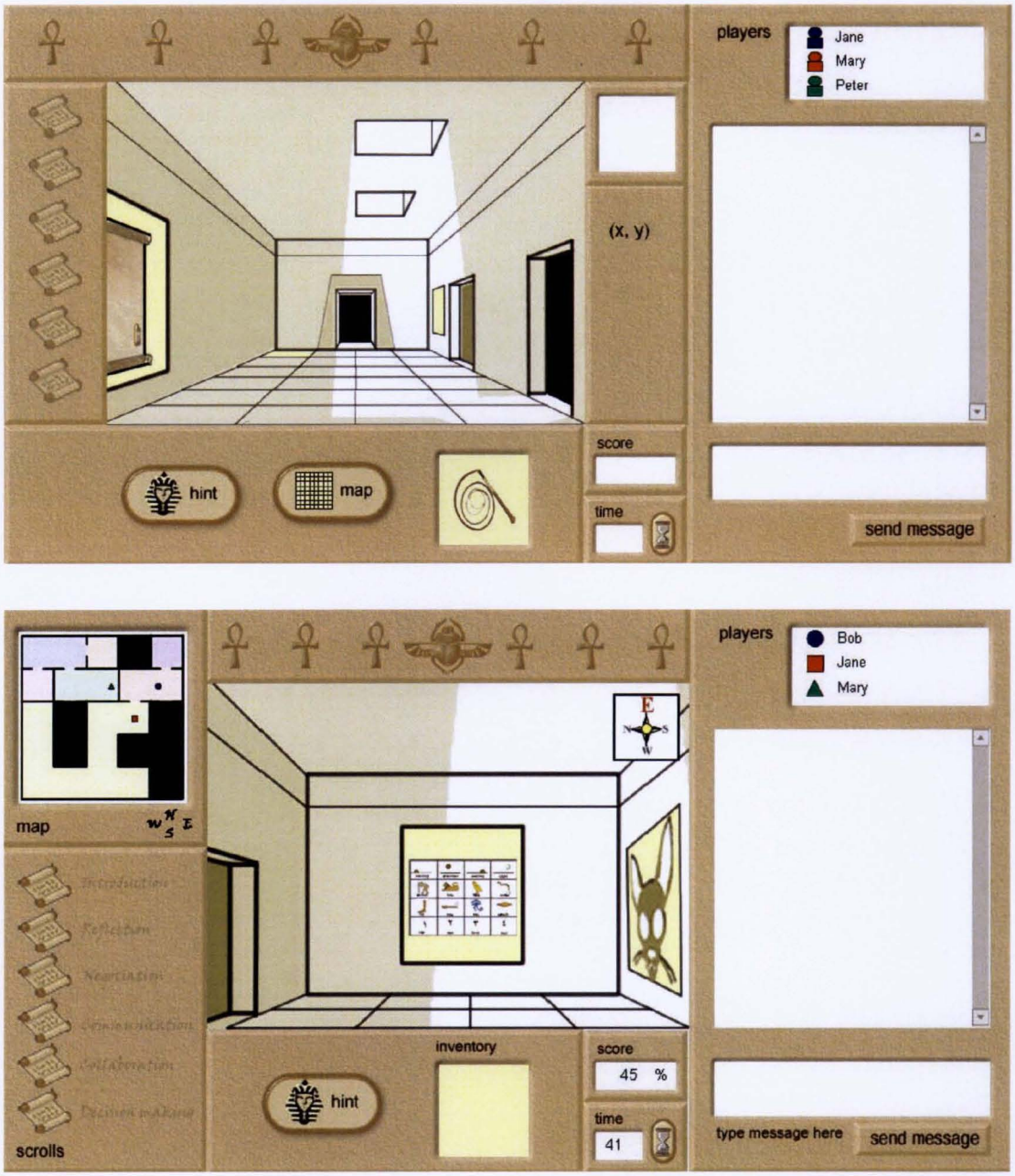

Figure 7-8: Version 1 (top) and version 2 (bottom) of the Pharaoh's Tomb interface

In the revised version of the interface, the map has been integrated rather than being available through a pop-up window and the compass has been integrated into the main window view of the environment. The tools and functions available have been named throughout and the rooms colour-tinted to match the colouring on the map. In addition, the scoring structure was changed so that an individual player could lose points for the whole team, so it is in the interests of all players to communicate with all members of the group and make sure that they are acting as a team.

7.2.3 Evaluation 3: Interface usability

The third stage of evaluation and development examined and refined the user interface and the tools that enable players to navigate, communicate, manipulate objects and solve the puzzles in the game. This set of evaluations was carried out with participants individually, with the researcher sitting next to them, and a volunteer, who was familiar with the game and located in another room, playing the parts of the two other game players. The participant was not aware that the other players were played by the same person at this stage. Four people participated in this stage of the evaluations.

The participants were asked to play the game, interacting with the other 'players' using the chat facility, but to talk aloud to the observer as they did so, making comments on the game itself or on the interface and explaining their chain of thought and the rationale for their actions. This gave the researcher the opportunity to clarify, question or probe at the appropriate time. At the end of each session the participant was introduced to the volunteer playing the other 'players' and given the opportunity to debrief.

Although items such as scrolls, hotspots and the scarab were mentioned in the instructions, pictures of them were not provided and players did not always know what these items were. In particular, participants could not necessarily recognise hotspots when they saw them. At several points during the evaluations the participants were not clear what it was they were supposed to be doing and they were sometimes unclear about whether an action had been effective or not. Participants read the instruction scrolls when they appeared automatically but did not make use of the functionality that allowed them to review them; in discussion, this feature appeared not to be necessary.

Ease of navigation appeared to be vastly improved, even for two of the evaluators who were not familiar or experienced with this type of game. The participants found the adjacent map very useful but still had some difficulties in determining which of the three icons represented themselves and which represented the other players; they also had problems visualising the direction in which they were facing and relating it to the view of the room and their position on the map.

Two issues arose with the external environment of the game. First, several players tried to click with the right mouse button to achieve actions in the game, when in fact this provides access to the functions of the Shockwave player in which the Flash movie is played. Second, two of the participants tried to move back through the game environment by using the browser back button, which removes the participant from the game altogether and necessitates a restart of the game.

The issues that arose in Stage 3, and their proposed solutions are summarised in Table 7-5.

Issue	**Solution**
Recognition of scrolls, hotspots, scarab	Clearer instructions with pictures. Change colour of hotspots.
Unclear instructions	Revise instructions for clarity. Remove review scrolls.
Interactions	Feedback on interactions. Clearer visual feedback on state changes.
Navigation	Make personal icon larger and central. Show direction of icons on map.
External environment	Disable right-click functionality. Open in browser without external controls.

Table 7-5: Issues arising from Evaluation 3

A final set of changes was made to the game, based on the feedback received from the third set of evaluations. A comparison of the second and the final versions of the interface is shown in Figure 7-9 below. A range of additional screenshots showing various aspects of the final game is shown in Appendix 17.

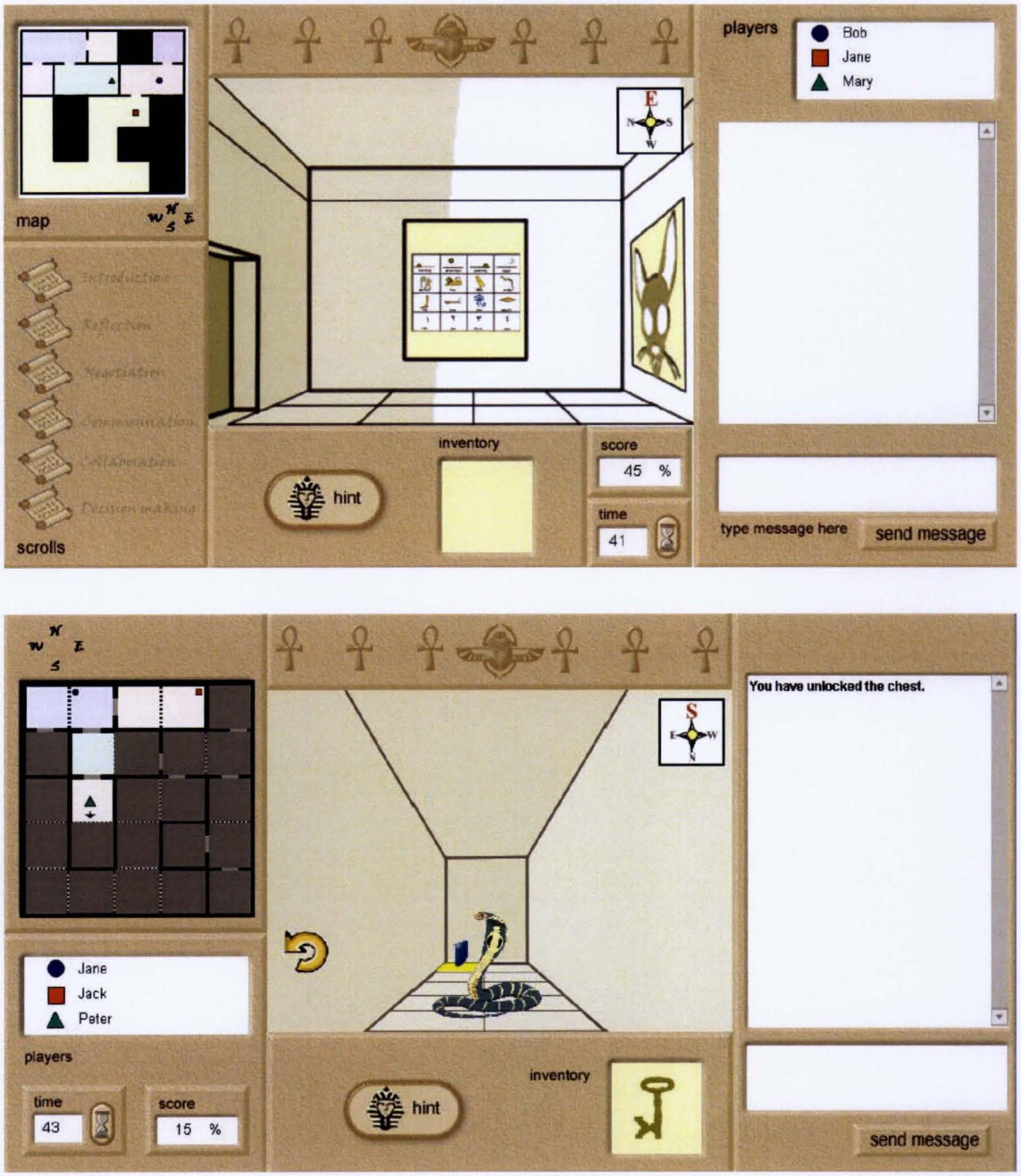

Figure 7-9: The second (top) and final (bottom) versions of the Pharaoh's Tomb interface

In the final version the size of the map has been increased, the relative sizes of the players changed to indicate which icon represents the player using that map, and an arrow added to the player icon to show the direction in which he or she is facing. The player information has been moved closer to the map so that players are easier to identify by their icons. The information scrolls have also been removed from the interface. This final version of the Pharaoh's Tomb interface was used as the basis for developing the Time Capsule application.

7.3 Development of the Time Capsule

The Time Capsule was adapted from the interface and underlying code for the Pharaoh's Tomb. This approach had two main practical benefits: first, it meant that the development time was less, as a lot of interface and programming (particularly multi-user programming) issues had already been solved; and secondly, it meant that there would be a similarity in graphic design and collaborative tools between the two applications, avoiding these additional variables that might contribute to a difference in learning or engagement.

Like the Pharaoh's Tomb, the Time Capsule provides a chat window in which students can communicate with one another, and a window that shows the other players taking part. Since the Time Capsule activity involves taking on a character role, players are shown in character, and interactions in the chat window are also presented in this way. In addition, since the aim of the activity is to reach agreement, there is a button that initiates the agreement process.

The students can see the full range of objects available for inclusion in the capsule and the price of each one; rolling the mouse over an object shows more detail about it. Clicking on an object will select it (or de-select if it is already selected); these interactions can be seen in real time by all of the characters. Status information is provided in terms of information on the total number of items selected, the total cost of the items selected and the time remaining to reach a collective decision. Instructions are available at all times, both on using the activity itself and personalised information on the character role that has been assigned.

The functional requirements of the Time Capsule were discussed in Chapter 6, and are summarised in Table 7-6 below. The Time Capsule interface was designed to meet these requirements and is shown in Figure 7-10 below.

The Time Capsule uses an identical chat facility to the Pharaoh's Tomb and shows the potential items available. Players can select items by clicking on them and they then become highlighted for all players.

Area	Functionality
Characters	View personal character information.
Objects	Select and de-select an object. See the items available and those selected so far.
Interaction with other players	See the characters that are taking part. Talk to other players. See when an item has been selected by another player. Reach a final agreement with other players.
Status information	See the time remaining. See the number of items selected and total cost so far.

Table 7-6: Functional requirements of the Time Capsule

A more detailed description of each item is provided in a panel below the object images when the mouse is held over the item. When one of the players is happy with the selection then he or she can select the 'I agree!' button, which prompts the other players to agree (or not if they wish); all players must agree before the game is completed.

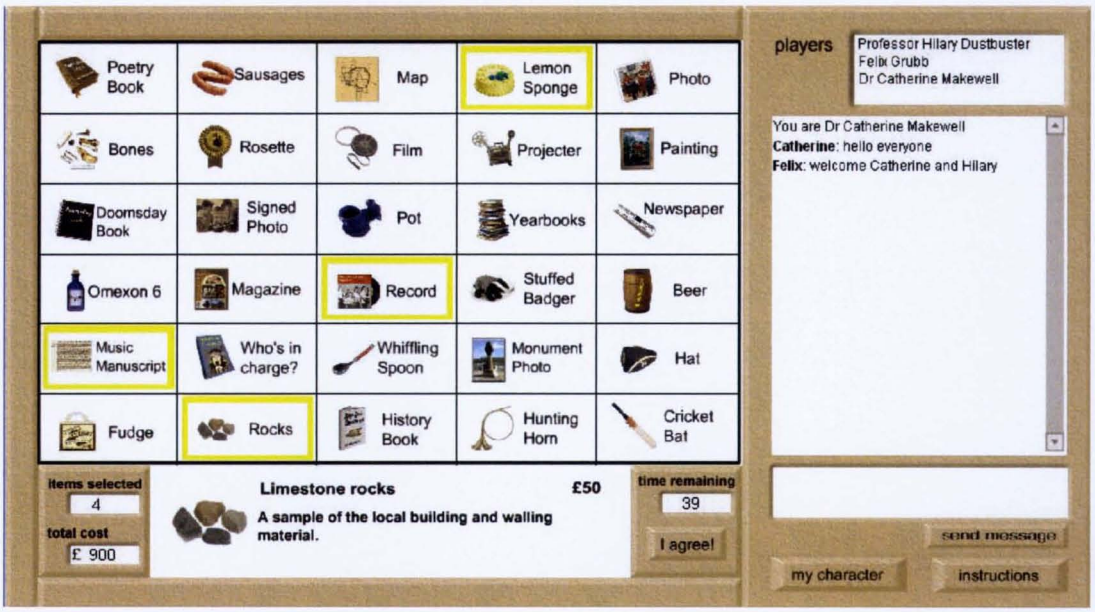

Figure 7-10: The Time Capsule interface

The evaluations for the Time Capsule were less extensive as the functionality was simpler and much of the interface had already been tested during the evaluation of the Pharaoh's Tomb. Two types of evaluation were carried out, each examining the functionality and the usability of the interface. Again the

ages of the participants ranged from 20s to 60s and four were female and three male. An overview of the evaluation methods is shown in Table 7-7.

Evaluation	Method	Number of participants
1	Think-aloud walkthrough Debriefing focus group	3
2	Observation Debriefing focus group Transcript analysis	4

Table 7-7: Evaluations for the Time Capsule

There were fewer issues highlighted during these evaluations than those for the Pharaoh's Tomb and fewer alterations were required. This is almost certainly because the interface is far simpler than that of the Pharaoh's Tomb, much had already been tested, and it does not require navigation of a virtual space, which was the hardest element of the interface to develop.

These evaluations highlighted issues associated with some of the terminology or vocabulary used (particularly with foreign students). However, when these students were allowed to use online translators there ceased to be a problem. The amount of online text presented, particularly in the case of the character information provided in Appendix 7, was difficult for some participants, so the information provided was revised and shortened, and paper copies were made available to those who preferred them.

The Time Capsule activity was adapted to enable four people to take part at once rather than three, which was much more practical for actual teaching situations, when it could not be guaranteed that there would be a multiple of three students in a class. This adaptation would also have been desirable in the Pharaoh's Tomb; however, owing to its complexity, it was not possible to add an additional player without a major re-write of the game. On the occasions when there were too many students in a class using the Pharaoh's Tomb, they were asked to pair up and work together as part of a larger team.

7.4 Applying the interface design criteria

In this final section the two game-based learning activities developed are considered in relation to the criteria for effective interface design of computer game-based learning applications presented in the final section of Chapter 5. Six criteria were discussed: flexible interaction; support for player community; transparent navigation; user control; robustness and appropriate visual design. Each criterion is now discussed in relation to the Time Capsule and the Pharaoh's Tomb activities.

Flexible interaction

The interaction methods for both applications are mouse-driven, using the keyboard to communicate with other users. There is more functionality and manipulation of virtual objects in the Pharaoh's Tomb, whereas the Time Capsule focuses on selection and deselection. In both cases these interaction methods are appropriate for the task. There is the potential for alternative keyboard interaction, through the use of shortcut keys for advanced users or arrow navigation in future versions. Feedback is provided through status indicators such as the time clock, score, item count and money count, which are updated in real time. Feedback is also provided in the way that objects interact (or fail to interact) and from talking to other users.

Support for player community

Both applications are collaborative and provide functionality for players to communicate with each other in real time. It is the nature of these games that they are designed to foster collaboration and group interaction and it is impossible to complete the goals of either of these activities without participation from all of the players.

Transparent navigation

Navigation was one of the more problematic areas of the Pharaoh's Tomb game, but was not an issue at all in the Time Capsule activity. The navigation method (forward and rotation arrows) aimed to be as straightforward as possible, but was still occasionally problematic, particularly for those participants with little prior experience of this sort of gaming environment. This could be an area that would be much improved by providing the option of use of

the keyboard arrows or alternative methods of navigation. The navigation aids such as the map and compass are prominently displayed, but additional aids such as map overlays or the ability to navigate via the map could be added.

User control

In terms of the amount of control the user has over the application environment, the instructions and goals of both applications were explicit and can be easily accessed by the user, both on paper and as part of the game environment. In the Pharaoh's Tomb game there is some scope for undertaking the tasks in a number of different orders. However, in neither application is it possible to adjust the pace or level of the activity, or undertake any level of customisation. This lack of functionality was partly due to the requirement of the applications being able to fit into a single hour of a teaching schedule, and the limitations of the development time. It should be emphasised, however, that in terms of learning, completion of the task is not essential; it is the debriefing on what was achieved that is essential to the learning.

Robustness

There were also issues with the reliability and robustness of both pieces of software. Although it was possible for users to recover from errors made inside the applications, it was also possible to take actions outside the environment that were irrecoverable (e.g. closing the browser window, using the browser back button), although disabling of browser controls addressed this issue to some extent. The functionality of buttons, controls and objects appeared to be obvious, appropriate and responsive to the users. Context-sensitive hints on the game tasks were available in the Pharaoh's Tomb but help on using the interface was not provided as it was felt that it could be more efficiently given by the researcher in a face-to-face situation. It would, however, clearly be useful if the games were to be used in a distance learning situation. Also, the ability to save the application was not provided, nor could players exit or re-join.

Appropriate visual design

The screen layout of both of the applications was consciously designed to be as simple and uncluttered as possible, while still being fit-for-purpose and looking game-like. Unnecessary graphics (e.g. interface decoration) are limited, and

annoying or distracting features are avoided (e.g. flashing). Information is chunked where possible and either provided only as needed (e.g. hints, instruction scrolls) or broken down into bullet points and accessible when needed (e.g. character descriptions). Pop-up information is placed consistently throughout each application and text is used in a font size and style considered to be most appropriate for legibility. Paper-based alternatives are provided when it is necessary to provide large amounts of textual information.

The simple graphics used in both applications appeared to be appropriate and were not displeasing to the users. Where possible, information was presented as both text and graphics (e.g. pictures and descriptions of objects for the Time Capsule) when it did not detract from game play (e.g. when discovering what objects are is part of the game). Avatars were not used; they might have been a positive addition to the game (less so perhaps to the Time Capsule) but were not practicable because of limitations on software development time.

Throughout the iterative development and evaluation of these prototype applications, the overriding effort was to ensure that the interface would be appropriate and easy-to-use, and that it would meet the guidelines for effective interface design identified earlier. There are, however, still areas that could benefit from further development, particularly a consideration of alternative interaction methods, customisability of the pace and level of the activity and of the interface, the robustness of the game environment, the ability to save and re-join the activity and the use of avatars.

This chapter has described the developmental and evaluative process used to create two collaborative game-based learning applications, and shown how they meet the criteria used to describe effective computer interfaces for game-based learning. In the following chapter, ways of determining the educational effectiveness of game-based applications are discussed.

8 Evaluating the educational effectiveness of games

This chapter considers how the educational effectiveness of computer game-based learning applications could be evaluated. With any new teaching technique it is important to consider and test what impact it might have on the learning experience, and ways in which computer game-based learning could be evaluated are considered here. This research aimed to evaluate the effectiveness of the two applications that were produced, the Time Capsule and the Pharaoh's Tomb, to provide evidence that they met their intended learning outcomes and also to compare the learning experience of the students using these two different examples of game-based learning.

The first section of the chapter considers ways to assess educational effectiveness, evaluating learning and engagement. There is a consideration of ways in which learning can be measured, how it is commonly evaluated in comparative experiments examining the differences between two educational interventions, and the advantages and disadvantages of these methods of measurement. The concept of engagement is considered and defined, and the relationship between engagement and learning is discussed and a rationale for using engagement as an indicator of educational effectiveness is presented; the development of a questionnaire to develop post-experiential engagement is also described.

The final two sections of the chapter describe additional studies that were carried out to provide evidence of the educational effectiveness of the two applications. Section 8.2 presents a small comparative study that was carried out to compare the self-reported learning of students using the original face-to-face version of the Time Capsule activity with that of students using the online version. Section 8.3 provides an analysis of the transcripts of students using the Time Capsule and Pharaoh's Tomb activities during the pilot phase of the comparative experiment (described in the following chapter) to provide evidence that the activities support achievement of the intended learning outcomes.

8.1 Evaluating educational effectiveness

One of the research questions of this thesis is concerned with comparing the learning and educational experience resulting from different types of game-based learning application. In order to do this, it is important to consider the alternative ways of measuring the learning resulting from an educational intervention.

The typical way to measure learning from a unit of study is through the assessment for that unit, which should be constructively aligned with the learning outcomes for that unit (Biggs, 2003). In a study involving a larger intervention, a comparison of assessment scores would be a potential way in which to compare learning; however, in the case of the Time Capsule and Pharaoh's Tomb, each relates to only one hour's worth of study, which would only make up a fraction of an assessed course. Therefore the effect of either game on the overall assessment score for a unit is likely to be negligible, and for this reason it was decided that using the assessment score was inappropriate in this instance.

In experimental design studies, the effectiveness of an educational intervention is often measured using a pre-test followed by the intervention, followed by a post-test; differences in the pre- and post-test scores can indicate that the intervention has caused different levels of learning in the target group compared to the control group. This technique has been used for a number of studies on game-based learning; for example, Ebner and Holzinger (2006) tested theoretical knowledge in chemical engineering, Kambouri and colleagues (2006) evaluated basic literacy skills, and Sung and colleagues (2006) examined children's understanding of taxonomic concepts.

Despite this being a common way of evaluating learning in studies of educational interventions, it was decided not to use a pre- and post-test in this research for a number of reasons. The intended learning from the game-based learning studies cited in the previous paragraph was knowledge-based and could be tested quickly by use of a questionnaire; however, the intended learning outcomes from the Time Capsule and Pharaoh's Tomb focused on the development of collaborative skills, which are higher-level cognitive skills than

the acquisition of knowledge (Bloom, 1956) and also involve the development of behaviours and attitude, and would therefore be less appropriate to be tested with a simple questionnaire. While it would be possible to design a pre- and post-test for these type of skills that also examined retention over time and application of learning to other contexts, it would involve undertaking comparable team tasks (which in itself might bias the results by acting as a learning as well as an evaluative activity) and would be time-consuming and impractical to administer. It was thought to be too difficult, if not impossible, to persuade students to give up extra time for this testing. Difficulties with getting students to co-operate with the pre-/post-test model because of the extra work required on their part are not uncommon. Squire (2005), for example, could not persuade the students in his sample group to complete a pre-test at all.

However, despite the inapplicability of the pre-test/post-test design to this research, it was felt that some indication of learning would be useful to triangulate with other findings. A 12-question questionnaire was designed to enable the students to self-report on what they felt they had learned from undertaking the activity (see Appendix 18). This questionnaire asked the students to evaluate any improvement in their own skills in a number of areas, based on the learning outcomes of the application. Two additional questions were added referring to skills that the students were not intended to learn during the activity, which were used to examine the validity of the questionnaire (see Section 9.3).

The self-report questionnaire was not seen, in itself, as a reliable enough indicator of learning to be used as a sole measure for comparison between the two game-based activities. So instead of evaluating learning from the game directly, it was felt that it was more appropriate in this situation to evaluate engagement with the game, as there is evidence that higher levels of engagement with a learning activity lead to increased learning from it. Preece and Jacques (1995) argue that designing interactions to be engaging can encourage and facilitate learning, and Lepper and Malone (1987) provide evidence that there is a link between intrinsic motivation to learn, engagement and instructional effectiveness. It is important, however, to distinguish between engagement with a game, and engagement with the intended learning from the

game. Ideally, educational games should be designed so that the game outcomes are aligned with the learning outcomes so that engagement in the game supports learning. Although the match will not always be perfect, applying the educational design guidelines described in Chapter 5 should help to ensure that this is the case.

For the reasons described, it was decided to use engagement as the primary indicator of educational effectiveness, and to develop a tool to measure relative engagement with a learning experience. The development process is described in the next sub-section.

8.1.1 Evaluating engagement

The most common methods employed to measure engagement in educational settings are the use of questionnaires, and measurements such as time-on-task or attendance rates (e.g. Chapman, 2003). Other techniques include analysis of facial expressions and body language (Hughey, 2002), observations (Read et al, 2002) and voluntary time on task (Virvou et al, 2004).

Since this study is concerned with psychological engagement it was felt that the only way to get a detailed picture of how an individual perceived an activity was by asking the individual him- or herself and trying to understand the individual perceptions of an experience. A questionnaire was used because this was more feasible than interviews in terms of the time available for each student to take part in the evaluation, and using a quantitative measure would enable the use of quantitative statistical analysis to examine a difference in engagement between two activities. The disadvantage of measuring engagement in this way is that there would be no qualitative data available to gain a deeper understanding of the nature of engagement; however, this was unavoidable given the problems of access to students.

In reported examples where engagement has been tested with self-reporting scales, there is often no evidence of the systematic development of the rating instrument (e.g. Davies, 2002) or the method of analysis is not appropriate for ordinal data (e.g. Chapman et al, 1999). In fact, no examples could be found in the literature of engagement questionnaires that had been rigorously developed

(this is not to say that the instruments used were unsound, just that there was no explicit mention of their genesis). For this reason it was decided to develop an original engagement inventory to ensure that the development process, as well as the application and analysis techniques, were sound and appropriate.

To measure the level of psychological engagement with an activity, it was felt that a self-rating questionnaire was a practical, relatively quick and simple to administer, yet not too intrusive, method of measurement. In examining the factors that make up the concept of engagement, Flow theory (Csikszentmihalyi, 1992) was used as a central basis, but acknowledging that flow is an extreme form of engagement and that it is possible to be engaged while not actually in a state of flow. The work of Malone (1980a; 1980b), in terms of challenge, curiosity and control, is also drawn upon. Also taken into consideration are the results from the interviews described in Chapter 4 on factors that appear to universally motivate or demotivate, backed up by adult learning theory regarding adults' motivations for learning (Knowles, 1988). Based on these theories, engagement was hypothesised to be made up of five separate factors; these are shown in Table 8-1.

Factor	**Description**	**Origin**
Challenge	The most complex of the factors, consisting of: the motivation to undertake the challenge; clarity as to what the challenge involves; and a perception that the challenge is achievable.	Csikszentmihalyi (1992) Malone (1980a; 1980b) Chapter 4 interviews.
Control	The fairness of the activity, the level of choice over types of action.	Csikszentmihalyi (1992) Malone (1980a; 1980b)
Immersion	The extent to which the individual is absorbed in the activity.	Csikszentmihalyi (1992)
Interest	The intrinsic interest of the individual in the activity or its subject matter.	Malone (1980a; 1980b) Chapter 4 interviews
Purpose	The perceived value of the activity, whether it is seen as being worthwhile and whether feedback is perceived as having a value.	Chapter 4 interviews Knowles (1988)

Table 8-1: Factors hypothesised to increase engagement

It was decided to use a Likert scale questionnaire for a number of reasons. This type of scale is widely used so would be familiar to participants, is relatively straightforward to develop (Robson, 2002) and has established statistical analysis techniques (Greene & D'Oliveria, 1993). It was decided to use a five-point scale because this was considered to provide a meaningful level of discrimination (e.g. between 'agree' and 'strongly agree') without forcing the participant to have an opinion.

A number of potential questions for each factor was generated by the researcher, which were then reviewed by three individuals with experience of developing attitude scales for clarity, ambiguity and language used. The original questions were then revised and refined and an original questionnaire was developed, which contained 42 questions (see Appendix 19 for the questions).

The questionnaire was then piloted by asking participants to play one or more of five games drawn from those examined in Chapter 5 (see Appendix 5). The five games used are shown in Table 8-2.

Activity	**Description**	**Number of responses**
Bookworm	Word-building game, testing spelling and vocabulary.	15
The Mystery of Time and Space	Point-and-click adventure game based around puzzle-solving, lateral thinking and investigation.	15
Laser beams	A series of spatial puzzles involving strategy and planning.	11
Typer shark	Typing arcade game testing speed and hand–eye co-ordination.	13
I-sketch	Multi-user picture drawing and guessing game, requiring lateral thinking and social skills.	11
	Total	65

Table 8-2: The games used as part of the testing process for the engagement questionnaire

This questionnaire was piloted with 33 participants, each of whom played at least one game (providing 65 responses in total). The testers were recruited by word of mouth and through email mailings forwarded by colleagues, and were adults who considered themselves to be computer literate. Participants were given instructions by email, asked to play a specific game for 15–20 minutes in their own time and to complete and return the questionnaire immediately afterwards. They were also asked if they would like to play another game, and most participants chose to play more than one game. Games were chosen for testing that were considered to have educational potential, and a range of different types was chosen to elicit variation in response.

In order to generate the final questionnaire for post-testing with students in the final comparative study, the overall responses in each group were first examined to determine whether they were in fact measuring the factor that it was hypothesised they were measuring. This was done by using the SPSS statistical package to first transform the data so that the results of negative questions were reversed, and then to calculate the Kendall Tau rank correlation coefficient (a statistic used to measure correlations between ordinal data) for each pair of questions within each hypothesised factor; a one-tailed test is used as it is hypothesised that the correlations will be positive. A summary of results is shown in Table 8-3; and a more detailed breakdown of the correlation data can be found in Appendix 20.

The questions that did not correlate with all of the other questions in the group at a 0.01 level of significance were removed from further analysis. These tended to be those that were poorly worded, more ambiguous or less clear whether they were a positive or negative influence on engagement.

In order to reduce the number of questions further to an appropriate size for the final questionnaire, the Discrimination Power (DP) of each question was calculated. The Discrimination Power, as described in Robson (2002), is the ability of the question to distinguish between the responses of the upper quartile of respondents overall and the responses of the lower quartile, that is, the degree to which the response to an individual question indicates the overall response to the questionnaire.

Factor	Questions (those underlined do not correlate)
Challenge (motivation)	I wanted to complete the activity I wanted to explore all the options available to me I did not care how the activity ended
Challenge (clarity)	I knew what I had to do to complete the activity The goal of the activity was not clear The instructions were clear I did not find it easy to get started I found using the application easy to learn
Challenge (achievability)	I felt that I could achieve the goal of the activity I had all the things I required to complete the activity successfully I had a fair chance of completing the activity successfully I found the activity difficult I found the activity frustrating From the start I felt that I could successfully complete the activity The activity was challenging
Control	I had lots of choices to make during the activity The types of task were too limited It wasn't clear what I could and couldn't do The activity was too complex The activity would not let me do what I wanted I could not tell what effect my actions had I had lots of potential options available to me I could not always do what I wanted to do
Immersion	I found the activity satisfying I felt absorbed in the activity I felt that time passed quickly I worried about losing control I felt emotion during the activity I felt self-conscious during the activity I felt excited during the activity
Interest	I had to concentrate hard on the activity I knew early on how the activity was going to end I found the activity boring I was not interested in exploring all of the environment I did not enjoy the activity The activity was aesthetically pleasing
Purpose	The activity was pointless The feedback I was given was not useful I did not receive feedback in enough detail I was given feedback at appropriate times It was not clear what I could learn The activity was worthwhile

Table 8-3: The questions hypothesised to measure each factor of engagement; underlined questions are those that do not correlate with all others in the group at the 0.01 level of significance

The questions with the highest discrimination powers in each factor were selected for the final scale with one exception where it was felt that a question with a slightly lower DP was more appropriate because it was less specific (see Appendix 21). Six questions were selected to measure challenge (two from each challenge sub-factor) and an additional three questions were selected from each of the other factors for the final scale, making 18 questions in all. This was felt to be a compromise between the greater reliability gained as the number of questions used to measure each factor is increased, and the decreased propensity for the respondents to complete the questionnaire correctly as the overall number of questions increases. All the questions were reviewed a final time and a small number were altered slightly or reversed to aid clarity. The final questionnaire is shown in Appendix 22.

As a matter of interest, the relative levels of engagement for the five games used for testing were examined, using only the 18 questions from the final scale. The average scores for engagement for each activity can be seen in Table 8-4; it is important to recognise that as absolute values these scores are meaningless but they can be used to compare levels of engagement in different activities.

Activity	**Engagement score**		
	Min	**Mean**	**Max**
Bookworm	40	62	77
The Mystery of Time and Space	30	60	84
Laser beams	38	58	75
Typer shark	53	70	82
I-sketch	29	51	73

Table 8-4: Maximum, mean and minimum engagement scores for each of the five games tested

It is interesting to note that it is the arcade-style game that that appears to be the most engaging, while the collaborative drawing game appears to be the least; but of course, it is difficult to draw any genuine conclusions regarding engagement and game type as the differences could be due to a number of other factors including the design of that specific game, for example the graphic quality, or interaction speed. It is also worth noting that for some games the

range of opinion seemed to be much greater than for others, indicating more polarity of opinion; the Mystery of Time and Space, for example, while having a similar average score to Bookworm shows much more variation in opinion.

The 18-question engagement questionnaire was used to evaluate the difference between the Time Capsule and the Pharaoh's Tomb in the set of comparative experiments that formed the final part of this research, and is described in the following chapter. The next section of this chapter describes an evaluation that was carried out to compare learning between the face-to-face and online versions of the Time Capsule activity.

8.2 Evaluating learning from the Time Capsule

The opportunity arose to use the Time Capsule exercise with a group of final year undergraduate marketing students as the introductory session to a module on marketing strategy, in which the students had to work in teams. This provided an excellent opportunity to examine any differences in perceived learning between students who used the online version of the activity and those who used the face-to-face version.

As this session was part of an existing course structure, the time available for evaluation on top of the time spent using the activities was very limited, so the only available option was a short self-perception of learning questionnaire immediately after students had undertaken the Time Capsule activity. The questionnaire was made up predominantly of closed questions, but also provided the respondents with the opportunity to make additional comments; it is shown in Appendix 23. Students were informed about the nature of the research and the evaluation before the session and given the opportunity not to complete the questionnaire if they wished, although they were still required to take part in the activity as it was a required part of their course of study.

A total of 60 students participated in the evaluation. Students were randomly placed into groups, with 17 using the online exercise and 43 using the face-to-face version. There was a limited number of computers available for the session, which is why the majority of students used the face-to-face activity. Fisher's exact statistical test was used to evaluate if there was a significant

difference between the responses of students using the online and face-to-face versions for each of the questions. A X^2 test was not considered appropriate because even though the data were nominal, that is, the students could be categorised as either agreeing or disagreeing with each of the statements (Greene & D'Oliveria, 1993), in the case of all questions, either a cell in the contingency table has an expected frequency of less than 1 or over 20% of cells have an expected frequency of less than 5, so X^2 is not applicable (Field, 2005). Therefore, Fisher's exact test is used instead of X^2 in this situation, as it is an appropriate test when expected values are low (Everitt, 2002); and a two-tailed test is used because it is only hypothesised that the variables (i.e. experimental group and perceived improvement) are related, not in which direction. The results of the statistical analysis, as well as a summary of the responses from each group are shown in Table 8-5 below.

Question	**Result**	**F-to-F agree (%)**	**Online agree (%)**
I understand how to make good decisions as part of a group.	All agree	100%	100%
I am more aware of what makes communication effective.	p=0.676	82%	88%
Constructive controversy is a good way to make decisions.	p=0.448	76%	86%
I understand what makes a group effective.	p=0.317	88%	95%
I will be better able to communicate with others in the future.	p=0.530	65%	74%
Group reflection is important for effective groups.	p=0.206	76%	91%
I will be better able to contribute to group decision-making in the future.	p=1.000	76%	76%
I appreciate the benefits of collaborating with others.	p=0.283	94%	100%
I can now contribute better to make group work more effective.	p=0.099	59%	81%
I enjoyed the exercise.	p=0.283	94%	100%
I found the instructions straightforward.	p=0.393	82%	91%

Table 8-5: Comparison of learning in the face-to-face (F-to-F) and online Time Capsule activities

These results show that there was no significant difference in the responses to any of the questions from either of the two groups, so there does not appear to be any difference in learning between the two groups. However, there is evidence that the majority of students perceive that they could meet the learning outcomes of the exercise (although it is not clear from the wording of the questions whether they perceive this is because of taking part in the activity; this was resolved in later versions of the questionnaire) and there is stronger evidence that the students found this to be an enjoyable activity to undertake. Although this was not a strictly rigorous trial, it does provide an indication that the Time Capsule is a workable activity within the boundaries of a real teaching situation and that there is no difference in self-perceived learning between the online and face-to-face versions of the activity.

In the final section of this chapter, additional evidence of learning through the Time Capsule and Pharaoh's Tomb activities is provided through analysis of the transcripts from the first pilot study.

8.3 Evidence of learning from transcripts

In order to evaluate the differences in engagement and self-reported learning between the Pharaoh's Tomb and the Time Capsule applications, a comparative experimental study was carried out, and this is described in the following chapter. Before the main study, however, two smaller pilot studies took place; the first of these involved student volunteers and provided the opportunity for the collection of the transcripts, which was not possible when the games were used in real teaching situations because the transcript data were not collected automatically but had to be copy-and-pasted at the end of the session – in the actual teaching situations students had left the game environment before this was possible. It was also felt that if students knew their conversation data were being collected for the main experiment then this might affect their behaviour online and impact upon their experience.

In total, six transcripts were available, three from sessions with participants using the Pharaoh's Tomb and three from the Time Capsule. These transcripts were analysed to see whether there was any evidence of behaviours during the games that would indicate that the intended learning outcomes were being met.

The learning outcomes for both of the activities were:

1. To know what a group is and to be aware of elements that make a group effective.
2. To appreciate the benefits of working as a group and be able to communicate and collaborate successfully with others.
3. To be able to work together to problem-solve and reach effective decisions.

The transcripts were analysed to see if examples could be found of behaviours that supported group effectiveness such as agreeing group goals, friendliness, openness and supporting one another; behaviours that support effective communication such as taking ownership of feelings, asking for feedback, describing behaviour without evaluating and behaviours that support problem-solving and effective decision-making, such as valuing all suggestions, negotiation, compromise and debate around problem-solving. Examples of transcripts of the Time Capsule and Pharaoh's Tomb can be found in Appendices 24 and 25. As well as analysing the contents of the transcripts, a quantitative analysis was carried out to examine the levels of interaction and the contribution rates of the different participants in each game. The results are shown in Table 8-6 below.

Game instance	Word count	Sentences			
		Player 1	Player 2	Player 3	Total
Time Capsule 1	1204	25	46	40	111
Time Capsule 2	622	49	29	54	132
Time Capsule 3	1464	38	33	58	129
Pharaoh's Tomb 1	1684	146	98	55	299
Pharaoh's Tomb 2	1104	30	67	61	158
Pharaoh's Tomb 3	1471	84	89	60	233

Table 8-6: Interaction and contribution rates in the pilot study using the Time Capsule and the Pharaoh's Tomb

It can be seen from this table that in all six cases, all three of the players participated in the game and contributed to the discussion to varying degrees. The total number of statements tended to be higher in the Pharaoh's Tomb but each statement tended to be shorter than in the Time Capsule, this is possibly

because the Pharaoh's Tomb provides more opportunities for interaction with the environment so there is less focus relatively on the communication, whereas the Time Capsule offers limited interaction so there is more focus on negotiation.

An in-depth analysis of the transcripts provided additional evidence that both games were fostering the types of group skills intended. Although this was not a strictly scientific analysis, and can clearly not show whether these skills were present beforehand or have been developed during the activity, the following excerpts from the transcripts do provide some evidence that the games actually did encourage the types of group behaviours that were intended.

There were a number of examples of the players exhibiting behaviours that support group effectiveness, such as clarifying the ground rules and strategies for achieving the group goals:

```
Hilary: we can either pick 2 personal objects each
Hilary: or 6 that are related to the area, my option of
course
Hilary: heritage is important
Hilary: and badgers
Catherine: ok so we pick 2 each at the moment
Felix: I have a few ideas as to what should go in, so let's
see what two we can come up with
Hilary: pick 2 each the and see what we come up with

Felix: Hilary, tell me about the capsule
Hilary: we have £1000 pounds to select 6 items
Hilary: I think it is one of the mayor's ideas
Catherine: we do, can we strike any off of the list straight
away? are there any we believe strongly should or shouldn't
be in the capsule?
```

There were also examples of supportive and friendly behaviour:

```
Jack: i have made a flute with the knife and the reeds
Jack: i will play to the snake
Phil: excellent
Mike: happy days,
Phil: that was clever

Rose: I think thats it!
Dave: bingo!!!!!
Dave: well done
Rose: great, have you got a bit of the scarab?
Amir: well done everyone
```

The transcripts also showed that the players exhibited a number of behaviours to support collaboration, such as expressing opinions in an open but non-aggressive manner, and taking responsibility for feelings:

```
Felix: I am of the opinion that things like bones and
historical artefacts should be in museums, but that's just my
view
Catherine: yes
Hilary: ah mmmmmm er good point

Catherine: Who's chosen 3 items?
Hilary: me
Catherine: Thta only leaves me with one choice. I feel thats
not very fair like.
```

Examples could also be found of the participants working together and supporting one another to achieve tasks as part of a team:

```
Bob: Are you in maze Sam?
Bob: ok
Sam: yea
Jim: Can we help?

Rose: Where is the vase?
Dave: in the big room
Rose: found it!
Rose: we could fill it with water, we havn't used the bucket
yet
Rose: I see someone has
Dave: already there lol!!!
```

There was also evidence that the players were exhibiting behaviours to support problem-solving and decision-making, such as negotiation and compromise:

```
Felix: We need another thing. Why don't we replace rocks with
something also worth £50?
Felix: rocks are cheap and also boring
Catherine: yes the beer
Hilary: no the fudge
Felix: How about the magazine which will not smell bad when it
goes off
Felix: But is also about food


Felix: If we go for the yearbooks, we've got £100,00 left for
the pub!
Catherine: perfect!
Hilary: I think Badgers are under-represented
Felix: So?
Hilary: ok i will agree
```

```
Catherine: while i see that badgers are lovely animals, i
still dont see how they are really uhique to us, im happy with
what we have
Felix: Maybe there's a picture of a badger in the yearbooks.
Hilary: I love badgers
Catherine: yeh, probably
Hilary: badger stew...mmm
Catherine: maybe we could make sure there is? that would work
```

Other examples include working together to try to solve problems and to make suggestions on how to approach tasks within the games:

```
Dave: think we need a key???
Amir: i have a key
Rose: There is a locked door here, do you want to try to open
it with your key?
Amir: how
Dave: go to the far east room with the key

Sam: how do i apply the whip to the snake?
Jim: drag the whip on screen
Bob: have you tried dragging and dropping it?
Sam: yeah no luck!!
```

From this small sample, it appeared that the types of behaviours exhibited in the case of people playing the Pharaoh's Tomb and the Time Capsule were different, which is almost certainly due to the differences in design and goals, with the Time Capsule focusing more on negotiation and the Pharaoh's Tomb more on problem-solving. However, there are certainly examples from each of the six transcripts examined that a range of team-building and collaborative behaviours are taking place when the game-based activities are being used, which are clearly related to the anticipated learning outcomes of the activities.

This chapter has aimed to consider the different ways in which the educational experiences of the students using the Time Capsule and Pharaoh's Tomb activities can be evaluated. Measurement of learning was first considered but would be difficult for a number of reasons discussed in Section 8.1; however, a self-rated perception of learning questionnaire was developed. The key measure of educational effectiveness used here was the measurement of post-experiential engagement and the rigorous development and piloting of a Likert questionnaire is described.

In addition, two small studies are discussed, which try to provide some additional evidence that the Time Capsule and the Pharaoh's Tomb actually support the type of learning that is intended. The next chapter builds on these studies and describes the large-scale comparative study that was carried out to compare the two game-based activities using the questionnaires (self-perceived learning and engagement) described in this chapter.

9 Comparative study

This chapter describes one of the key pieces of work of this project: the set of comparative experiments that conclude this research. The purpose of these experiments was to compare two game-based learning activities, the Time Capsule and the Pharaoh's Tomb, the design and development of which are described in Chapters 6 and 7. These studies aimed to determine if there were any differences in educational effectiveness – using self-reported learning and engagement as indicators – between students using each of these activities as part of their course of study.

First, the design of the overall learning session, of which the game-based activity formed part, is described and differences between the two activities are considered in relation to the characteristics of games determined in Chapter 2. This is followed by a description of the experimental design and use of pilot studies. The final two sections of the chapter describe the results from the self-reported learning questionnaire and the engagement questionnaire.

9.1 Comparing the Time Capsule and the Pharaoh's Tomb

Two collaborative game-based activities were developed: the Time Capsule, a direct online translation of a face-to-face collaborative activity; and the Pharaoh's Tomb, a graphical multi-player adventure game. While it was considered that both of these applications were examples of game-based learning, using the inclusive definition from Chapter 2, the Pharaoh's Tomb was designed to exhibit all of the characteristics of games determined previously, whereas the Time Capsule was developed as a direct online translation of a more traditional activity and only exhibited some of them. The game characteristics (first shown in Table 2-1 in Chapter 2) are applied to the Time Capsule and the Pharaoh's Tomb in Table 9-1 below.

The Pharaoh's Tomb is a three-dimensional collaborative graphical adventure game that offers a range of challenges based around group problem-solving and has explicit group goals of returning an object to a certain place within the tomb and enabling the whole team to escape, and implicit rules as to what the team members can do (e.g. each player can carry only one object at a time).

	Pharaoh's Tomb	Time Capsule
Competition	✓	×
Difficulty	✓	✓
Exploration	✓	×
Fantasy	✓	✓
Goals	✓	✓
Interaction	✓	✓
Outcomes	✓	×
People	✓	✓
Rules	✓	✓
Safety	✓	✓

Table 9-1: Analysis of game characteristics (from Table 2-1) applied to the Pharaoh's Tomb and the Time Capsule applications

The Pharaoh's Tomb game is scored, which means that there are measured outcomes (as opposed to simply achieving the goal or not) and teams can compare themselves with other teams, introducing an element of competition. The game is not designed to support inter-group competition because this would be at odds with the collaborative nature of the exercise. It provides a fantasy environment of an Egyptian Pharaoh's tomb that can be navigated and explored; characters can interact with objects and gain feedback from the environment as well as from other players.

The Time Capsule, in contrast, is an interactive group negotiation activity that exhibits fewer characteristics of games. While the activity is difficult (certainly non-trivial) and students are presented with an explicit goal to agree on items to be placed in a time capsule and clear rules regarding the number of items and their total cost, there are no measured outcomes or scoring. Therefore, beyond achieving the goal or not, it is not possible for teams to compare themselves with others, removing the element of competition. The Time Capsule provides a fantasy scenario for the participants but it does not present an immersive world that can be explored as part of that scenario, although it does provide interactivity and feedback to actions. Neither activity is assessed, so, as far as is possible within a non-voluntary learning environment, participation in the activity is not deemed to have consequences in the real world.

Both game-based activities were designed to take the same time to complete and with the same set of learning outcomes and supporting materials. Each of the sessions was designed to fit into a one-hour time slot, because this fitted with the timing of lessons at the universities where the trials were undertaken. The timings of the sessions were as follows:

- Students are given a verbal introduction to the aims of the session and the nature of the research, including time for questions (at this stage participants were given the option to opt out of the research element if they wished); students read two-page briefing on learning outcomes (approx. 10 minutes).
- Students are asked to complete the background questionnaire (see Appendix 4).
- The game-based learning activity is played (approx. 30–40 minutes).
- Students are asked to complete the engagement questionnaire (see Appendix 22).
- There is a debriefing session in which students are asked to consider and discuss their team behaviours during the game and relate to the learning outcomes (approx. 10 minutes).
- Students are asked to complete the self-reported learning questionnaire (see Appendix 18).

Paper-based support materials were provided, including instruction sheets for the Time Capsule (Appendix 12) and Pharaoh's Tomb (Appendix 13), briefing on learning outcomes (Appendix 6) and the debriefing exercise (Appendix 10). The following section explains how the comparative experiments were implemented.

9.2 Experimental design

The population of students selected for this trial were undergraduate computing students, because it was expected that this would be a group in which there was a relatively high level of computer literacy and, being predominantly male and under 30 years of age, likely to have more experience with playing computer games (Entertainment Software Association, 2007); therefore it was hypothesised that there would be a lower impact on learning engagement of factors such as learning to interact with the interface or use the games themselves so any effects could be attributed to the design of the game. On a more practical level, it was a group of students on a course and in a department

to which the researcher had access. The experiment was designed so that the students were split into two groups, each group undertaking only one of the two activities; the relative levels of self-reported learning and engagement could then be compared for students undertaking each of the activities.

Initially it was planned to recruit students for this study from the pool of those taking group project modules in Napier University School of Computing as an extra-curricular activity to support their studies; however, it proved impossible to recruit enough students in this way to have a meaningful sample. In order to increase recruitment rates, funding was secured to enable payment for participation, but again recruitment rates were low and only 15 students took part – this was then used as a pilot study. Subsequently an opportunity arose to trial the activities with a group of 19 final year marketing students at the City University of Hong Kong. This second small-scale study was used to test the practicalities of carrying out the experiment in a classroom setting and to collect additional data.

Finally, co-operation was secured to embed the learning activity into a first year professional skills module so that it was then part of the core curriculum. On this third occasion 78 students took part. The fact that the game-based learning activities were embedded into the curriculum meant that ethical issues regarding the issue of informed consent and right not to take part in an experiment had to be considered. To address this, students were briefed about the nature of the research, provided with the opportunity to ask questions, and given the option not to complete the questionnaires if they wished; however, all were happy to do so. In addition, the fact that individuals were not self-selecting adds validity to the experimental design in that it removes any selection bias from undue representation of people who are motivated to play games. Table 9-2 below provides a summary of the three trials.

	Date	*n*
Napier pilot (NP)	March 2006	15
Hong Kong pilot (HK)	September 2006	19
Napier trial (NT)	November 2006	78

Table 9-2: Summary of the experimental trials to compare the Time Capsule and the Pharaoh's Tomb

In each trial students were allocated to one of the two game-based learning activities – Pharaoh's Tomb or the Time Capsule. In the case of the first two pilots, members of the group were randomly allocated to one condition or other, and in the case of the final Napier trial the games were used in six separate tutorial classes, with three classes randomly allocated to each condition; the original allocation of students to tutorial groups was random. When a student logged in to the multi-user software engine he or she was automatically allocated to the next available game, which effectively meant that players were allocated to teams at random. The breakdown of participants for each of the two pilot studies is shown in Table 9-3.

	Napier pilot (NP)		Hong Kong pilot (HK)		Napier study (NS)	
	PT	**TC**	**PT**	**TC**	**PT**	**TC**
Number	8	7	12	7	42	36
Average age (mode)	20–29	30–39	20–29	20–29	Under 20	Under 20
Gender split (m/f)	7/1	5/2	7/5	2/5	36/6	30/6
Computer game players	100%	71%	92%	71%	93%	89%
Motivated to learn with games	88%	71%	100%	71%	50%	61%

Table 9-3: Summary of number of students and characteristics of students allocated to each condition in the comparative studies

It can be seen from the table above that the majority of each group had experience of playing computer games, which supports the hypothesis that they are very likely to be familiar with gaming interfaces but, interestingly, only 50% and 61% of the students taking part in the Napier trial said that they would be positively motivated to learn using games, which might indicate that although

the students in this group are able to interact with computer games, and enjoy using them in their leisure time, they may not wish to do so as part of their learning experience. In the next section, the results of the student self-reported learning questionnaire are discussed.

9.3 Evaluating learning

At the end of each of the learning sessions with one or other of the game-based learning applications, the students were asked to complete a questionnaire that examined what they felt they had learned during the session (see Appendix 18). In order to consider the reliability of this questionnaire (i.e. that students were not just answering what they thought they were expected to) two dummy statements were added to the questionnaire that did not match the intended learning outcomes from the session. The two dummy statements were:

- How to be an effective leader.
- Ways of generating new ideas.

Table 9-4 below shows the responses of the students who felt that that they had improved on each of the questions in the questionnaire. From the total of 112 students who took part in the trial, only 10% (11 students) responded that they had not improved to all of the questions in the self-perception questionnaire, which could be indicative of the fairly basic nature of the learning outcomes. This provides some basic validation that the students themselves perceived they had leaned something from the activity.

It can be seen from this table that responses to one of the dummy questions (How to be an effective leader) is rated considerably lower than for the other factors (< 30% combined), which provides some evidence that the students are not just responding in a way that they feel they are expected to. However, the other question (ways of generating new ideas) elicited a higher percentage of positive responses (44% combined), which is comparable with the other questions. On reflection, it is quite possible that, while this is not one of the intended learning outcomes of the session, the nature of the tasks does indeed require the generation of new ideas, so this could, in fact, be an unintentional learning outcome and not reflect on the validity of the scale. However, it should he highlighted that these questions are, at best, indicative of learning and their

use here is primarily as a triangulation measure to support any findings of the engagement questionnaire.

	Percentage of students reporting an improvement (%)		
	Time Capsule	**Pharaoh's Tomb**	**Combined**
How to make good decisions as part of a group.	28	48	38
What makes communication effective.	44	60	52
Constructive controversy as a way of making decisions.	42	35	38
What makes a group effective.	53	53	54
How to be an effective leader.	30	27	28
How to communicate with others in the future.	42	63	53
Ways of generating new ideas.	34	52	44
The importance of group reflection for effective groups.	40	44	41
How to contribute to group decision making in the future.	52	45	47
The roles that people take in teams.	48	47	47
The benefits of collaborating with others.	44	50	46
Contributing to make group work more effective.	46	53	50

Table 9-4: Responses to self-reported learning questionnaire from groups using the Time Capsule and the Pharaoh's Tomb

In order to determine statistically whether there was any significant difference between the responses from the students who had used the Time Capsule and the Pharaoh's Tomb, a Chi-squared (X^2) analysis was undertaken using the SPSS statistical software. In order that the data could be analysed using this technique, they were first re-coded into two categories: 'improvement' and 'no improvement' which created a 2×2 contingency table using the two experimental conditions; as each of these tests is undertaken with a 2×2 table, Yates' continuity correction is applied to prevent overestimation of statistical significance (Field, 2005), and a two-tailed test is used because it is not hypothesised that one particular condition will be more favorable than the other, simply that there will be a difference. The results are shown in Table 9-5 below.

These data show that there is no significant difference in self-reported learning on the majority of questions; however, two questions show a difference at the

0.05 level of significance: how to make good decisions as part of a group, and how to communicate with others in the future. Both of these questions showed a significant difference in the number of respondents who reported having learned from the Pharaoh's Tomb as opposed to the Time Capsule. It is worth remembering, however, that at a 0.05 level of significance, 1 in 20 tests would be expected to show a false significance by chance, so that while these results might indicate self-reported learning is greater with the Pharaoh's Tomb, it is important not to read too much into them.

	X^2	*p*
How to make good decisions as part of a group.	4.006	0.045
What makes communication effective.	2.136	0.114
Constructive controversy as a way of making decisions.	0.260	0.610
What makes a group effective.	0.010	0.919
How to be an effective leader.	0.008	0.928
How to communicate with others in the future.	0.058	0.044
Ways of generating new ideas.	2.810	0.095
The importance of group reflection for effective groups.	0.034	0.853
How to contribute to group decision making in the future.	0.281	0.596
The roles that people take in teams.	0.000	1.000
The benefits of collaborating with others.	0.195	0.659
Contributing to make group work more effective.	0.325	0.569

Table 9-5: The X^2 and *p* values for each of the questions in the self-reported learning questionnaire

The respondents were also asked if they would like to work with the same team again, and 85% of students who had used the Pharaoh's Tomb and 82% who used the Time Capsule said that they would like to work with the same team again. While this does not show any difference between the activities, it does provide some evidence that the students valued working in the team they were allocated and would be prepared to work in the same team in the future.

The next section follows on from this examination of self-perceived learning as a measure of educational effectiveness, to consider the differences in the levels of engagement as a comparative measure.

9.4 Evaluating engagement

This section presents and analyses the results from the questionnaire that was used to measure engagement (see Appendix 22). Before examining the comparative levels of engagement between the two experimental conditions (students using the Time Capsule and those using the Pharaoh's Tomb), the Cronbach's Alpha statistic for each experimental group was calculated using SPSS. First the responses were coded on a scale of 1 to 5 (the choice of scale was arbitrary as the questionnaire was not used to produce an absolute score but to compare ranked data), and nine questions were re-coded so that the direction of the scale was the same for all. A summary of the results is provided in Appendix 26. Cronbach's Alpha is a measure commonly used to assess the internal consistency reliability of several items in a questionnaire that are intended to be summed to make an overall score; Alpha should be positive and greater in value than 0.70 to provide good support for internal consistency reliability (Morgan, 2004). The results are shown in Table 9-6 below.

	Cronbach's Alpha
Napier pilot	0.897
Hong Kong pilot	0.759
Napier trial	0.860

Table 9-6: Cronbach's Alpha score for each use of the engagement questionnaire

In all three cases Alpha is positive and the reliability level is well above 0.7, which would indicated that the questions are internally consistent (i.e. they are all measuring the same concept).

The responses to each question in the questionnaire were summed to produce an overall engagement score for each individual. To see whether there is a significant difference between the levels of engagement of those students using the Pharaoh's Tomb game and those using the Time Capsule learning activity, the Mann–Whitney statistical test was used. This is an appropriate non-parametric statistical test to use when a single ranked variable is being analysed with different participants in two experimental conditions (Greene & D'Oliveria, 1993).

The hypotheses of this experiment are as follows:

H_0: There is no difference in engagement between the two conditions.

H_1: There is a difference in engagement between the two conditions.

As H_1 does not suppose a difference in engagement in a specific direction (i.e. that a particular condition is likely to show more engagement), a two-tailed test is used. The Mann–Whitney *U* statistic was calculated for each of the studies, which translates into a probability (*p*). These are shown in Table 9-7, where n_1 is the number of students who were in the Pharaoh's Tomb condition and n_2 is the number in the Time Capsule condition.

	n_1 (PT)	n_2 (TC)	*U*	*p*
Napier pilot	8	7	19.0	0.296
Hong Kong pilot	12	7	40.0	0.865
Napier trial	42	36	693.0	0.531
Total	62	50	1491.5	0.732

Table 9-7: Mann–Whitney *U* and *p* for each experimental condition

In none of these cases does *p* approach significance (at the 1% level of significance this would require a *p* value of less than 0.01), and therefore the null hypothesis (H_0) should be accepted; there is no significant difference in engagement overall between the students who used the Time Capsule and those who used the Pharaoh's Tomb.

However, engagement was hypothesised to be made up of five factors: challenge, control, interest, immersion and purpose, and the questionnaire was developed so that specific questions mapped to each of these factors. It was therefore also possible to use the Mann–Whitney statistical analysis to examine whether there was a significant difference in any of the factors between the two experimental conditions.

Before the analysis was carried out, correlations between the questions that were hypothesised to measure each factor were carried out using the Kendall's Tau statistic for measuring correlations between ordinal data. In the case of each factor, every question correlated with every other question that was intended to measure that factor (at the 0.01 level of significance in every case

except for two of the questions that measured immersion, which correlated at the 0.05 significance level). A detailed breakdown of these correlations is shown in Appendix 27. This provides evidence that the questions in the questionnaire that aim to measure each factor are internally consistent.

In order to generate a data set large enough for there to be sufficient variation in each of the factors for application of the Mann–Whitney statistical analysis, data from all three studies were aggregated. The totals for each factor were summed and tested, again using the Mann–Whitney test for significant differences between the conditions. The *U* and *p* values for each factor are shown in Table 9-8 below.

	Challenge	Control	Interest	Immersion	Purpose
U	1493.5	1135.0	1354.0	1288.0	1524.0
p	0.739	0.014	0.242	0.119	0.878

Table 9-8: Results of the Mann–Whitney test to compare the factors contributing to engagement across the two experimental conditions

This shows that there is no significant difference between the level of challenge, interest, immersion and purpose between the two activities. However, there is a significant difference, at the 0.01 level of significance, in perceived control between the two activities, with the Time Capsule activity being rated more highly for control. This is a particularly interesting finding as it provides evidence that, while the Pharaoh's Tomb was designed to provide an environment with many options and objects that could be manipulated, students actually felt a significantly higher level of control using the Time Capsule application. This could be due to the greater complexity in the interface of the Pharaoh's Tomb, or the fact that the Pharaoh's Tomb required three-dimensional spatial navigation skills, which left a small number of students unable to move around in the environment, whereas the time Capsule did not require the players to master navigation or interact with objects in a virtual environment.

In all, this chapter has presented the results of a series of comparative studies to examine differences in educational effectiveness, measured through self-perceived learning and engagement, between the Time Capsule negotiation

activity and the Pharaoh's Tomb adventure game. The statistical analyses showed that there were no significant differences between these two game-based activities in terms of either self-reported learning or engagement. However, the difference in perceived control is important when considering the extent to which game-based learning activities need to exhibit all of the characteristics of games to be effective learning environments. In the final concluding chapter, the implications of this, and the other research presented in this thesis, are discussed.

10 Conclusions

In this final chapter of the thesis, the work of the previous chapters is drawn together, discussed and reflected upon, in order to examine what the research as a whole has discovered, to highlight insights into the field of game-based learning in Higher Education and to consider what has been learned and how it might be applied.

The first section of this chapter revisits the research questions that were introduced in Chapter 1, and considers to what extent each has been answered by the work undertaken. Section 10.2 provides a discussion of the contribution to knowledge that is made by this work, a critique of the research methods used and consideration of ways in which the design of the research could have been improved, and provides a discussion of the results from the various studies detailed in this thesis. The chapter finishes by considering possible future directions for research in the field of collaborative game-based learning in Higher Education.

10.1 Overview of the research questions

Four research questions were posed at the start of this thesis, relating to whether there is a compelling rationale for using games for learning in Higher Education, the best way to design such educational games, how to evaluate the educational effects of computer game-based learning, and a consideration of whether different types of game-based learning lead to different levels of learning or engagement. In the sub-sections that follow, each of these questions is discussed in relation to the findings of this thesis.

10.1.1 What is the rationale for using computer games?

The first research question considered if there was a rationale for using computer game-based learning in Higher Education. From the literature review undertaken in Chapter 2 there emerged a number of sound educational reasons for using certain types of games, based on constructivist theories of learning. If games are experiential, active, problem-based and collaborative then they have the potential to be valid environments for learning, not specifically because they are games but because they exhibit the characteristics of constructivist learning

environments. However, this thesis has provided no evidence to support the common assumption, found in the literature on educational gaming, that games are a valid way to teach because they are intrinsically motivating, or that using games as a way to motivate students to learn, without even knowing that they have done so, is appropriate for adult learners.

There is also evidence, from the background studies described in Chapter 3, that there is no link between an individual's propensity to play games recreationally and that same individual's motivation to play games for learning. In fact, what has emerged is evidence that games may be engaging and support learning, but only if they are well designed and pedagogically sound, with the learning outcomes closely aligned with the goals of the game, and not simply because they are games. There is also evidence from these background studies that, although we cannot assume that games are, in themselves, motivating for everyone, this is not necessarily a reason not to use them. Adult learners, in particular, want to learn something in the most efficient manner, and if a game is perceived as being the most effective way to learn something then that in itself will be motivational.

To summarise, there is a strong rationale for games being a viable and appropriate educational medium, not for the motivational reasons commonly cited in the literature but because well-designed computer games share many of the characteristics and learning goals of well-designed educational activities.

10.1.2 Designing games to be usable and enhance learning

The second research question addressed the best ways in which computer games could be designed to support learning and also to increase usability of the gaming interface and functionality. Chapter 5 presented and discussed a selection of the literature on the design of educational multimedia interfaces and the design of computer-based learning activities. The later part of the chapter describes an analysis that was undertaken to synthesise this research with first-hand evaluations of 16 online games. These were used to produce two sets of six criteria that can be used to support the design and development of computer game-based learning, one relating to the interface design and one relating to the educational design.

The educational design criteria for game-based learning applications, which were highlighted in Chapter 5, focus on the degree to which an application supports active learning and engenders engagement, and whether it is appropriate for the intended teaching situation, encourages reflection, and provides an equitable experience for all users, as well as providing ongoing support and help. The interface design criteria, also described in that chapter, examine the level of flexible interaction provided by the interface, the support for player community and transparent navigation features, and whether there is an appropriate level of user control, system robustness, and quality of visual design. These criteria have the potential to be applied to inform the design of new game-based learning activities and also as a tool with which to evaluate the possible worth of existing games in specific learning situations.

Chapters 6 and 7 describe the design and development process of two examples of computer game-based learning applications with identical learning outcomes: the Time Capsule and the Pharaoh's Tomb; both were designed with the previously identified criteria in mind and evaluated against them. The Time Capsule is a collaborative activity, based on an existing face-to-face classroom activity, that exhibited many features of game-based learning but did not provide an environment that could be explored, use scored outcomes or support competition. The Pharaoh's Tomb is a multi-player adventure game set in a virtual environment, within which the players can navigate, explore and interact with objects. The evaluation of both of these activities against the educational design and interface design criteria showed that they implemented good practice in design, as far as was feasible within the pragmatic constraints of the project.

10.1.3 Measuring the educational effectiveness of games

The third research question focused on ways in which the educational effectiveness of games can be measured and, in particular, ways that were appropriate to measure the effectiveness of the Time Capsule and the Pharaoh's Tomb. Chapter 8 examined different ways in which learning can be measured and provided reasons why established methods (e.g. the pre-test/post-test model) would not be appropriate for the games developed as part

of this work. The development of a questionnaire to test students self-evaluation of their learning with the examples of game-based learning was described.

Chapter 8 then proposes engagement as an alternative indicator of educational effectiveness and describes the rigorous development and testing of a questionnaire to measure post-experiential engagement. From the literature on engagement, coupled with factors emerging from the interviews described in Chapter 4, five factors were drawn out that were hypothesised to contribute to overall engagement with an activity; these are an appropriate challenge (consisting of motivation to attempt the task, clarity of what is required and a perception that the task is achievable), control over the environment, immersion and absorption in the activity, intrinsic interest in the activity and subject matter, and a perception of the activity having a purpose and not being pointless or a waste of time. An 18-question Likert evaluation questionnaire, based on eliciting engagement as a combination of these five factors, was developed and tested.

10.1.4 Comparing different examples of game-based learning

The fourth, and final, research question considered how differences in game design would affect the educational experience of the students using the game. To address this question, the final area of research involved a series of three comparative experiments, comprised of two small pilot studies and one larger final study. The implementation of these three experimental studies is summarised in Table 10-1.

	Pilot Study 1	**Pilot Study 2**	**Final Study**
Location	Napier University	City University of Hong Kong	Napier University
Date	March 2006	September 2006	November 2006
Time Capsule (*n*)	7	7	36
Pharaoh's Tomb (*n*)	8	12	42
Total participants (*n*)	15	19	78

Table 10-1: Summary of the implementation of the comparative experiments

In each study, each student was allocated to one of two conditions, using either the Time Capsule or Pharaoh's Tomb activity. After completing the activity, levels of self-reported learning and engagement were measured using two

questionnaires. The design, implementation and results of these experiments were described in detail in Chapter 9.

There was little evidence for a significant difference in either learning or engagement between the two experimental conditions (i.e. the use of the two different games), although there was some indication that the Pharaoh's Tomb increased self-reported learning in some areas. However, since these findings were relatively inconclusive, it would be difficult to draw any definite inferences from these data. There was, however, a significant difference in the levels of control participants perceived themselves to have using each activity, with students having a greater sense of control when using the Time Capsule. This provides evidence that computer game-based learning materials need not exhibit all the characteristics of games to be just as engaging and appropriate for learning as games that do, and, in fact, a more straightforward application may lead to greater feelings of control during the game.

10.2 Contribution to knowledge

This section highlights and discusses the significant original contributions to knowledge that have been presented in this thesis. These have been in two areas. First, the research has provided insights into and a greater understanding of the potential use of game-based learning in Higher Education. It has provided a pedagogic rationale for employing games in certain teaching and learning situations, increased understanding of the characteristics that affect motivation and engagement with adult learners, and provided evidence of differences in educational effectiveness from different types of collaborative computer game-based learning applications. Second, it has produced practical tools to understand and evaluate game-based learning: a framework for defining different examples of game-based learning through their characteristics; two sets of criteria to support the design, development and evaluation of engaging and usable educational games; and a robust and rigorously tested questionnaire to measure post-experiential engagement. The next two sub-sections of this section provide a critique of the research methods employed and a discussion of the implications of the results.

10.2.1 Increased understanding of the nature of game-based learning

This thesis has provided an increased understanding of game-based learning in Higher Education by presenting a sound and explicit pedagogic rationale for the use of game-based learning; by increasing the understanding of motivation for game playing both for leisure and learning; and by showing that game-based learning applications do not need to be set in virtual worlds that can be explored to be engaging and appropriate for learning. Indeed, the virtual world may even be a learning environment that decreases the learners' sense of control and disadvantages students who have difficulty navigating the environment. This work argues that while games do have educational potential in Higher Education, they are not the solution to educating future generations that they are sometimes claimed to be (e.g. Prensky, 2001; Oblinger, 2004).

Academics in the field of educational games research often rely on the fact that games are perceived as intrinsically motivational for most people as a rationale for using them. This thesis asserts that this assumption is simply not true, particularly in the case of adult learners in Higher Education, and provides evidence that even in a population of computing students fewer than two-thirds were motivated to learn with games and, more crucially, there is no link between being motivated to play games recreationally and a motivation to play games for learning. This thesis has highlighted that adults will use the way to learn that they perceive to be most effective (Knowles, 1998) and this does not preclude games – but they must be seen as an appropriate way to learn and not simply as a gimmick or motivational tool.

Despite showing that the accepted rationale for using game-based learning is unsubstantiated, this thesis does not argue that game-based learning is inappropriate for learning in Higher Education, but instead presents a rationale based on the characteristics of certain types of game – adventure games, simulations, strategy games and role-playing games in particular – and constructivist learning environments (Wilson, 1996) that support experiential (Kolb, 1984), problem-based (Boud & Feletti, 1991), and collaborative (McConnell, 2000; Wenger, 2000) learning. This rationale provides a context for game-based learning within learning theory and highlights the importance of using games that are designed for learning and not simply because they are

games – close alignment of the gaming objectives and the learning outcomes is essential to ensure that engagement with the game leads to engagement with learning. The work described here has also added to knowledge regarding game playing and motivation, presenting a number of motivations for recreational game playing in adults. An appreciation that a range of motivations exist and an understanding of these different motivations will better enable the creation of games for both education and entertainment that meet the needs of a range of different types of game players.

As well as providing insights into the nature of game-playing for learning and student motivation, this thesis also contributes evidence as to the relative merits of different types of game-based learning for educational use. In the comparative study described in Chapter 9, the Pharaoh's Tomb, a competitive and immersive adventure game, was compared with the Time Capsule, a computer-based implementation of a more traditional activity for teaching group skills. The experiment showed that there was very little difference in learning or engagement between the groups of students that had taken part in each of the activities, but, those who had used the simpler interface of the Time Capsule had a significantly greater perception of control than those who used the more complex virtual environment. This shows that when game-based learning is considered it is worth remembering that it is not necessarily the activities that exhibit more of the characteristics of games that are most engaging or suitable for learning. When considering the use of game-based learning it is worth remembering that a simpler environment or less game-like activity may be as effective pedagogically as an activity that is completely game-like. It is more important that any game-based learning application is thoughtfully designed to meet the needs of the learners in a way that integrates appropriately with the curriculum, teaching situation and intended learning outcomes.

10.2.2 Tools to evaluate game-based learning

As well as contributing to the theoretical knowledge on game-based learning in Higher Education, this thesis has provided three practical tools for evaluating game-based learning. These are: a framework for classifying game-based learning activities; two sets of objective criteria to evaluate game-based learning, as well as to inform the design and development of activities; and a

tested questionnaire for evaluating post-experiential engagement with an activity.

Chapter 2 of this thesis provides a number of different definitions of games used by academics, developers and researchers in the field of gaming; these are amalgamated to present an inclusive definition of game-based learning and a single set of characteristics onto which all activities of this type can be mapped (see Table 2-1). This framework removes the somewhat artificial boundaries between different types of active and game-like learning activities and allows them all to exist on a continuum depending on their characteristics, thus presenting an open yet flexible definition of game-based learning.

This thesis also builds on and synthesises existing guidelines in multimedia design, interface design and the design of constructivist learning environments to present two sets of objective criteria specifically designed to support the design, development and evaluation of computer game-based learning activities in Higher Education. The first set provides criteria for the effective educational design of game-based learning on sound pedagogic principles, and the second provides a means to evaluate the design of game-based learning interfaces to ensure their applicability for supporting learning. As well as being used as an evaluative tool, these criteria can be used to inform and influence the design and development of future educational games.

The final contribution of this thesis is provided in the form of a practical tested tool for measuring engagement with a learning experience. This is based on a five-factor model of engagement, which in turn is based upon the work of Malone (1980a; 1980b), Csikszentmihalyi (1992) and the first-hand research described in Chapter 4 of this thesis. This questionnaire was rigorously tested, refined and used to evaluate engagement in the comparative experiments described in Chapter 9. It was also shown that the questionnaire as a whole and each of the factors used to measure engagement were internally consistent. This questionnaire is one of the important outputs of this work and has the potential to be used in a variety of teaching and learning situations to compare engagement under two or more conditions; it is easy to administer and straightforward to analyse.

In all, the research presented here and three tools described make a significant contribution to furthering the understanding of the field of computer game-based learning and to providing robust conclusions and outputs that can be confidently taken forward and applied in future research.

10.2.3 Critique of research methods

In this section the research methods used in this work are critiqued and issues that arose, associated with the research design, and lessons learned are discussed.

One major issue with the work presented here, particularly coming from the educational perspective that it does, is the focus on quantitative data collection methods rather than qualitative ones. In the field of computer game-based learning much of the research is anecdotal or based on qualitative studies that lack rigour, so it was important that this research was based on a strong evidential foundation, using a range of methods and a relatively large population. Qualitative research is best suited to exploration of an issue, and generation of topics or ideas, and was used at two points in this research: initially to explore the range of issues surrounding game playing and learning, and during the evaluation phase of the activity development. Triangulating the research using a mixture of methods, each to their best advantage, aimed to provide a more robust set of outcomes.

A pragmatic reason for the heavy leaning towards quantitative data collection and analysis techniques was the difficulty in recruiting volunteers to take part in the research, even with a monetary reward. While students could be asked to take part in an activity as part of their learning and could realistically be expected to spend a few minutes completing a questionnaire, it was not possible or practical to spend the large amounts of time with participants that qualitative research requires. If participation were no object, then further qualitative work to explore the perceptions of the same individuals using each of the activities would be an interesting way to extend the work and gain a deeper understanding of the preferences and attitudes of the population.

Using self-reporting of learning and engagement as indicators of educational effectiveness is not as robust a method as actually assessing learning itself in some manner. However, since this type of testing was not feasible for the trials, because the additional time was not available for testing, and there was difficulty in testing the learning outcomes without influencing subsequent learning, it is felt to be an acceptable way of measurement in the circumstances. Again, if resources and access to participants were no object, a larger intervention using pre-tests and post-tests at varying intervals would provide more robust data.

There might also be an issue with engagement in that students may experience too much engagement or be engaged in the game play rather than in the learning. For that reason it was particularly important that there is a clear and strong mapping between any educational game and the learning outcomes, so that engagement in the game would necessarily equate to engagement with the learning outcomes. While using engagement is not ideal as a single measure, it was triangulated with self-perceived learning and was felt to be a practical way to assess learning given the constraints of time and availability of participants.

A further research criticism was the lack of time given to briefing and debriefing in the comparative studies. This was because of practical and administrative constraints imposed by inflexible timetabling systems. The possibility of insufficient detailed briefing and debriefing sessions has implications for an understanding of the purpose of any experiential learning activity, which depends on reflection about key learning outcomes. Such understanding and reflection is a central feature of adult learning theory and constructivist perspectives of learning. The limited time for briefing and debriefing during these studies meant that these aspects may not have been adequately implemented, thereby limiting potential learning from the game activities. In an ideal situation, at least as much time would be given to the reflective processes around the game as to the game itself.

Another difficulty in the research design is related to the population used in the sample – computing students. There are characteristics associated with this sample, for example computer literacy, experience with computer games, typing

speeds and attitudes towards computers, which are unlikely to match those attributes in the general population. For this reason care must be taken when generalising from these results. However, one of the reasons for choosing computing students was that they were considered to be the group most likely to accept computer game-based learning and that if it would work with this group then there would at least be evidence for the viability of further research; if there was no evidence for its acceptability with this group of students then it was hypothesised that it would be less likely to be acceptable elsewhere. Also, the demographics of this group are such that they might be expected to play games and therefore be motivated to learn using games. There was, however, no evidence that this is the case in this group, and motivation is unlikely to be higher in the general population.

10.2.4 Discussion of results

In terms of providing a rationale for the use of computer game-based learning in Higher Education, this thesis has shown that there seems to be no evidence for the assumption that students will like to learn with games because they are intrinsically motivating, or even that people who are motivated to play games in their leisure time will be motivated to use them to learn. It is not appropriate to use games for their motivational power alone, without considering the appropriateness of the game for the topic under study and the particular group of students. However, there are strong arguments in favour of the use of educational games, but only if they are designed for learning, supported in the learning context and perceived by the students as the best way to learn. The right type of game, used in the right type of environment can foster collaboration, provide active and experiential learning, and be highly engaging.

This thesis argues that it is not the fact that a learning activity is a game, per se, that gives it the potential to be engaging, but the fact that it is designed as an effective educational experience, embodying constructivist learning principles. The characteristics of game-based learning applications also share many of the characteristics of effective learning environments, and a range of activities that embody the characteristics of game-based learning have the potential to be equally engaging. Game-based learning does not have to exhibit every characteristic of games to be effective and appropriate for learning.

In Chapter 2, game-based learning applications were defined as having certain characteristics, and an inclusive and open view was taken of what is defined as game-based learning. Originally it was intended to use these characteristics to distinguish between and test two activities that were seen as a 'game' and a 'non-game', but this distinction did not turn out to be a useful one, as individuals' perceptions of game-based learning differ. As well as comparing two examples of game-based learning it may have been more meaningful to test game-based activities against a more traditional teaching method, such as a lecture, and there may be a far greater differential between these two teaching mediums. However, it was felt that there was clearly more educational benefit in an active learning method, so the students taking part in the lecture would be at a disadvantage, which would be unethical.

From observations, the students taking part in the trial seemed to be generally enthused about using the applications, the Pharaoh's Tomb game or the Time Capsule activity, and this appeared to be party because of the fact that it was something different, unlike the teaching they were used to. There is undoubtedly a novelty effect associated with introduction of any new type of learning method, and it is possible that any motivational or engagement effects would diminish if games became commonplace in education.

There was also observed to be a greater polarity of reaction among students who used the Pharoah's Tomb game, with some finding it instantly immersive and others finding it more difficult to get started. This diversity was not apparent with the collaborative Time Capsule activity. When students found it difficult to engage it was usually associated with an inability to navigate through the gaming environment. A small number of people seemed completely unable to visualise the game as a three-dimensional space and themselves within it and therefore found it very difficult to navigate around the environment. It is important to be aware that any type of game may be inaccessible to some students, and although making the applications fully accessible was not an aim of this research, the potential of disadvantaging certain students would be an important consideration if this type of application were to be used on a wider scale.

Although games have a clear educational potential, it is still not clear whether the disadvantages of games for learning, such as the expense, the time taken to develop and learn, and the difficulties of integration into the curriculum and assessment, outweigh the advantages. For educational games to be effective it is important that they are designed as constructivist learning environments, that the gaming outcomes match the learning outcomes, and that appropriate reflective activities are designed around the game. For this reason, using commercial games, while having greater production value and leading to greater engagement, may be inappropriate for learning unless specifically designed for this purpose.

This thesis argues that certain computer game-based learning has the potential to be effective in certain situations, but that it is not the answer to reforming education. It has a place alongside a whole host of other teaching and learning methods, electronic and traditional, and should be the most effective way to learn something rather than simply being a gimmick to motivate and engage students into learning without being aware of it.

Overall, this work has provided a range of contributions to knowledge, both theoretical and practical. It is hoped that these contributions will be used to inform and underpin future work in the field, both by the researcher and by others. The final section of this chapter considers a range of potential areas for future research in the field.

10.3 Areas for future research

A number of directions for future research are suggested by the work presented here. Five areas, which are of particular interest, are discussed in the sub-sections that follow. These are: the potential for evaluating larger-scale development and implementation of game-based learning; the use of in-depth qualitative investigative techniques; additional quantitative studies; investigation into the perception of three-dimensional environments; research into novel and experimental interface designs; and the potential for the design of asynchronous games for use in virtual learning environments to support distance learners.

10.3.1 Large-scale implementation

One of the limitations of the two game-based applications developed as part of this study was that they only represented one hour's worth of learning. An obvious future direction for this research is to implement collaborative game-based learning on a larger scale, for example its use across a unit or programme built around a game-based environment, or delivered in an immersive game-like environment, which would enable a more rigorous evaluation of the effects on learning over time. In particular, such work would enable effects arising because of the novelty factors associated with game-based learning to be evaluated.

There is great potential for collaborative adventure-gaming environments to support social interaction and group work in a range of contexts and situations, with a range of students, and the development and evaluation of such environments is a natural extension of the research described in this thesis. There is also scope for evaluating a range of associated issues such as the organisational and managerial issues associated with implementing a change in teaching such as this in the Higher Education context; technical and software design issues for supporting larger-scale multi-user interaction across local and distributed networks; and teaching and learning issues such as appropriate ways to assess game-based learning courses.

10.3.2 Qualitative evaluation

A second limitation of the research described here is its focus on quantitative data collection and analysis techniques, which meant that the collection of rich and in-depth qualitative data was limited. This suggests that a second potential area for future research would be to undertake more qualitative explorative work in the field of game-based learning, for example ethnographic investigations into virtual gaming communities or a larger phenomenographic study into the ways in which people perceive computer games in Higher Education, looking at different populations of individuals to discover the factors that make games appropriate for learning in different student populations, in terms, for example, of subject, age, gender and previous experience with computer games. This type of rich qualitative research would make an attempt to better understand the nature of game-based learning from the perspectives of the range of individuals

that are involved in the phenomenon. Qualitative analysis of this sort would also enable the investigation of more sensitive topics of study relating to games and game playing such as game addiction, the link between aggression and certain types of game, and gender roles and stereotyping in gaming environments.

10.3.3 Quantitative studies

As well as a need for further qualitative work, more robust and rigorous quantitative studies are also required. Two areas in particular are highlighted here for further study: examination of evidence of the link between engagement and learning and comparative experimental designs using a control group.

Although there is an intuitive link between engagement in an activity and learning from it, there is little research evidence detailing the nature or extent of the relationship. Correlation of measures of learning and measures of engagement using the same group of learners in future studies would allow this relationship to be explored in greater detail and provide empirical evidence of the extent to which increased engagement is related to increased learning.

Use of a control group, for example students using a traditional format such as a lecture, was not used in the study described here, primarily for ethical reasons in that it was felt by the researcher that the students in a lecture condition would be at a disadvantage compared to groups learning in a more active manner. However, there is a clear need for empirical studies of this type so that traditional teaching models can be compared with new learning methods, in order to get a true picture of the educational value of innovations. The ethical issues could be countered by ensuring that studies using a control of this nature did not affect students' assessments in any respect, for example, by recruiting and paying students as an activity separate to their studies.

10.3.4 Three-dimensional environments

A small percentage of users of the Pharaoh's Tomb appeared to find it particularly difficult to navigate in a three-dimensional virtual environment. It would be possible to undertake further research in this area to examine the links between visual awareness and spatial perception and to consider ways in which three-dimensional interfaces could be adapted to support navigation and, in

particular, users with less experience of them. It would also be interesting to examine the cause and effect relationship: do some individuals not play three-dimensional games because of a lack of spatial ability or do they have less well-developed spatial abilities because they play fewer computer games of this type? If the latter, then there would be strong evidence for the acquisition of spatial skills through gaming.

10.3.5 Interaction devices

A fourth area of interest for future research would be to consider alternative methods of interaction between game interfaces and players, with a particular focus on investigating the emerging range of interface devices used on console games machines, for example dance mats, microphones, and controllers that are sensitive to movement. This would enable the consideration of the development of games for learning physical skills and provide games that would appeal to people who are motivated to play games for the physical challenge.

Future research in this area could also examine the range of ways that individuals in collaborative virtual environments could be represented, how they could be controlled by a range of interaction devices, and the methods of interaction with other people who are present in the environment. Issues of accessibility are particularly relevant here, as the use of game-based learning environments may create an inequitable experience for those learners with less experience or with physical or cognitive disabilities.

10.3.6 Asynchronous communication

The game-based learning activities created for this research were created to be played synchronously because this was thought to be more appropriate for the skills being taught but also because it was more practical to use and evaluate these games in a synchronous manner. However, this mode would not always be practical, particularly in online or distance education where students are not necessarily online at the same time. A final area for possible future research is in the development of asynchronous games, which could provide more flexibility for the students. Issues for potential study include the design of game-play for an asynchronous environment, and ways of ensuring and testing engagement over time.

There are a number of potential areas of future research in the field of game-based learning and the five here only provide some examples of work that leads directly from the work covered in this thesis. The research described here has aimed to provide insights into the nature of game-based learning and its applicability to Higher Education as well as practical tools for investigating the area. This field is one in which the amount of interest and research is fast increasing and it is hoped that the work presented here will be of use to other researchers by providing a sound theoretical and pedagogic underpinning for the use of game-based learning in Higher Education as well as practical tools for supporting and evaluating future research in the discipline.

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Appendix 1: Initial interview structure and crib sheet

Thank you for taking part in this interview, which should take no more than one hour.

Are you happy for me to tape record the session?

Background

Sex / Age (Under 20 / 20 – 29 / 30 – 39 / 40 – 49 / 50 – 59 / 60 +)

What is your educational background?

What is your experience with computers?

Attitudes to gaming

What do you understand by the term 'game'? What makes something a game?

Do you play games? If so, what types do you play / enjoy?

Why do you play games / why don't you play games?

If you do play games:

What type of games do you enjoy / not enjoy? Why?

Do you play computer games? Why / why not?

If so, what types of computer games do you enjoy / not enjoy? Why?

Leisure activities

Which activities do you do in your leisure time?

What are the aspects of these activities that you enjoy? Why do you do these activities?

Do you use your computer for any leisure activity (apart from games)? If so, what?

Attitudes to learning

Describe to me how you would go about learning something new (facts, skills).

Would you consider using a game to learn? Why / why not?

Have you ever used games / computer games for learning? What was your experience?

Types of games

Computer
adventure / role-play / shooter / simulation / multi-player / quick (solitaire, minesweeper)

Board
monopoly / chess / draughts / go

Gambling
roulette / slot machines

Cards
poker / bridge / snap / solitaire

Active
football / golf / bowling

Quiz
trivial pursuits / quiz machines / pub quizzes

Other activities

Active
walking / gardening / running / cycling / travelling

Reading
fiction / non-fiction / technical / magazines / newspapers

Creating
painting / modelling / pottery / writing / cooking / playing a musical instrument

Passive
television / cinema / listening to music / concerts / art galleries / museums

Social
meeting friends / pub / eating out

Learning
evening classes / languages

Collecting
stamps / train spotting

Campaigning
politics / charity / religion

Purchasing
shopping / window-shopping / internet-shopping

Thinking
puzzles / crosswords

Appendix 2: Example transcript segments

Excerpt from Interview H

Why do you play games?

Because it's good fun. I sometimes, if I'm feeling competitive, I like winning, but then it doesn't matter if I don't if it's a good fun game. Pictionary, I like Pictionary and I quite like, em Chris has got one which is a sort of a riddle game, but no I really will play anything, I'll play Ker-plunk or anything that anyone says 'do you want to play?'

So is there any game that you wouldn't play?

Chess.

Why's that?

'Cause it's too much forward planning and strategic thinking and I just can't be bothered when you play with people who take half an hour to make a move. Ugh! <laughs> I just can't be doing with that. Other than that, no, I can't think of anything I wouldn't play.

Do you play computer games?

A little bit, not massively, because I don't have that many but probably if I did have I would play.

Which sort do you play, or have you played?

I play Scabby Queen, its one of these card ones, pass the, you've got to pass the Scabby Queen and then…

Do you play that online or on your own?

No, no, no, that's just on the computer, and I've got Patience and I play that and Chris has a very good one called Brain Drain, which I play, you know that? [*I don't think so.*] No? It's quite good.

What type of game?

That is, you get all sorts of little shapes and then, basically what happens is you get an example of shapes you meant to be like… for example it'll randomly generate a thing that you have to follow and by rotating them you've got to get the same shape, and it's a timed thing. And when Myles was small we used to play this, I suppose you call it an adventure game, and it was in China and you had to go up all these different levels and get magic potions and duh-duh-duh-duh… I found that quite tedious.

Why's that?

'Cause I kept getting chucked back to the beginning and I'd have to go through the whole lot again and I don't like that.

Anything else, other computer games that you play?

I don't know. I used to play Pac-man, does that count? [*Oh yes.*] Years ago, when we lived in Paris I played that one. Yeah. But no, because I don't have a vast collection of them I don't necessarily play that many, but if I did have you know I would, I would waste hours.

Why's it a waste?

Well because you're not doing anything productive are you, you're playing and it is a waste of time. I was going to say something and it's gone… I think Mavis Beacon, Teach Yourself Typing, I think that's a game, I spend hours playing that.

Excerpt from Interview D

Okay, so do you play games?

No <laughs>. Not really, but I take my broad sort of definition of what I would call a game, and I guess I'm including sports and leisure activities in this as well then I do enjoy doing a number of things, mostly individual activities, running for example, and I get quite competitive with myself about that in terms of paying quite close attention to how far I'm running, times, and things like that although recently I've been frustrated by the fact that I haven't had much time to do things like that, so yes, running, although that's not really a game but I see it was something where I'm sort of like competitive against myself. Em… in the past I have been involved in competitive sports, I was really quite into Karate and martial arts in general when I was younger, I certainly enjoyed the discipline side of it, and the different ways to challenge yourself doing something like that, yeah, quite often that would involve taking part in competitions and, you know, sometimes sparring against other people from other clubs and things like that so I have participated in games in a broad sense in the past… I have occasionally played computer games although there aren't any games that I'm a particularly big fan of, and I'm not, I wouldn't, I'm a dabbler more than anything else, I have played computer games before, I have played some competitive physical games before but no, on the whole, I wouldn't really say that I play games now… [*okay*] particularly often.

Why do you think that is?

I get quite bored of, well in terms of em, if we talk in a broader sense about sports and physical games and leave aside the issue of computer games just now, I get quite bored with the competitive element of it, where that's involved. Not sure exactly why that is but I find them more, I find it more rewarding when it's something that I'm sort of doing myself to challenge myself, also I find that one of the reasons I like undertaking the sort of activities that I do is physical relaxation, and I find something like running or even sort of like circuit training,

which I used to do a lot of, I find that more relaxing when it's just you yourself testing yourself, if you like, I find that much more relaxing than competitive situations which I don't find particularly stressful as such but I don't like the way that other people get stressed in those situations. In terms of other types of games, well I guess that most people, perhaps I should have mentioned this before now I start thinking about it in a bit more detail, I do now and again play board games and things like that, those I don't mind at all, they're usually just part of a social activity where we've got friends round, whatever, wouldn't always chose to play board games but I don't mind taking, you know, I don't mind playing them when I know it's just fun, there's nothing in it. Computer games, video games, things like that as I say I've played those in the past and, mostly when I was younger than now, but I was never a huge fan or a huge game player. My main reason now would be that I spend most of the day of my working week staring at computer screens, doing things with computers, I don't particularly want to go home at the weekends or in the evenings and sit and play computer games where again I'm staring at digitised images on a screen, it's not something that appeals to me mainly for that reason, nothing more that really, you know we own a games console, which we get out now and again but it tends to be the kinds of thing we do, either myself and my partner will play a few games against each other on one game or another or I'll get it out myself but it tends to be a last resort, nothing on the TV, can't go out for whatever reason, nothing on the radio, don't fancy any of the board games then we'll dig the games console out but it's really a boredom breaker more than anything else.

Okay, you mentioned that you played computer games in the past, what types did you particularly like playing, what types have you tried?

I'm no expert, but I guess what they sort of call platform games, the main one I remember when I was younger was Jet Set Willy, a popular game in the early eighties where you'd run around this house, all the different levels, collecting things and so on, that was the main one and I guess I got into that because all my friends played it. There were various other games that were similar to that, what did I like about those, I liked the sort of exploratory aspect of them and just that fact that they were quite light-hearted and not particularly, you know, they weren't much of a brain drain, they were fairly simple games, yeah, they just took up some time for a little while.

Okay, are there any types of games that you can think of that you really don't get, that you just wouldn't play, that you don't understand why people play them?

Again, the sort of games that I think I don't like, well they're really just based on sort of general impressions I've got, what those games are and what they involve, maybe the impressions I've got about the people that play them, so this isn't really from any sort of well-experienced point of view or anything. I find myself bored rigid when I've ever tried to play any fantasy-type game where you're sort of like assuming the role of a character and be trying to solve puzzles and riddles and things like that…

Appendix 3: Game play questionnaire

Please take a few minutes to answer all the questions on this sheet as honestly as possible. Your help is very much appreciated.

Age ☐ under 20 / ☐ 20–29 / ☐ 30–39 / ☐ 40–49 / ☐ 50–59 / ☐ 60 plus

Sex ☐ male / ☐ female

Have you ever played computer games? ☐ Yes / ☐ No

Do you play computer games now? ☐ Never / ☐ Occasionally / ☐ Regularly

If you do play computer games, what types do you play? (You can select more than one.)

☐ Adventure ☐ Simulation ☐ Puzzle ☐ Multi-player

☐ Role-playing ☐ Shooter ☐ Strategy ☐ Platform

☐ Other _____

If you do play computer games, why? (You can select more than one.)

☐ Playing with others ☐ Mental challenge ☐ Physical challenge

☐ Boredom ☐ To make social situations easier

☐ Other _____

Do you play any other types of games? ☐ Yes / ☐ No

If yes, what types do you play regularly? (You can select more than one.)

☐ Board games ☐ Card games ☐ Gambling ☐ Sports

☐ Quiz games ☐ Puzzles ☐ Role playing

☐ Other _____

Please turn over to complete the questionnaire.

If you do play other types of games, why? (You can select more than one.)

☐ Playing with others ☐ Mental challenge ☐ Physical challenge

☐ Boredom ☐ To make social situations easier

☐ Other _____

Have you ever played an educational game? ☐ Yes / ☐ No

If yes, please give details.

Are you motivated by the idea of learning with a game? (Please select one only.)

☐ You would be positively motivated

☐ It would not motivate you either way

☐ You would not like the idea of learning with a game

Thank you for completing this questionnaire.

If you would consider being interviewed during the next stage of this research, please provide details of your name and email address.

Name _____

Email _____

If you would like further information about this research, please contact:

Nicola Beasley
n.beasley@napier.ac.uk

Appendix 4: Contingency tables

Propensity to play computer games for leisure against motivation to learn with games

		Motivation to learn with games			Total
		1 Yes	2 Neither way	3 No	
Propensity to play computer games	1 Never	18	7	1	26
	2 Occasionally	54	16	5	75
	3 Regularly	53	33	11	97
Total		125	56	17	198

Note: 2 cases have been removed where data are missing

Propensity to play games for leisure against motivation to learn with games

		Motivation to learn with games			Total
		1 Yes	2 Neither way	3 No	
Propensity to play games	1 Yes	99	44	12	155
	2 No	26	12	5	43
Total		125	56	17	198

Note: 2 cases have been removed where data are missing

Appendix 5: URLs for games used for review

Avatar High
http://www.the-n.com/games/avHigh/ahigh.php

Bookworm
http://www.shockwave.com/sw/content/bookworm

Bootlegger
http://mysterymanor.net/bootlegger/index.htm

The Crimson Room
http://www.ebaumsworld.com/crimsonroom.html

Grow
http://www.eyezmaze.com/grow3/

Hamlet
http://www.robinjohnson.f9.co.uk/adventure/hamlet.html

iSketch
http://www.isketch.net/

Laser Beams
http://www.microprizes.com/mp55.htm

Law and Order II
http://www.shockwave.com/sw/content/lawandorder2

Lemonade
www.lemonadegame.com/

Mini golf
http://www.electrotank.com/playGame.electro?gId=119

The Mystery of Time and Space
http://www.albartus.com/motas/

Runescape
http://www.runescape.com/

Samorost
http://www.amanitadesign.com/samorost/

Typer shark
http://www.shockwave.com/sw/content/typershark

Whizzball
http://kids.discovery.com/games/whizzball/whizzball.html

Appendix 6: Introduction to effective group work

At the end of this session, you should:

- know what a group is and to be aware of the elements that make a group effective;
- appreciate the benefits of working as a group, and be able to communicate and collaborate successfully with others;
- be able to successfully work together to problem-solve and reach effective decisions.

Effective groups
A group can be defined as:

- three or more people;
- with a common goal;
- who work together and influence each other;
- and see themselves as a group.

Learning about how to work together in small groups is important because, as humans, group membership is an integral part of our lives and groups are central to our family lives, work lives, education and psychological health.

Getting to know and trust the other group members is a vital first step to working together effectively. There are a number of ways to develop an atmosphere of trust:

- be open in sharing information, thoughts and feelings, materials and resources;
- show a willingness to accept each individual and their contributions to the group;
- support each other and recognise the strengths and weaknesses of each person.

For small groups to work well, they should also have **positive interdependence** and **individual accountability**. Positive interdependence means that achieving the goal relies on the group working together rather than as single individuals; but individual accountability means that people are personally responsible for achieving their own tasks and helping others achieve theirs.

Explicit goals are also important for any effective group. Goals should be clear and common to all group members. The first job of any group should be to determine, modify and clarify its goals until a consensus exists that is understood by all members. Conflicts of interest, where there are differences between group and individual goals, should also be considered.

Group reflection is also important for maintaining an effective group. The group should consider periodically how they are functioning and plan to improve the work processes in the group.

Working collaboratively
Working collaboratively can bring a number of benefits, including:

- allowing people to work to their strengths and preferences;
- bringing together a range of skills, approaches and knowledge;
- development of improved solutions through critical discussion;
- being able to achieve goals quicker and more effectively;
- social benefits and peer support.

Effective communication is central to collaboration. When communicating with others:

- use personal pronouns to talk about your opinions (e.g. "I think that the sky is blue" rather than "The sky is blue");
- make sure that what you say is complete, clear and specific;
- make the message appropriate and relevant to the person receiving it;
- ask for feedback on whether others understood what you were saying; if you are not sure you understand something, ask for clarification;
- describe behaviour without evaluating it, and describe the effect that it has on you (e.g. "When you shout it makes me feel upset" rather than "It is wrong for you to shout").

Fun and humour are an important element of relationship-forming and group communication; however, this can be culturally-specific and exclusive, so it is important to be sensitive to this and careful that jokes, sarcasm, or banter is not misconstrued. Always give others the benefit of the doubt if you think it's possible you may have misinterpreted something, and ask for clarification.

Making decisions in groups

Group decision-making is often more effective because:

- group discussions lead to more ideas and insights;
- incorrect solutions are more likely to be recognised and rejected;
- groups have a more accurate memory of facts and events;
- groups have the confidence to make riskier decisions.

Decisions can be made by groups in a number of ways, for example by the leader with or without discussion, by an expert group member, by a sub-group, by the majority vote, or by consensus. Consensus is the best option for high-quality decisions, which are innovative and increase commitment.

An effective decision can be described as one where:

- the group uses all the resources available;
- time is used well;
- the decision is thought to be a good decision (in that it is acceptable, realistic and likely to have a good outcome);
- the ability of the group to work together is increased.

Controversy is often seen as being destructive, rather than a constructive method of decision-making. This can be because people are afraid of confrontation and do not know how to effectively engage in controversy.

To use controversy constructively for decision-making:

- Be aware of the common need to make the best decision possible.
- Avoid arguing blindly for your own opinions but present your position as clearly and logically as possible,
- Encourage others to advocate their positions and listen to other members' reactions and consider them carefully before pressing a point.
- Understand, then challenge, opposing ideas and positions. Differences of opinion should be sought and discussed and all people should be encouraged to participate.
- Do not take personally other members' disagreements and rejection of your ideas.
- Synthesise the best ideas from all viewpoints and perspectives.

Appendix 7: Time Capsule character briefings

Professor Hilary Dustbuster

You are a well-respected local historian, and made your name heading the faculty of local history at the local university. Your research is famous for several miles around and you are best known for your controversial investigations into the role of badgers in local history.

You are keen on preserving any items that relate to local history, particularly those that are graphical, such as paintings or photographs.

You have a particular interest in keeping alive the memory of your great aunt Augusta Dustbuster, a local poet.

Three months ago, you made the greatest find of your career. While excavating on Old Mill Hill you discovered ancient badger bones; you believe this proves the existence of a Roman settlement in the area.

You are a very serious person with a dislike of all things frivolous, such as music, laughter, cats and cake.

However, in your younger years you were the lead singer in the girl group 'Hilary and the Hornets'. This is now an extreme embarrassment to you and you want to obliterate every memory of the group.

In your spare time, you are an enthusiastic taxidermist.

Another particular area of interest for you is the manufacture of whiffling spoons in Tudor times. Whiffling spoons were used to scoop the scum (or 'whiffle') from the top of badger stew, a local favourite of the era.

Your best-selling (in the local historical non-fiction charts) book, "Badger Quest: Beyond the Myth" is, you feel, one of your finest achievements.

Felix Grubb

You are one of the town's leading businessmen. You own a lucrative chain of butchers' shops, are head of the Chamber of Commerce and close personal friend of the Mayor. You give a lot of money to local charities (but you don't like to talk about it).

You have no relatives to carry on the family name or the family business so it is extremely important for you that you are remembered in some way by future generations.

You are rightfully proud of the prize-winning sausages produced by your firm; however, their image has never really recovered since the unfortunate food-poisoning incident at the Mayor's inauguration banquet. Even now, thinking of that day upsets you.

You were very upset recently when some old movie footage of American soldiers during WW2 was discovered, which contained many disparaging comments about Grubb's sausages.

You are known for your knowledge of fine foods and wines and your love of all things culinary.

Your messy divorce from local potter, Petra Pottington, last year has left you emotionally embittered.

You are a huge sports fan, and your particular hero is Wilbur Grace, who captained the local rugby team to league victory seven times between 1930 and 1945.

As part of its charitable works, Grubb's has for many years sponsored activities in the local schools, including the Doomsday project and yearbook production.

Despite your wealth, you are a man of the people and feel that precious objects should be made publicly available in museums and galleries. The thought that any such works of art should be included in the time capsule is abhorrent to you.

Dr Catherine Makewell

You are the town's local GP. You are known as a strict woman of principle and are well respected by all who know you. Your knowledge of local ailments is second to none.

You have always been a strong advocate of natural foods and healthy eating and have been a staunch vegetarian since suffering severe food poisoning at the Mayor's inauguration banquet. You are teetotal and campaign strongly for the banning of all alcohol.

A distant ancestor of yours, "Dirty" Dick Makewell was a notorious highwayman and was hanged in 1837. You are deeply ashamed of this.

Your sister is married to local celebrity Seth Bainbridge and you have secretly always harboured a passion for him.

You are a fervent animal lover and were devastated when your prize-winning cat, Snookums, died last year after a long and successful show career. You buried Snookums in your favourite spot on Old Mill Hill and were upset recently when you discovered that the remains had been disturbed. You blame the local children.

You were a key member of a research team that developed wonder drug Omexon 6, which can cure a range of ailments. Its use has been limited at the present time, however, owing to its toxic effects on badgers.

You have a long-running feud with the head teacher of the local school, Dorothy Spiggot, who you accused of stealing your recipe for lemon drizzle cake.

Your best friend is local potter, Petra Pottington.

You are old-fashioned in your tastes and dislike noisy modern music. In fact, there has never been a song that tops your all-time favourite from 1963, "Bing Boom a Bang Bang" by Hilary and the Hornets.

Mayor Titus Bobbins

You are the esteemed Mayor of the town. The time capsule is your idea and will be named after you, so you don't really care what goes into it (after all you'll be long gone by the time it's opened).

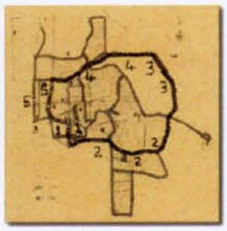
What you do care about, however, is making sure that the capsule is ready in time, contains the correct number of items, and comes in on budget (or preferably below budget).

You will not agree to any selection of items that go above the budget of £1,000.

Appendix 8: Time Capsule object list

1. Poetry book **£500**
A first edition of 'Poetry what I wrote' by Augusta Dustbuster. One of the few surviving copies of this little-acknowledged work by the local poet.

2. Sausage selection **£100**
A vacuum-packed crate containing a selection of Grubb's prize-winning sausages, black puddings and assorted offal.



3. Map of the town **£600**
A hand-crafted map of the town and its environs, specially commissioned from master cartographer and celebrity pilot, Seth Bainbridge.

4. Lemon sponge **£50**
A hermetically-sealed Tupperware box containing one of Dorothy Spiggot's famous lemon drizzle cakes.

5. A photograph of the High Street **£100**

This photograph was taken on the day of the Mayor's inauguration and shows happy crowds. The Mayoral party looks somewhat nauseous.

6. A rosette **£200**

Final rosette awarded to famed local cat, Snookums, at the County Cat Show. Sadly Snookums has since died.

7. Movie film **£100**

Original movie film of the town during the war, including extensive interview footage with American GIs stationed at the nearby air base.

8. Cine projector **£500**

Projector for showing reel-to-reel movie film.

9. A painting **£600**

A painting of the Old Mill in 1873, by famous artist Vincent van Driver.

10. The doomsday book **£100**

A somewhat amateurish effort by the town's school children to reproduce the Doomsday book, undertaken in 1983. With pictures.

11. A signed photo **£150**

A signed photo of local sporting hero, rugby player Wilbur Grace.

12. Petra's Pot **£250**

A charming example of the potter's art created by local potter, Petra Pottington.

13. Yearbooks **£50**

A copy of every yearbook from the local school since the custom was adopted in 1994.

14. Newspaper **£50**

A laminated copy of the local newspaper from the day that the capsule goes in to the ground.

15. A phial of Omexon 6 **£600**

Enough Omexon 6 to enable future generations to develop their own production facility.

16. Magazine **£50**

A copy of 'Flavours of the Country' from 1973, featuring in-depth article about the high quality of sausage production in the area.

17. Record **£100**

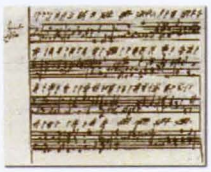
A rare copy of 'Bing Boom a Bang Bang', by local group, Hilary and the Hornets, which made it to number 23 in the charts in 1967.

18. Stuffed badger **£300**

Prize-winning work of acclaimed local taxidermist, Ebenezer Sponge.

19. Local beer **£50**

A keg of the much-praised 'Old Tubthumper' local ale, brewed on the premises of the Stag and Raven pub.



20. Manuscript **£700**

A copy of the manuscript of 17th-century composer Michel Flaubert's masterpiece 'The Old Mill', thought to have been composed while staying at the Old Mill.

21. A copy of Who's in Charge? **£100**

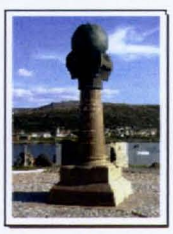
A compendium of all the speeches of the Lord Mayor (autographed).

22. Animal bones **£300**

Animal bones recently discovered on the Old Mill Hill. They are believed to be of Roman origin.

23. A genuine Tudor whiffling spoon **£600**

An unusual artefact, unique to the local area.



24. Photograph of the Grubb monument **£50**

Framed photograph of the centrepiece of the town square, named after Sir Hubert Grubb, one of the town's founding fathers.

25. Highwayman's hat **£300**

Believed to belong to legendry local highwayman and philanderer "Dirty" Dick Makewell.

26. Globman's fudge **£50**

A party box of the celebrated local confectionary.

27. Limestone rocks **£50**

A sample of the local building and walling material.

28. History book **£250**

A signed copy of 'Badger Quest: Beyond the Myth' by H. Dustbuster.

29. Hunting horn **£200**

Silver hunting horn used on the annual badger-drive between 1730 and 1910, before such barbaric practices were outlawed.

30. Cricket bat **£500**

The cricket bat that won the local team's historic town championship victory in 1932.

Appendix 9: The Time Capsule Exercise Instructions

In its wisdom, your local town council has decided that the best way to spend its spare revenue is to invest in putting together a time capsule, containing six items of interest to future generations, not to be opened until the year 3006. It is hoped that this capsule will provide a unique insight into life in your town.

The council has a budget of £1,000 and the Major is adamant that this can not be exceeded, so to help him make the all-important decision about which items to select for the capsule, he has invited three prominent local citizens to help him.

You will be acting as one of these people, and will be provided with:

- an information sheet giving you details of your character;
- a list of potential items for the time capsule.

You have 40 minutes to agree on the six items that should be placed in the capsule. All of you must agree.

Part 1: Getting to know the other group members
Spend a few minutes introducing yourself to the other members of the group (in character).

Agree as a group what your group goal is and your constraints (e.g. time, money, etc.) Feel free to share as much (or as little) information as you wish about your character's personal goals.

Once you know who everyone else is, move on to Part 2.

Part 2: What can we put in the capsule?
You have thirty potential items available to put in the capsule. Some of the items are specialist and you may need help from the other characters to find out what they are and what value they might have to future generations.

Spend the next ten minutes making sure that all members of the group know what all the items are and are aware of their merits. Don't spend time at this stage arguing for particular items to go into the capsule, just make sure that everyone is informed.

When all group members are happy with this, you can move on to Part 3.

Part 3: What shall we put in the capsule?
In this final stage, your group must come to a decision, which is acceptable to all parties, about what should go into the capsule.

Your character sheet will give you more detail about the items that you think are important.

All characters must agree on the final decision. You must not go over the budget of £1,000.

Appendix 10: Debriefing Exercise

The purpose of this exercise was to give you some experience of working collaboratively as a group, to achieve a definite goal with limited resources and time.

It does not really matter how you performed in the exercise or whether you achieved the objective in time, what is more important is thinking about the process by which you communicated with each other and made decisions, how effectively you negotiated with others, and what you can learn from that process.

You do not need to write anything down, but take ten minutes to discuss the following questions with your group:

The outcome:

- Did you manage to reach a conclusion that was satisfactory to everyone in the time?
- If not, what stopped you doing this?
- Which behaviours were positive for the team? Which were negative?
- What could you have done that would have led to a better outcome?
- How did you decide on what to do? Do you think the group made good decisions?
- Do you think this was fair? Would there have been better ways to decide?

Group processes:

- Did you take time to find out who everyone else was?
- Did you agree about the group goal? If not, would this have been useful?
- Was everyone open to sharing information? Were you willing to trust others and share?
- Was there controversy within the group? Did you use this constructively?

Communication:

- Were you given the opportunity to make your points? Did you give other people the chance to make theirs?
- Did you clarify that you understood the opinions and ideas of others?
- Did you really work as a group or as individuals?
- What could you do to improve the ways in which you communicated and worked with others in the group?

Appendix 11: Detailed design of the Pharaoh's Tomb

There are six separate areas that need to be solved in the Pharaoh's Tomb. At the start of the game, each player has a different object, these are: ankh; whip; key 1.

Items in brackets were included in the original design but were removed from the final version of the game.

1. Entrance		
Purpose	**Objects**	**Puzzles**
Training area. Practice manipulating objects.	Movable: • Bucket • Key 2 • Bamboo Stationary: • Tap • Fire • Chest • Door • (Ankh hole)	Remove fire to reach chest • fill bucket at tap • use full bucket on fire Open chest • use key 1 on chest • take key 2 from chest Open door • use key 2 on door • (use ankh in hole)

2. Scarab room		
Purpose	**Objects**	**Puzzles**
More difficult interactions, practise working together.	Movable: • Scarab piece 1 • Scarab piece 2 • Scarab piece 3 • Knife • (Paper) Stationary: • Scarab picture • (Ankh hole) • (Code entry)	Find scarab piece 1 • use whip on shelf Find scarab piece 2 • use bamboo and knife to make flute • use flute to charm snake Find scarab piece 3 • fill bucket with water • use water in urn (Get piece of paper • get code by turning paper upside down) Open door • place scarab pieces in picture • (use ankh in hole) • (enter code)

3. Labyrinth		
Purpose	**Objects**	**Puzzles**
Forces collaboration by making players guide another player through a maze	Movable: • Cat's eye jewel	Only one player can enter the labyrinth. Player who enters loses access to map and must be guided through by other players. • Get cat's eye jewel

4. Riddle room		
Purpose	**Objects**	**Puzzles**
Forces collaboration by making players communicate between rooms to solve a code	Stationary: • Code scroll • Code input Movable: • Cat's eye jewel	Only one player can enter the riddle room. Player who enters can see a coded riddle, but the code is outside the room so players must work together to decode and solve the riddle. • Rewarded with cat's eye jewel

5. Cat room		
Purpose	**Objects**	**Puzzles**
Lateral thinking, working together to find out how to leave the room.	Stationary: • Code key scroll • (Ankh hole)	Open door • Place jewels in eyes of cat picture • (Use ankh in hole)

6. Pharaoh's anteroom		
Purpose	**Objects**	**Puzzles**
Forces communication and tests teamwork.	Movable: • Gold Stationary: • Platform • (Ankh hole)	Room contains two doors. (To open one door • use ankh in hole) The open door reveals a platform, which, when held down, opens the door to the tomb. One player must hold the platform while another enters the tomb. • Return ankh to Pharaoh. • Rewarded with gold. The player in the tomb can now leave with the gold, or return to the platform and use the gold to weigh it down so that the whole team can escape.

Appendix 12: The Time Capsule Online Instructions

In its wisdom, your local town council has decided that the best way to spend its spare revenue is to invest in putting together a time capsule, containing six items, to be opened in the year 3006. It is hoped that this capsule will provide a unique insight for future generations into life in your town.

The council has a budget of £1,000 and the Mayor is adamant that this can not be exceeded, so to help him make the all-important decision about which items to select for the capsule, he has invited three prominent local citizens to help him.

You will be acting as one of these people, using an online real-time collaborative application. Within the interface you will be provided with:

- information about your character;
- a set of potential items for the time capsule.

(More detail about the application interface is shown on the next page.)

You have 40 minutes to agree on the six items that should be placed in the capsule. All of you must agree.

Tips for effective team working

- Spend a few minutes introducing yourself to the other members of the group (in character).

- Agree as a group what your group goal is and your constraints (e.g. time, money, etc.) Feel free to share as much (or as little) information as you wish about your character's personal goals.

- You have thirty potential items available to put in the capsule. Some of the items are specialist and you may need help from the other characters to find out what they are and what value they might have to future generations.

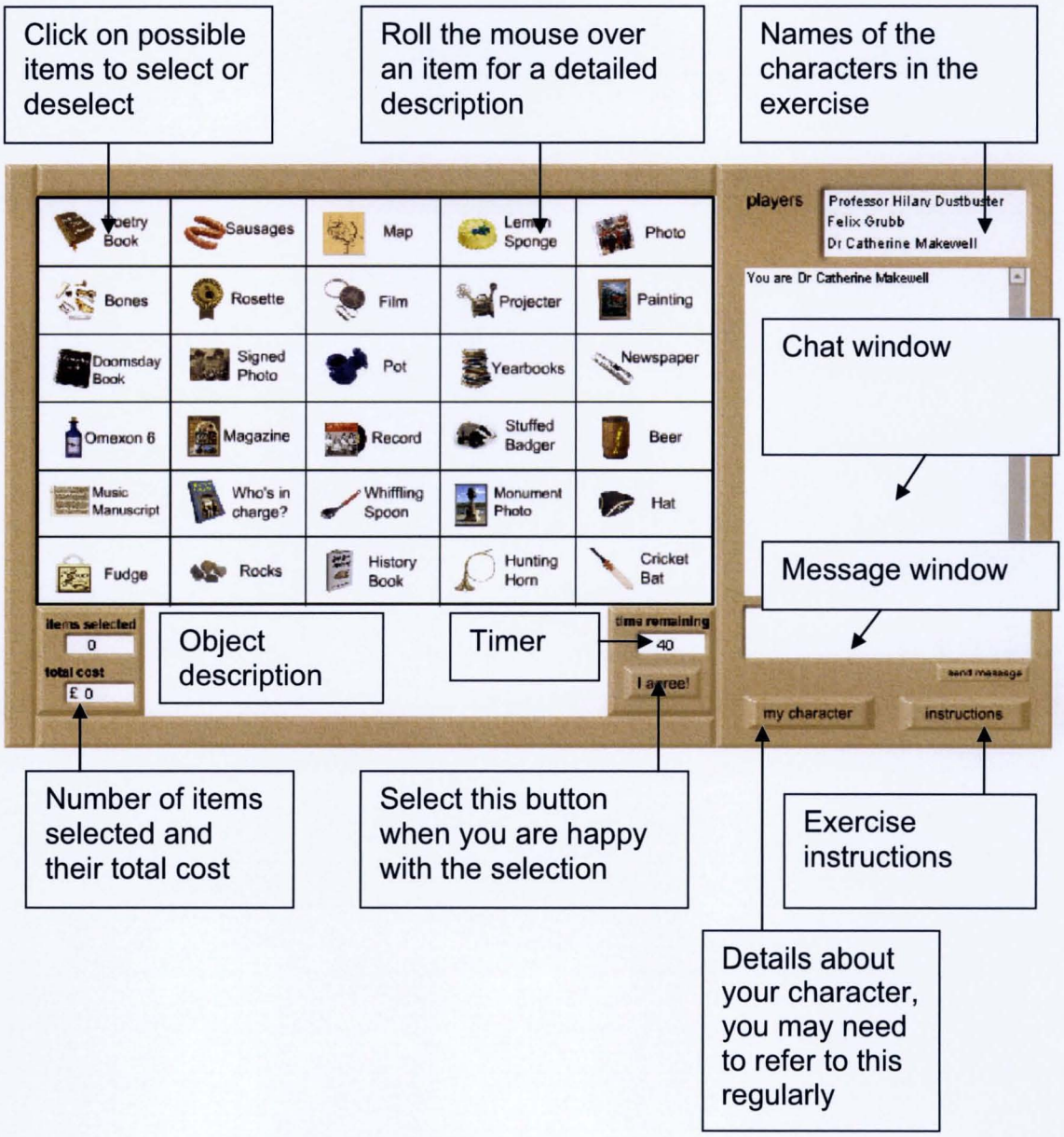
- Your group must come to a decision that is acceptable to all parties, about what should go into the capsule. Your character information will give you more detail about the items that you think are important.

All characters must agree on the final decision. You must select six items and you must not go over the budget of £1,000.

The Interface

When you first log in you will see the information about your character. Close this window using the close button in the top right-hand corner (you can always open your character information again using the 'my character' button).

The interface should now look like this:



Appendix 13: The Pharaoh's Tomb Instructions

In 1921 the famous archaeologist Dr Idaho Smith led a successful expedition to recover the sacred treasure of Pharaoh Rameses III. Among the treasures discovered was a brass ankh (see right).

However, since the expedition to Rameses's Tomb, nothing has gone well for the Smith family and now the aged Dr Smith believes the ankh to be cursed. He has asked for volunteers to return the ankh to the tomb and you and two fellow intrepid adventurers have accepted the task of returning the cursed ankh to the Pharaoh.

Your group must:

- Return the cursed ankh to the Pharaoh.
- Ensure the whole team escapes from the tomb.

Once in the tomb you will be presented with a series of rooms that you must navigate through in order to find the pharaoh's tomb and return the ankh. You can pick up some objects and use them with other objects to help you in your quest.

You have only 40 minutes to complete this task before the air in the tomb becomes fatal.

Tips for effective team working

- Spend a few minutes introducing yourself to the other members of the group and making sure that the whole group is comfortable moving around and handling objects.

- It is important that you make sure that all the members of your team are aware of what you are doing and what is going on. Don't let one of your team members get left behind.

- Your initial aim is to get through the first locked door. You will need to use objects together. Some objects can be picked up (e.g. the bucket) and others not (e.g. the tap). Using objects together will make things happen (e.g. using the bucket and the tap will fill the bucket).

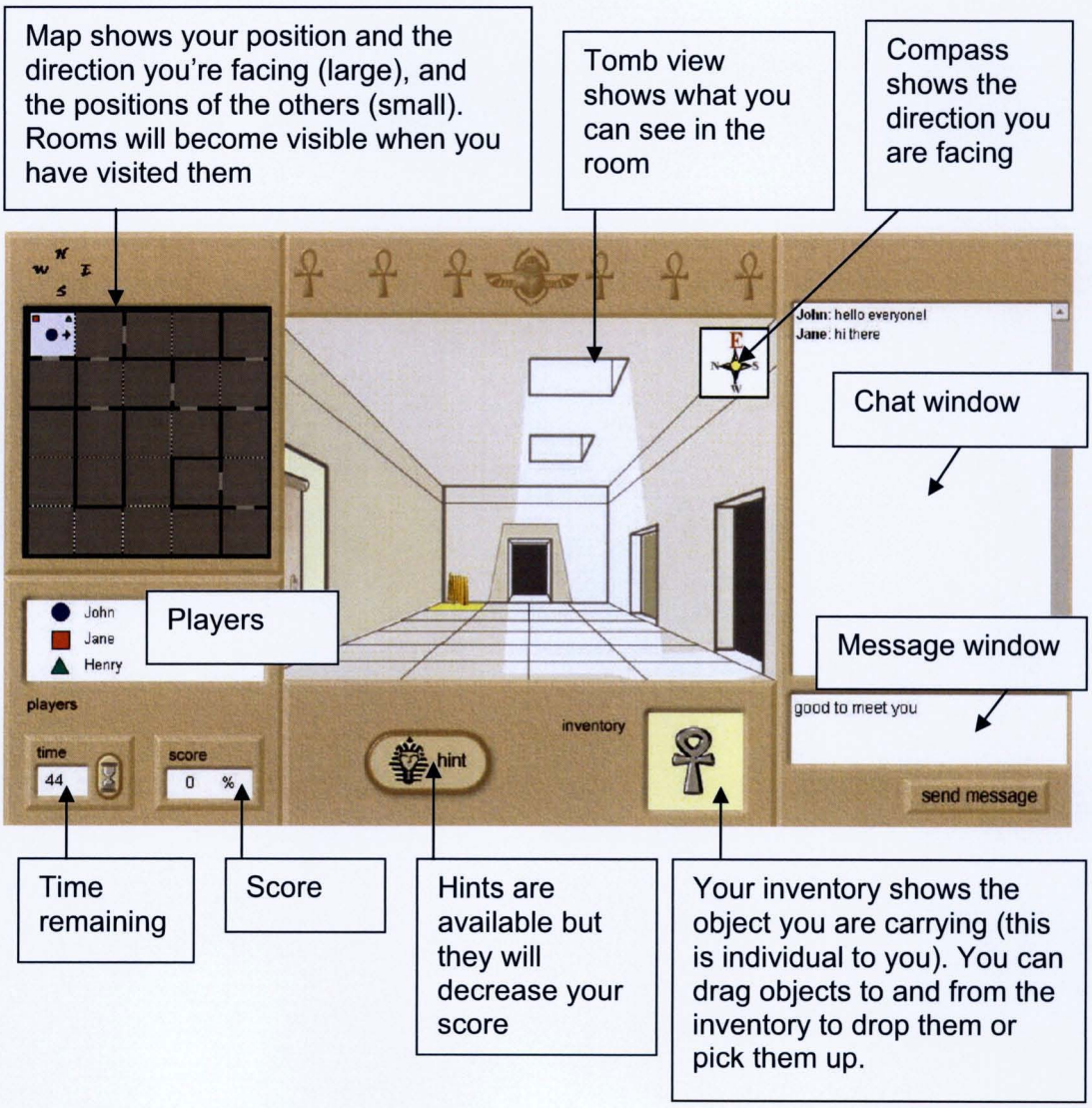
- Each player will start with different objects and can carry only one object (that's three in total for the group). You will need to talk to each other to find out what everyone is carrying and think about how they can be used.

- If you get stuck, you can ask for a hint, but remember that you will lose points every time you do. You can save points by sharing hints with other members of your team.

The Interface

When you first log in you will see information about the first part of the tomb and what you need to do. Close this window using the close button in the top right-hand corner (you can always open it again by clicking on the scroll on the wall to the left).

The interface should now look like this:



Navigation

When you move your mouse around the Tomb View, navigation arrows will appear.

When the cursor is moved to the left or right you will see curved arrows, which will rotate you 90° left or right ( ).

When it is possible to go forward, a straight navigation arrow will appear, which will take you forward into the next square or through a door ( ).

Note that to go backward you need to rotate 180° and go forwards.

The map shows areas that you have visited, your position and the direction you are facing, and the positions of your other team members. (Note that if you can't see a player then they are probably in an area you haven't visited yet). Players' positions are denoted using the same icon as in the players window.

Using objects

Once in the tomb you must work your way through a series of rooms. There will be a number of objects available to you in these rooms. You can pick up some objects (only one at a time) and use objects with other objects.

Objects that you can pick up can be found on yellow hotspots. You can drag an item from a hotspot to your inventory to pick it up, or drag your inventory item to a hotspot to put it down. You must be right next to a hotspot to use it.

To use a movable object (e.g. bucket) with a non-movable object (e.g. tap) drag the movable object over the non-movable one (e.g. drag the bucket over the tap).

To use two movable objects together drag either one over the other.

Scrolls

When you enter a new area a scroll will appear telling you what you have to do.

It is important to read the scrolls when you enter each room, to find out what you should (and shouldn't) do in that room.

Each of these scrolls also hangs on the wall of the room it appears in, so once you have closed the scroll you can view it again by clicking on the scroll in the room.

Scoring

When you achieve things your score will increase, but you can also lose points, so think carefully before you act.

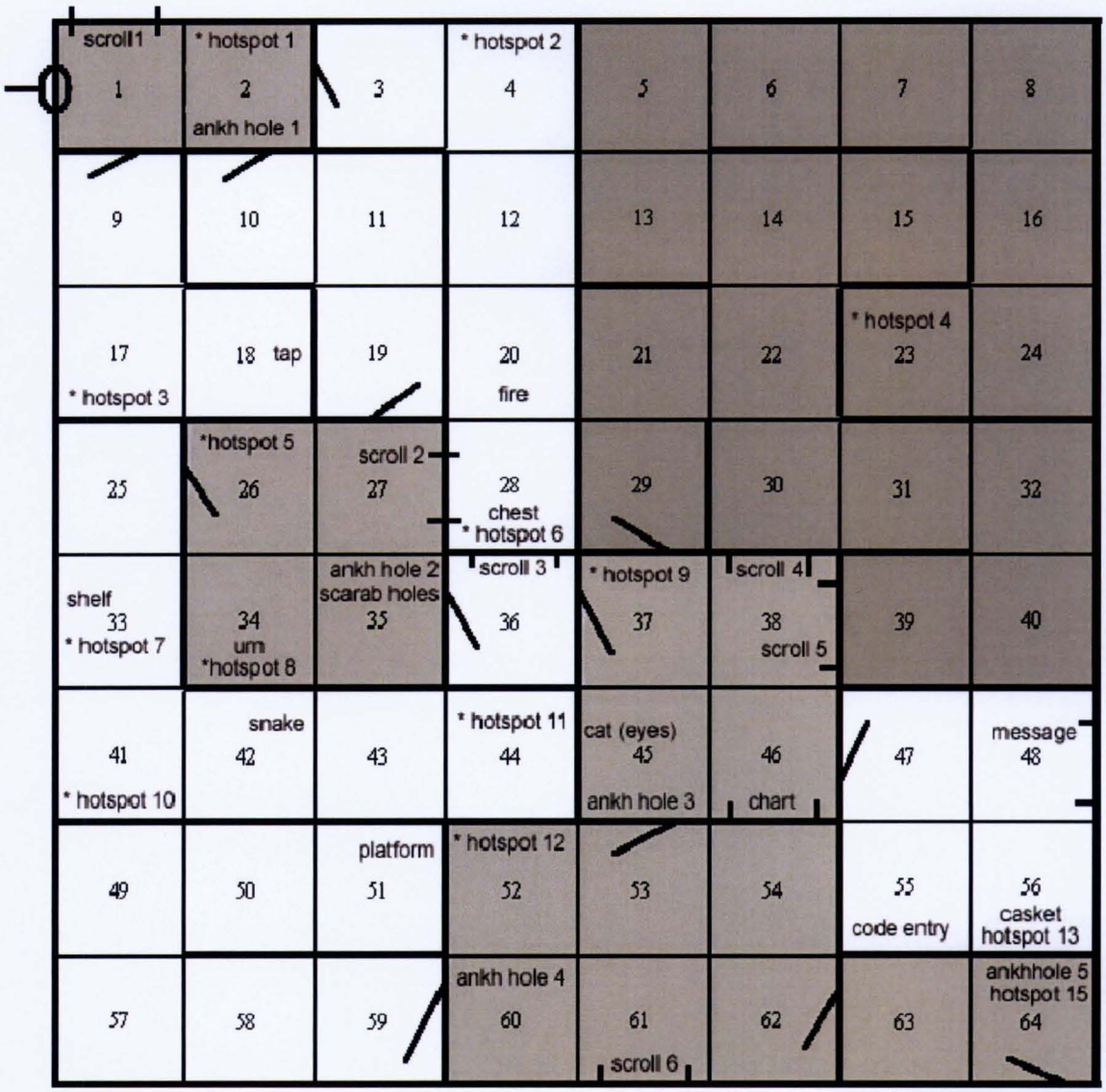
You will lose a point every time a member of your team asks for a hint.

You have 40 minutes to achieve the highest score you can, up to 100%. Remember though that the game is scored for the group – not for an individual. Good luck!

Appendix 14: Initial design of the Pharaoh's Tomb

Players start in square 1 facing east. They start with the following objects:

Player 1: Cursed ankh
Player 2: Whip
Player 3: Small key



Squares	Room	Objects
1, 2	Entrance	Scroll 1 Hotspot 1 (bucket) Door (locked) Ankh-shaped hole in the wall
3, 4, 12, 20, 28	Central corridor	Hotspot 2 Fire Chest (closed) Hotspot 6 (within chest)

5, 6, 7, 8, 13, 14, 15, 16, 21, 22, 23, 24, 29, 30, 31, 32, 39, 40	Labyrinth	Hotspot 4 (jewel)
9, 17, 18	North west corridor	Hotspot 3 (bamboo cane) Tap
10, 11, 19	Corridor	
25, 33, 41, 42, 43, 44	West central corridor	Shelf Hotspot 7 appears once whip used with shelf (scarab part) Hotspot 10 (paper) Snake Hotspot 11 (scarab part)
26, 27, 34, 35	Scarab room	Scroll 2 Hotspot 5 (knife) Urn Hotspot 8 appears once water used with urn (scarab part) Door (locked) Ankh-shaped hole in the wall Scarab hole (head) Scarab hole (left torso) Scarab hole (right torso) Combination lock
36	Central corridor	Scroll 3
37, 38, 45, 46	Cat room	Scroll 4 Scroll 5 Door (locked) Hotspot 9 Ankh-shaped hole in wall Cat statue right socket Cat statue left socket Hieroglyphic chart
47, 48, 55, 56	Riddle room	Hieroglyphic message Code entry mechanism Casket Hotspot 13 within casket (jewel)
49, 50, 51, 57, 58, 59	South west corridor	Platform
52, 53, 54, 60, 61, 62	Pharaoh's anteroom	Scroll 6 Hotspot 12 Door (locked) Ankh-shaped hole in wall
63, 64	Pharaoh's tomb	Ankh-shaped hole in coffin Door (locked) Hotspot 15 appears when ankh placed in hole (gold bar)

Appendix 15: Pharaoh's Tomb evaluation sheet

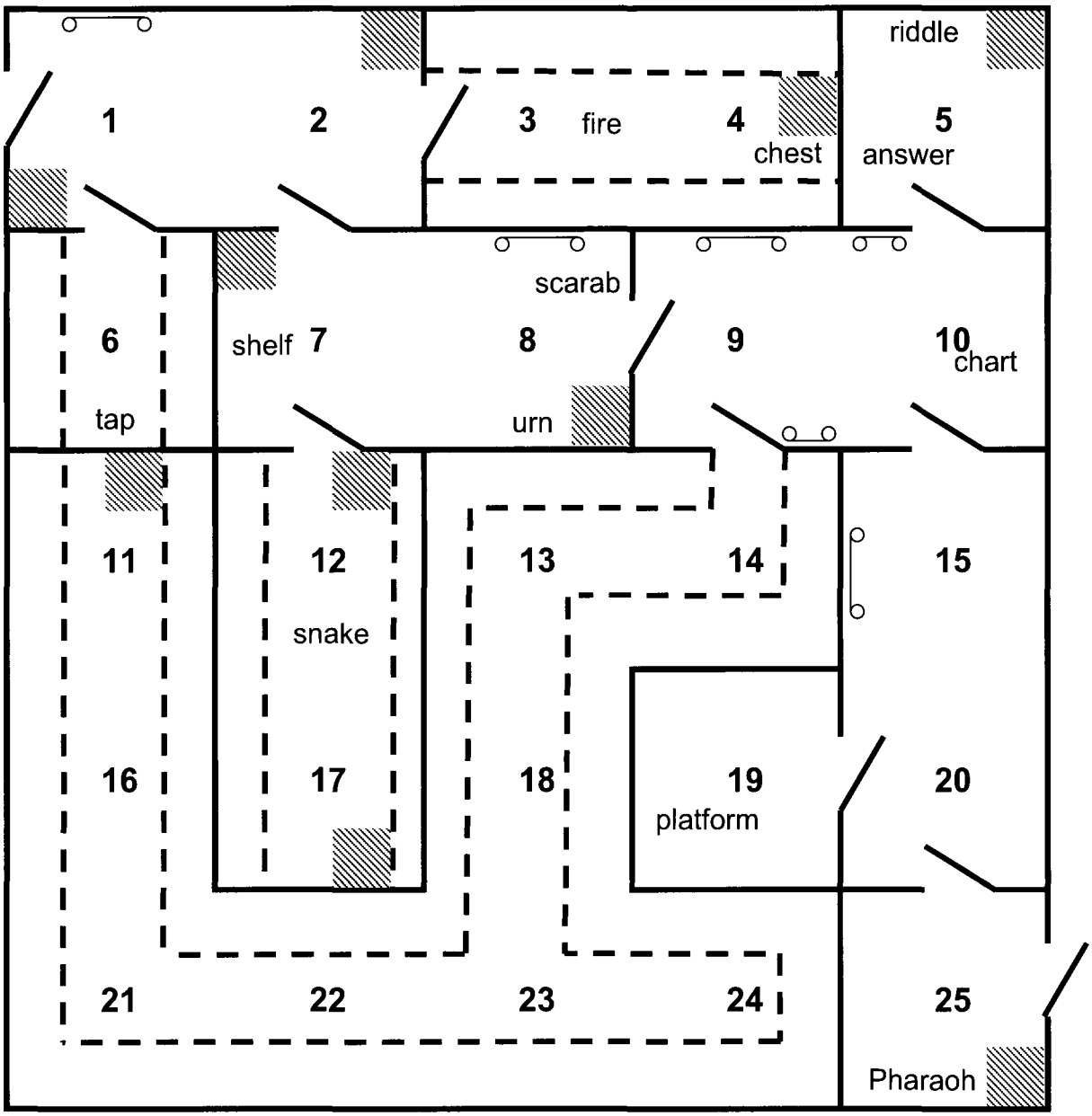
Date: Players:

Time taken:

Puzzle	Notes	Bugs
Entrance		
Scarab room		
Cat room		
Labyrinth		

Riddle		
Anteroom		
Other, interface, navigation, interaction, etc.		

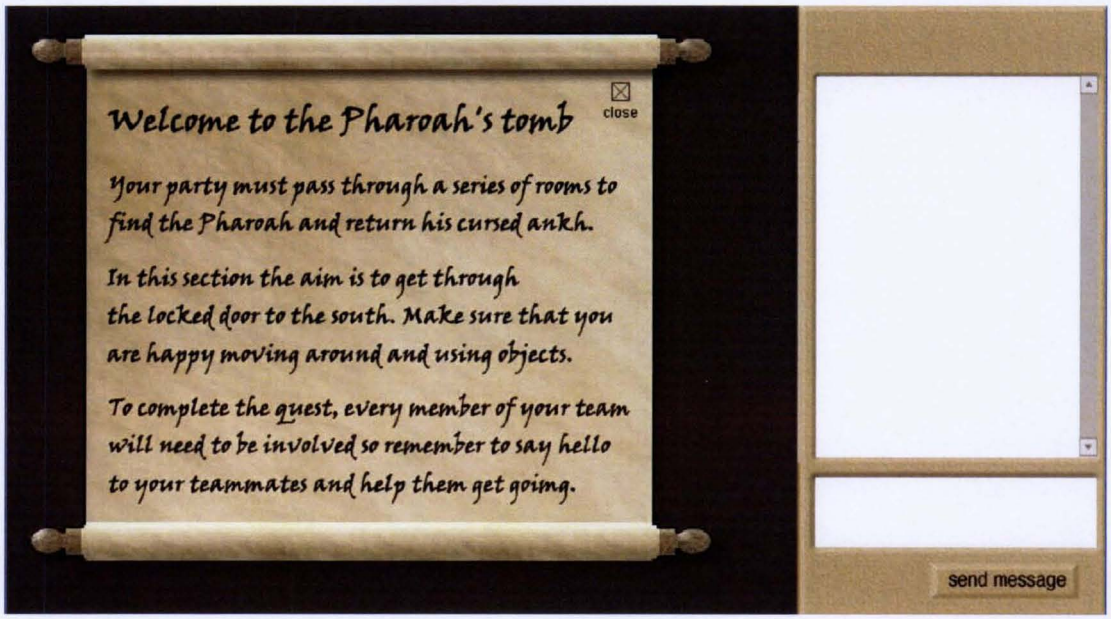
Appendix 16: Pharaoh's Tomb final design



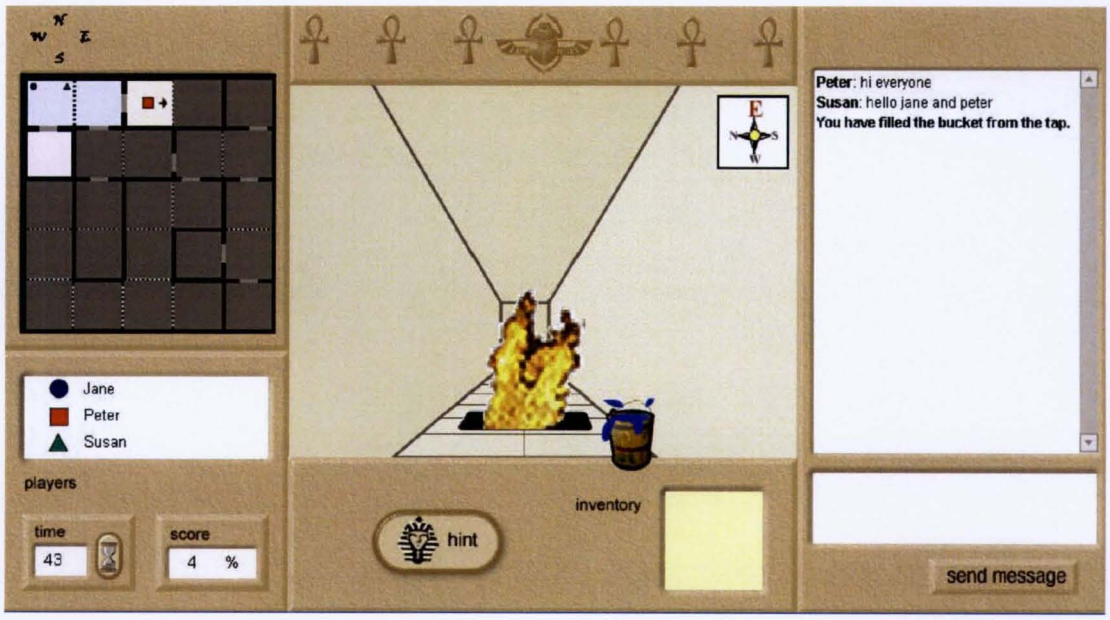
Hotspots

Information scrolls

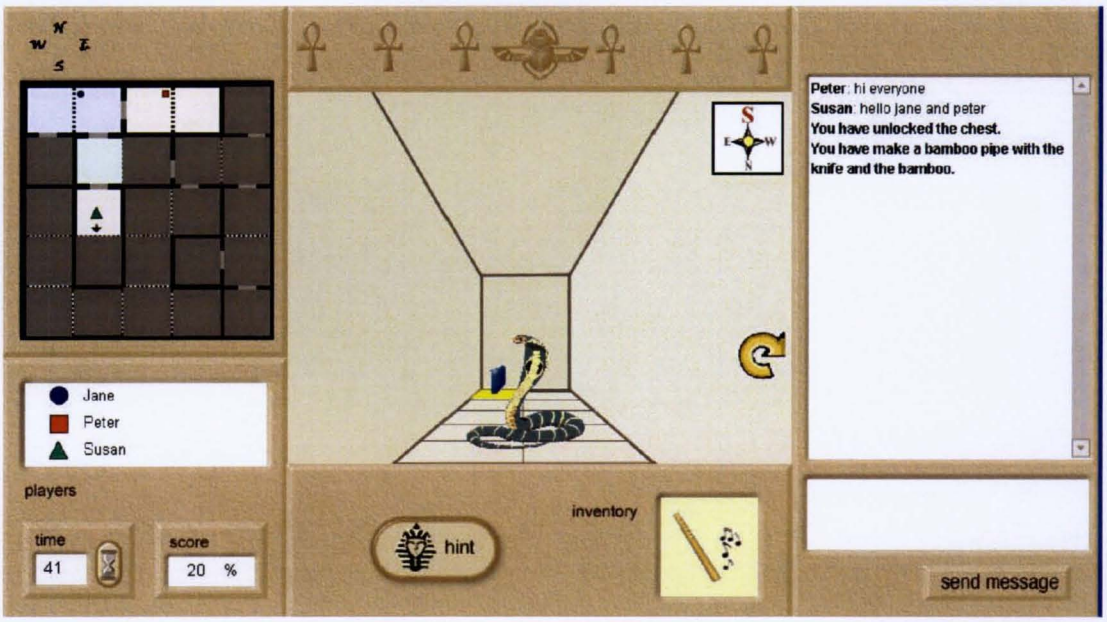
Appendix 17: Screenshots from the Pharaoh's Tomb



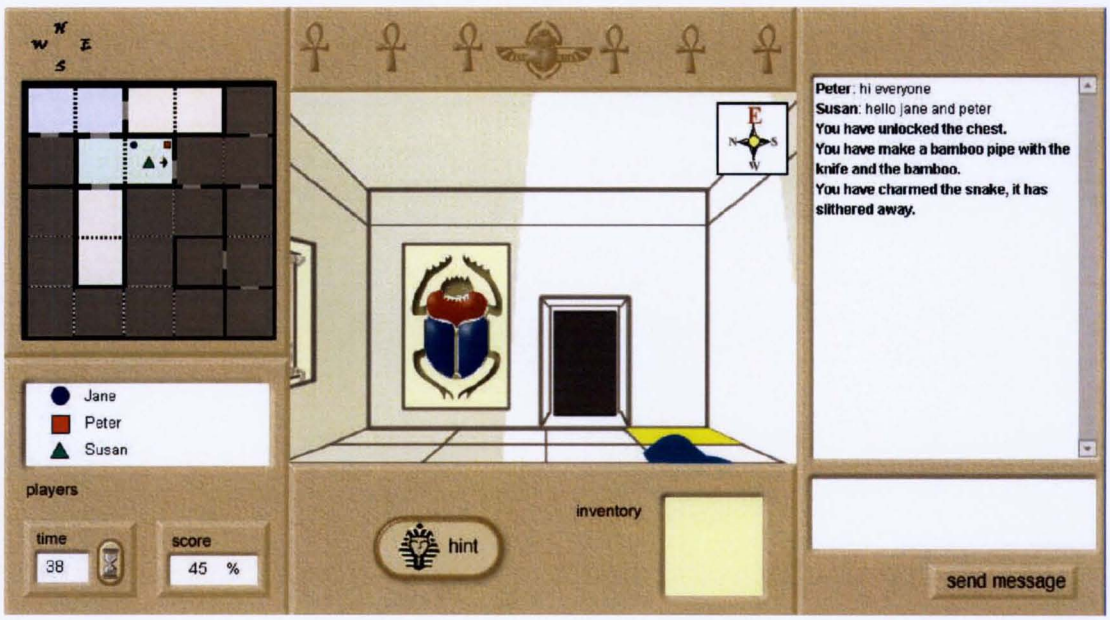
Starting the Pharaoh's Tomb



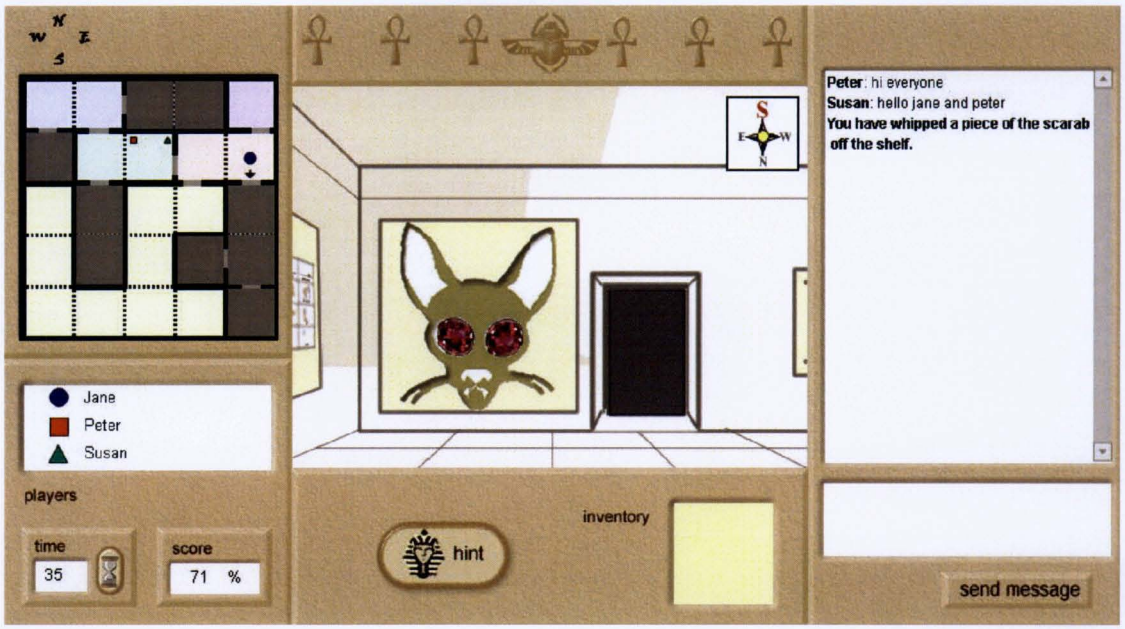
Putting out the fire



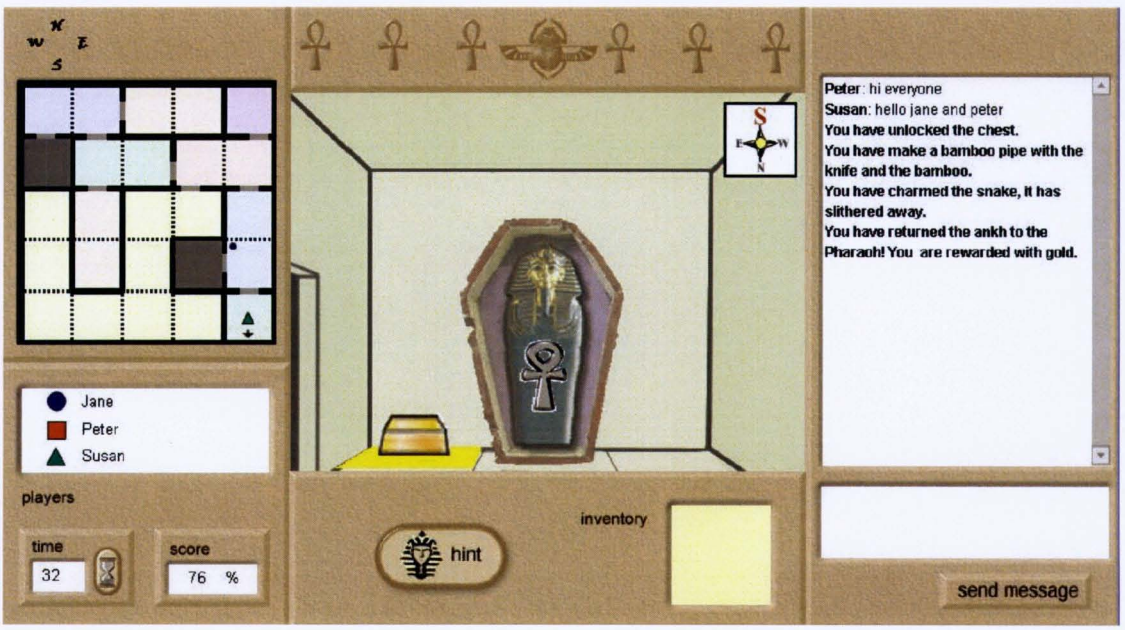
Charming the snake



Opening the door to the scarab room



Leaving the cat room



Returning the ankh to the Pharaoh and receiving gold

Appendix 18: Self-rated learning questionnaire

Please indicate whether you feel that using the activity has improved your understanding of the following concepts.

	Worse	Same	Improved
How to make good decisions as part of a group.	❍	❍	❍
What makes communication effective.	❍	❍	❍
Constructive controversy as a way of making decisions.	❍	❍	❍
What makes a group effective.	❍	❍	❍
How to be an effective leader.	❍	❍	❍
How to communicate with others in the future.	❍	❍	❍
Ways of generating new ideas.	❍	❍	❍
The importance of group reflection for effective groups.	❍	❍	❍
How to contribute to group decision-making in the future.	❍	❍	❍
The roles that people take in teams.	❍	❍	❍
The benefits of collaborating with others.	❍	❍	❍
Contributing to make group work more effective.	❍	❍	❍

Have you ever used a similar exercise before? ☐ Yes / ☐ No

Would you like to work with the same team again? ☐ Yes / ☐ No

How could the exercise be improved?

Any other comments?

Appendix 19: Original engagement questions

Note: R indicates that the scale of the question is reversed.

Challenge (made up of three sub-factors)

Motivation
4. I wanted to complete the activity
28. I wanted to explore all the options available to me
37. I did not care how the activity ended (R)

Clarity
8. I knew what I had to do to complete the activity
23. The goal of the activity was not clear (R)
32. The instructions were clear
35. I found using the application easy to learn
34. I did not find it easy to get started (R)

Achievability
1. I felt that I could achieve the goal of the activity
9. I had all the things I required to complete the activity successfully
11. I had a fair chance of completing the activity successfully
20. I found the activity difficult (R)
25. I found the activity frustrating (R)
29. From the start I felt that I could successfully complete the activity
33. The activity was challenging

Control
2. I had lots of choices to make during the activity
3. The types of task were too limited (R)
5. It wasn't clear what I could and couldn't do
6. The activity was too complex (R)
14. The activity would not let me do what I wanted (R)
18. I could not tell what effect my actions had (R)
21. I had lots of potential options available to me
42. I could not always do what I wanted to do (R)

Immersion
7. I found the activity satisfying
13. I felt absorbed in the activity
19. I felt that time passed quickly
27. I worried about losing control (R)
30. I felt emotion during the activity
40. I felt excited during the activity
36. I felt self-conscious during the activity (R)

Interest

15. I had to concentrate hard on the activity
16. I knew early on how the activity was going to end (R)
17. I found the activity boring (R)
24. I was not interested in exploring all of the environment (R)
31. I did not enjoy the activity (R)
39. The activity was aesthetically pleasing

Purpose

10. The activity was pointless (R)
12. The feedback I was given was not useful (R)
22. I did not receive feedback in enough detail (R)
26. I was given feedback at appropriate times
38. It was not clear what I could learn (R)
41. The activity was worthwhile

Appendix 20: Correlation data from questionnaire

Note that where a question has the letter R in front of it, the scale has been reversed. Questions with a dagger (†) do not correlate with the group.

Challenge (motivation)

Q4 I wanted to complete the activity
Q28 I wanted to explore all the options available to me
R37 I did not care how the activity ended

	Q4	Q28	R37
Q4	1.000	0.340(**)	0.486(**)
Q28		1.000	0.458(**)
R37			1.000

** Correlation is significant at the 0.01 level (1-tailed).

Challenge (clarity)

Q8 I knew what I had to do to complete the activity
R23 The goal of the activity was not clear
Q32 The instructions were clear
R34 I did not find it easy to get started
† Q35 I found using the application easy to learn

	Q8	R23	Q32	R34	† Q35
Q8	1.000	0.488(**)	0.518(**)	0.446(**)	0.195(*)
R23		1.000	0.522(**)	0.472(**)	0.143
Q32			1.000	0.616(**)	0.537(**)
R34				1.000	0.467(**)
† Q35					1.000

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Challenge (achievability)

Q1 I felt that I could achieve the goal of the activity
Q9 I had all the things I required to complete the activity successfully
Q11 I had a fair chance of completing the activity successfully
† R20 I found the activity difficult
R25 I found the activity frustrating
Q29 From the start I felt that I could successfully complete the activity
† Q33 The activity was challenging

	Q1	Q9	Q11	† R20	R25	Q29	† Q33
Q1	1.000	0.563(**)	0.587(**)	–0.297(**)	0.514(**)	0.582(**)	0.130
Q9		1.000	0.601(**)	–0.110	0.500(**)	0.342(**)	0.097
Q11			1.000	–0.230(*)	0.498(**)	0.478(**)	–0.053
† R20				1.000	–0.335(**)	–0.312(**)	0.337(**)
R25					1.000	0.477(**)	0.175
Q29						1.000	0.006
† Q33							1.000

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Control

† Q2 I had lots of choices to make during the activity
R3 The types of task were too limited
R5 It wasn't clear what I could and couldn't do
R6 The activity was too complex
R14 The activity would not let me do what I wanted
R18 I could not tell what effect my actions had
† Q21 I had lots of potential options available to me
R42 I could not always do what I wanted to do

	† Q2	R3	R5	R6	R14	R18	† Q21	R42
† Q2	1.000	0.215(*)	–0.035	–0.098	0.128	0.243(*)	0.623(**)	–0.088
R3		1.000	0.324(**)	0.217(*)	0.421(**)	0.301(**)	0.243(*)	0.253(**)
R5			1.000	0.561(**)	0.564(**)	0.349(**)	0.090	0.525(**)
R6				1.000	0.517(**)	0.281(**)	–0.033	0.444(**)
R14					1.000	0.324(**)	0.191(*)	0.607(**)
R18						1.000	0.193(*)	0.261(**)
† Q21							1.000	0.050
R42								1.000

* Correlation is significant at the 0.05 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).

Immersion

Q7 I found the activity satisfying
Q13 I felt absorbed in the activity
Q19 I felt that time passed quickly
† R27 I worried about losing control
† Q30 I felt emotion during the activity
† R36 I felt self-conscious during the activity
Q40 I felt excited during the activity

	Q7	Q13	Q19	† R27	† Q30	† R36	Q40
Q7	1.000	0.610(**)	0.572(**)	–0.074	0.217(*)	0.146	0.442(**)
Q13		1.000	0.652(**)	0.089	0.167	0.133	0.472(**)
Q19			1.000	–0.076	0.297(**)	0.115	0.518(**)
† R27				1.000	–0.279(**)	0.206(*)	–0.060
† Q30					1.000	–0.098	0.510(**)
† R36						1.000	–0.164
Q40							1.000

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Interest

† Q15 I had to concentrate hard on the activity
† R16 I knew early on how the activity was going to end
R17 I found the activity boring
R24 I was not interested in exploring all of the environment
R31 I did not enjoy the activity
Q39 The activity was aesthetically pleasing

	† Q15	† R16	R17	R24	R31	Q39
† Q15	1.000	–0.010	0.171	0.142	0.063	0.080
† R16		1.000	–0.118	–0.145	0.003	–0.034
R17			1.000	0.432(**)	0.528(**)	0.277(**)
R24				1.000	0.555(**)	0.291(**)
R31					1.000	0.280(**)
Q39						1.000

** Correlation is significant at the 0.01 level (1-tailed).

Purpose

R10	The activity was pointless
R12	The feedback I was given was not useful
† R22	I did not receive feedback in enough detail
Q26	I was given feedback at appropriate times
R38	It was not clear what I could learn
Q41	The activity was worthwhile

	R10	R12	† R22	Q26	R38	Q41
R10	1.000	0.347(**)	0.220(*)	0.322(**)	0.480(**)	0.587(**)
R12		1.000	0.421(**)	0.240(*)	0.369(**)	0.332(**)
† R22			1.000	0.498(**)	0.366(**)	0.294(**)
Q26				1.000	0.285(**)	0.264(**)
R38					1.000	0.572(**)
Q41						1.000

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Appendix 21: Analysis of discrimination powers

Note: starred questions are those selected for the final inventory.
NC means not correlated.

Question	Factor	DP
* I did not care how the activity ended	motivation	2.1875
* I wanted to complete the activity	motivation	1.875
I wanted to explore all the options available to me	motivation	1.125
* I did not find it easy to get started	clarity	1.625
* I knew what I had to do to complete the activity	clarity	1.5625
The goal of the activity was not clear	clarity	1.1875
The instructions were clear	clarity	1.125
I found using the application easy to learn (NC)	clarity	0.875
* I found the activity frustrating	achievability	2
* I felt that I could achieve the goal of the activity	achievability	1.9375
I had all the things I required to complete the activity successfully	achievability	1.75
From the start I felt that I could successfully complete the activity	achievability	1.375
I had a fair chance of completing the activity successfully	achievability	1.1875
The activity was challenging (NC)	achievability	1.125
I found the activity difficult (NC)	achievability	-0.125
* It wasn't clear what I could and couldn't do	control	2
* The activity would not let me do what I wanted	control	1.4375
* I could not tell what effect my actions had	control	1.4375
The activity was too complex	control	1.4375
I could not always do what I wanted to do	control	1.1875
The types of task were too limited	control	0.8125
I had lots of potential options available to me (NC)	control	0.1875
I had lots of choices to make during the activity (NC)	control	0
* The activity was pointless	purpose	2.1875
* It was not clear what I could learn	purpose	2
The activity was worthwhile	purpose	1.8125
I was given feedback at appropriate times	purpose	1.375
I did not receive feedback in enough detail (NC)	purpose	1.3125
* The feedback I was given was not useful	purpose	1.25

Question	Factor	DP
* I did not enjoy the activity	interest	2.375
* I was not interested in exploring all of the environment	interest	1.9375
* I found the activity boring	interest	1.625
The activity was aesthetically pleasing	interest	1.0625
I had to concentrate hard on the activity (NC)	interest	0.8125
I knew early on how the activity was going to end (NC)	interest	-0.625
* I found the activity satisfying	immersion	2.1875
* I felt absorbed in the activity	immersion	2.125
* I felt that time passed quickly	immersion	1.6875
I felt excited during the activity	immersion	1.4375
I felt emotion during the activity (NC)	immersion	1.0625
I felt self-conscious during the activity (NC)	immersion	0.6875
I worried about losing control (NC)	immersion	-0.25

The final question selected in the purpose factor ('The feedback I was given was not useful') is not that with the highest discrimination power but was selected because it was less specific than the other question that related to feedback that had a slightly higher DP. The question 'The activity was worthwhile' was not included as it was considered to be exactly opposite to 'The activity was pointless'.

Appendix 22: Engagement questionnaire

Thinking about the activity you have just done, please indicate the level to which you agree with the following statements:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I wanted to complete the activity	❍	❍	❍	❍	❍
I found the activity frustrating	❍	❍	❍	❍	❍
I felt that I could achieve the goal of the activity	❍	❍	❍	❍	❍
I knew what I had to do to complete the activity	❍	❍	❍	❍	❍
I found the activity boring	❍	❍	❍	❍	❍
It wasn't clear what I could and couldn't do	❍	❍	❍	❍	❍
It was clear what I could learn from the activity	❍	❍	❍	❍	❍
I felt absorbed in the activity	❍	❍	❍	❍	❍
The activity was pointless	❍	❍	❍	❍	❍
I was not interested in exploring the options available	❍	❍	❍	❍	❍
I did not care how the activity ended	❍	❍	❍	❍	❍
I felt that time passed quickly	❍	❍	❍	❍	❍
I found the activity satisfying	❍	❍	❍	❍	❍
The activity would not let me do what I wanted	❍	❍	❍	❍	❍
I could not tell what effect my actions had	❍	❍	❍	❍	❍
I did not enjoy the activity	❍	❍	❍	❍	❍
Feedback I was given was useful	❍	❍	❍	❍	❍
I found it easy to get started	❍	❍	❍	❍	❍

Questions as they relate to engagement factors

Question	Factor
I wanted to complete the activity	Challenge (motivation)
I found the activity frustrating	Challenge (achievability)
I felt that I could achieve the goal of the activity	Challenge (achievability)
I knew what I had to do to complete the activity	Challenge (clarity)
I found the activity boring	Interest
It wasn't clear what I could and couldn't do	Control
It was clear what I could learn from the activity	Purpose
I felt absorbed in the activity	Immersion
The activity was pointless	Purpose
I was not interested in exploring the options available	Interest
I did not care how the activity ended	Challenge (motivation)
I felt that time passed quickly	Immersion
I found the activity satisfying	Immersion
The activity would not let me do what I wanted	Control
I could not tell what effect my actions had	Control
I did not enjoy the activity	Interest
Feedback I was given was useful	Purpose
I found it easy to get started	Challenge (clarity)

Appendix 23: Time Capsule learning questionnaire

Please take a few moments to complete this questionnaire on the Time Capsule Exercise. Indicate whether, after undertaking the exercise, you agree or disagree with the following statements

	Disagree	Agree
I understand how to make good decisions as part of a group.	❍	❍
I am more aware of what makes communication effective.	❍	❍
Constructive controversy is a good way to make decisions.	❍	❍
I understand what makes a group effective.	❍	❍
I will be better able to communicate with others in the future.	❍	❍
Group reflection is important for effective groups.	❍	❍
I will be better able to contribute to group decision-making in the future.	❍	❍
I appreciate the benefits of collaborating with others.	❍	❍
I can now contribute better to make group work more effective.	❍	❍
I enjoyed the exercise.	❍	❍
I found the instructions straightforward.	❍	❍

Any other comments?

Thank you for completing this questionnaire.

Appendix 24: Transcript of Time Capsule

Hilary: Hello there i am Professor Hilary Dustbuster
Felix: Hello all, I'm Felix Grubb
Hilary: who am i talking to
Felix: I'm the owner of the best chain of butchers in town
Catherine: Hi i am Dr Catherine Makewell
Hilary: I am in love with badgers
Hilary: and everythign to do with them
Felix: I am proud of my prize-winning sausages
Hilary: i am very big for my boots
Hilary: and like all things poetic and antiqueish
Catherine: i am a strong advocate of natural foods and helathy eating
Hilary: Right have you all been told that we need to pick some items to put in a capsule
Felix: Yes do you have any suggestions?
Hilary: well why dont you just let me pick
Hilary: who picked that
Felix: I think we're jumping the gun a wee bit here- why the record? Any reason?
Hilary: catherine your a bit on the quiet side are you not
Hilary: oh god thats my record
Hilary: no way
Catherine: yes i ve jsut understood how to see the different items
Felix: Of course, I think my prize-winning sausages should go in
Hilary: this is supposed to be a time capsule with things that people would like to see
Felix: They are, despite vicious rumours to the contrary, the finest sausages you'll ever taste
Hilary: we have a couple of options
Catherine: why not selecte 3 each items
Hilary: we can either pick 2 personal objects
Hilary: each
Hilary: or 6 that are related to the area, my option of course
Hilary: heritage is important
Hilary: and badgers
Catherine: ok so we pick 2 each at the moment
Felix: I have a few ideas as to what should go in, so let's see what two we can come up with
Hilary: pick 2 each the and see what we come up with
Felix: I like the look of the signed photo of sporting legend Wilbur Grace, and also either the Doomsday book or the yearbooks
Felix: Local heritage and all that
Hilary: why dont you pick two options
Hilary: please
Catherine: be careful we are over 1000
Hilary: we are over budget someone will have to change
Felix: It seems the bones and the poetry are most expensive
Catherine: at the moment i ve chosen jsut one and it cost £50
Hilary: but very important
Hilary: who picked three come one admit it
Felix: I've only picked two, I don't know who picked the record- my lot comes to £2
Felix: £200 rather
Hilary: well if we can still change something that would be good
Hilary: but the bones are rather famous you know
Hilary: and great aunty augustus we have to keep her memory going
Hilary: with the poetry and all that
Catherine: is it the poetry book very important?

Felix: I am of the opinion that things like bones and historical artifacts should be in museums, but that's just my view
Catherine: yes
Hilary: ah mmmmmm er good point
Hilary: beer should be in pubs
Hilary: shall we agree to move them out
Catherine: but beer is only £50
Hilary: and wont last in the time capsule
Felix: True
Hilary: will it???????????
Catherine: ok we camn remove it
Hilary: i have chosen the map
Felix: I think things like the yearbooks would last a while and be interesting to read 1000 years down the line
Felix: Yes I like the map actually
Catherine: like the newspaper
Hilary: ah we seem to have reached the 6 items and the money
Hilary: would do u two dudes think
Hilary: about tat
Hilary: horrible contraptions these computers
Hilary: give me a badger any day
Felix: Er, have a few misgivings about the film
Hilary: uhuh
Catherine: ca we remove the signed photo?
Hilary: remove away
Felix: It features some less than complimentary views about my fine business
Felix: I rather like local sports myself, but fair enough
Hilary: ah and if they dont have the projector either
Felix: Oh, woops, good point
Catherine: yep
Catherine: like the rocks what is the point?
Hilary: what about my book
Hilary: fine sample of good reading
Hilary: its all about badgers
Felix: I'm indifferent about the rocks. Anyone thought about the culinary magazine?
Felix: It features an article on fine local sausages
Catherine: ok for the history book
Hilary: but not enough money
Hilary: now
Felix: D'oh, the history book has taken us to the limit
Hilary: yes
Catherine: we can stay like that we reach teh £1000
Hilary: but only 5 items selected
Hilary: we need one more
Catherine: is it an obligation?
Hilary: yes
Felix: We need another thing. Why don't we replace rocks with something also worth £50?
Felix: rocks are cheap and also boring
Catherine: yes the beer
Hilary: no the fudge
Felix: How about the magazine which will not smell bad when it goes off
Felix: But is also about food
Hilary: compared to what
Felix: Rotting fudge or something
Hilary: mmmmm
Catherine: ok for me go for th emagasine
Felix: Unless fudge lasts for ages with all those preservatives

Hilary: still one down and at our limit
Hilary: something will have to go
Hilary: the map
Hilary: cos my book is all about me
Felix: The map is quite dear, true
Hilary: what about the doomsday book
Felix: yes that is a fine example of our local kiddies' talent
Catherine: if we remove the map we can select the beer the fudge and the dsausage
Felix: I am a strong believer in supporting local schools
Hilary: but that will be too many then
Hilary: what is your doctorate in, surely not mathematic
Felix: Erm, let's just take the map off and see what happens
Hilary: so are we deciding on the doomsday, we dont hae to spend all the money
Hilary: space for one more if you like
Felix: I'll root for the doomsday book. Do we want a foody thing?
Hilary: badgers are nice
Felix: sausages are also nice
Hilary: badgers are rare and sacred
Hilary: there wont be any by the time the capsule is opened
Felix: Um, the photo, the mayor looks sort of off-colour, this is not a good way to remember him surely
Hilary: would a badger be a nice thing to see
Hilary: the whiffling spoon is full of heritage
Hilary: who picked the photo
Hilary: i want to know
Felix: It was not me, I don't like the look of the mayor in that photo
Hilary: catherine
Felix: He looks somewhat nauseous for some unknown reason
Hilary: why the photo
Catherine: with the picture they will see the happy crowds
Felix: That day was not a happy day for Grubbs Plc
Hilary: but the badger they get to touch and see
Hilary: badger
Hilary: badger
Hilary: badger
Hilary: stuffed badger even
Catherine: ok go for it
Felix: I like the badger
Felix: It is furry
Hilary: are we allowed to be under our budget
Felix: And won't smell
Catherine: yes
Felix: I think so
Hilary: shall we agree
Hilary: we seem to have all our items
Catherine: i agree
Felix: I think it looks good from here
Hilary: then press the button
Felix: Righto

Appendix 25: Transcript of Pharaoh's Tomb

Jane: Hello!
Pete: Hi!!!
Mike: hi
Jane: Nice to meet you!
Mike: nice to meet u 2
Jane: Do you have anything on you? I think I have the ankh
Pete: a wipe
Mike: i have bucket
Jane: Useful if anyone has an accident
Pete: whats that in the first room?
Pete: top left?
Jane: I don't know, lets go closer and look
Pete: banboo
Pete: maybe?
Jane: Did you just put down a whip in its place?
Pete: yer
Jane: I see!
Pete: then put it back
Mike: what will put fire out? is my hint
Pete: water!!!
Jane: Did you use the hint button?
Mike: yes
Mike: i have a key too
Pete: got a bucket full of water
Pete: follow me
Jane: You loose points for taking hints (I am far too competative)
Pete: found a chest
Mike: oops
Pete: think we need a key???
Mike: i have a key
Jane: There is a locked door here, do you want to try to open it with your key?
Mike: how
Pete: go to the far east room with the key
Pete: where are you?
Jane: I am the blue ball on the map
Pete: where is Mike??
Jane: Have you gone wondering?
Mike: i am green triangle
Pete: Mike can you go east?
Mike: how
Pete: is there a door?
Jane: It's okay, you have left your key! I'll open the door
Mike: good
Jane: Did someone else just pick it up?
Pete: i unlocked the chest!!!
Pete: now have a yellow key
Jane: What did you find, and where are you both?
Mike: good- i have a whip now and i think wood
Jane: Pete, do you want to try the yellow key in the door?
Pete: you can now get in the green room
Jane: What is in there?
Pete: a big vase
Pete: another locked door
Jane: Any scroll?
Pete: there is another room as well
Jane: I have found bucket & tap anyone got any ideas?
Mike: i have found an ankh

Pete: and something on a shelve
Jane: I just put that down
Pete: who has the whip?
Jane: Just found a snake
Mike: just found a chest with key - my co-ords are (4,1)
Pete: what the blue thing ijn the snake room?
Pete: and in the room on the far wall?
Jane: I have found the whip, do you want me to get the thing off the shelf
Pete: yer try it
Pete: did it work?
Pete: just made a flute
Jane: Can't find it!
Pete: snake charm!!!
Jane: Good plan
Mike: i am in the scarab room
You have whipped a piece of the scarab off the shelf.
Pete: have the blue thing from the room
Pete: have no idea what it is???
Pete: i will put it down
Mike: need three parts to access the next room
Pete: good call
Jane: Apparently its a piece of the scarab, where did you find the scarab room?
Pete: i see now!!!
Pete: the beetle on the wall
Pete: we need the head bit
Jane: I have put a piece in
Jane: Looks like we need another key?
Jane: I'll go get the ince from the chest
Pete: try the first blue one maybe??
Pete: no luck
Pete: that vase has something i know it
Jane: Yellow key dosn't work
Jane: Where is the vase?
Pete: in the big room
Jane: found it!
Jane: we could fill it with water, we havn't used the bucket yet
Jane: I see someone has
Pete: already there lol!!!
Mike: i have found a musical bat!!
Jane: Freaky!
Pete: ladies first
Jane: So the floor is wet, where does that get us?
Pete: through the door
Jane: What else is there?
Jane: Oh yes, should have moved my view!
Mike: a chart
Jane: Who fancies a trail then?
Pete: whats the chart mean??
Jane: Trial I mean
Jane: Read the scroll
Mike: it has in heiros 1,2,3,4 leg arm eye etc
Mike: morning afternoon evening night
Jane: Is it the key to the riddle in the chamber of riddles?
Pete: its like the crystal maze!!!
Mike: person lion bird snake
Mike: leg arm eye mouth
Pete: good call writing the chart stuff
Jane: I am standing by the door of the chamber of riddles, shall we do this challenge first?

Pete: we made need to recall it
Mike: what should we do with the chart
Pete: who wants what task then?
Jane: I think we should do one all together
Jane: Group work and all that
Pete: i think you can only do then by yourself
Pete: the others stay outside and help?
Jane: If you read the scroll for the chamber of riddles it says you will need your fellows to unlock the puzzle
Pete: read the scroll to the far north west
Jane: That sounds right, Pete, do you want to go in?
Pete: we better hurry up
Pete: ok i will go
Jane: Grand, let us know what you find
Pete: i have a riddle
Jane: sweet
Pete: its from the chart on the wall
Jane: okay, I have the chart in front of me
Pete: the first is one of the bottom numbers
Pete: like a backwards 3
Mike: yep
Jane: four
Pete: or a E lol
Pete: the next is a backwards 7
Jane: two
Pete: 3,2
Pete: the a larger backwards seven
Jane: three
Pete: 3,2,3
Jane: the three has two curves to the top line
Pete: then there are loads of feet?
Jane: leg
Pete: what the one with one curve
Mike: yes legs three of them
Pete: 4,2,3
Jane: If the larger backwards seven has two curves on the top stroke, then it is the symbol for three
Pete: then loads of sun rises
Pete: one in the west
Jane: one in west = evening
Pete: one slightly west of the top
Jane: one slightly west of the top = afternoon
Pete: 4 leg evening!!!!
Pete: 2, leg afternoon
Jane: Four legs in the evening
Jane: two legs in the afternoon
Pete: next sun is in the east
Jane: sun is in the east = morning
Pete: three leg morning!!!
Jane: Does this ring any bells with you?
Mike: no
Pete: not sure i have to select a object on the wall
Pete: there is a lion
Pete: old man
Pete: chick
Pete: some of those numbers
Jane: That must be the answer to the riddle:
Pete: what?
Pete: a moon
Jane: Four legs in the evening, two legs in the afternoon, three leg in the morning

Pete: a bent arm
Pete: a foot
Pete: a eye symbol
Mike: its man
Jane: I think thats it!
Pete: bingo!!!!!
Pete: well done
Jane: great, have you got a bit of the scarab?
Mike: well done everyone
Pete: how did you get that?
Jane: Well done
Pete: that cat on the wall
Pete: now has a eye
Pete: Mike do you want the next room?
Jane: So do we need to find more jewels
Mike: yes
Pete: think so
Jane: lets read the next scroll
Pete: go for it
Pete: Mike choose a room
Pete: one of the south one
Mike: the south one right
Pete: yer either of them
Jane: Labyrinth Chamber
Mike: Labyrinth chamber
Pete: they have locks???
Jane: Has one of you gone in?
Mike: must rely on teammates to navigate
Mike: where am i
Pete: ok
Mike: dark very
Jane: we can watch you on the map
Pete: where are you?
Mike: i don't know
Pete: i cant see you on the map
Pete: can you see yourself?
Mike: no
Jane: I can see myself and Pete
Mike: its completely dark here
Pete: the room makes the map useless
Jane: I see you
Mike: have found jewel
Pete: bring the jewel to the cat
Jane: can you see to get out now?
Mike: no
Jane: go north twice
Pete: ok go east
Pete: twice
Pete: east
Mike: and now
Pete: once you have gone east twice go north three times
Pete: then east again
Pete: then north once
Jane: are you looking at the compass at the top of the screen?
Mike: no
Pete: lol
Pete: may help lol!!!
Mike: can't get out
Jane: which way are you faceing at the mo?
Pete: you aint moving
Mike: south

Pete: face east
Pete: then move twice forward
Pete: tahts it one more
Pete: now north twivce
Pete: now east once
Pete: then north once
Mike: functionality not good
Pete: try to go east
Pete: once
Jane: you are very close, one room away from us
Mike: so close yet so far
Pete: no wrong way
Jane: you are going away now
Pete: turn north
Pete: then move twice
Mike: can't move well feel somewhat wounded
Pete: lol
Pete: crawl!!!
Pete: now east
Pete: once
Jane: move it, just seven minutes to go!
Mike: functionality gone
Pete: turn east
Pete: then move forward
Jane: where you banging your head against a wall?
Pete: bingo!!!
Jane: well done!
Pete: good to see ya
Mike: 5 minutes
Jane: better focus!
Jane: can you put the jewl in
Pete: nice
Mike: done
Pete: Jane your turn
Jane: human sacrifice!
Pete: what do you see??
Jane: lovked door
Jane: step
Pete: anything else
Jane: I can push the stp down
Pete: hey i am in the room to
Mike: me too
Jane: can someone stand on the step and seee if the door opens?
Pete: who has the ankh?
Jane: are you watching the door
Jane: not me
Jane: does anyone have it?
Mike: standing on step
Pete: found it
Jane: Pete, where are you? are you getting the ankh?
Jane: coolio
Pete has left the game
Jane: you sod
Pete: i left!!!
Pete: cya
Mike: how could u
Jane: the air is getting thin in here.....
Pete: run!!!!
Mike: not playing with him again
Jane: Mike, if I stand on the step can you go into the room?
Pete: hurry up!!!

Appendix 26: Engagement questionnaire results

Napier pilot

		Engagement score		
	n	Min	Mean	Max
Pharaoh's Tomb	8	43	69.5	86
Time Capsule	7	56	67.9	82

HK pilot

		Engagement score		
	n	Min	Mean	Max
Pharaoh's Tomb	12	55	64.1	75
Time Capsule	7	58	65.0	78

Napier trial

		Engagement score		
	n	Min	Mean	Max
Pharaoh's Tomb	42	47	65.6	90
Time Capsule	36	44	66.4	90

Appendix 27: Engagement factor correlations

Challenge: motivation

Q1: I wanted to complete the activity
Q11: I did not care how the activity ended (reversed)

	Q1	Q11
Q1	1.000	0.423(**)
Q11		1.000

** Correlation is significant at the 0.01 level (1-tailed).

Challenge: clarity

Q4: I knew what I had to do to complete the activity
Q18: I found it easy to get started

	Q4	Q18
Q4	1.000	0.285(**)
Q18		1.000

** Correlation is significant at the 0.01 level (1-tailed).

Challenge: achievability

Q2: I found the activity frustrating (reversed)
Q3: I felt I could achieve the goal of the activity

	Q2	Q3
Q2	1.000	0.306(**)
Q3		1.000

** Correlation is significant at the 0.01 level (1-tailed).

Control

Q6: It wasn't clear what I could and couldn't do (reversed)
Q14: The activity would not let me do what I wanted (reversed)
Q15: I could not tell what effect my actions had (reversed)

	Q6	Q14	Q15
Q6	1.000	0.359(**)	0.346(**)
Q14		1.000	0.351(**)
Q15			1.000

** Correlation is significant at the 0.01 level (1-tailed).

Interest

Q5: I found the activity boring (reversed)
Q10: I was not interested in exploring the options available (reversed)
Q16: I did not enjoy the activity (reversed)

	Q5	Q10	Q16
Q5	1.000	0.430(**)	0.522(**)
Q10		1.000	0.406(**)
Q16			1.000

** Correlation is significant at the 0.01 level (1-tailed).

Immersion

Q8: I felt absorbed in the activity
Q12: I felt that time passed quickly
Q13: I found the activity satisfying

	Q8	Q12	Q13
Q8	1.000	0.151(*)	0.377(**)
Q12			0.337(**)
Q13			1.000

* Correlation is significant at the 0.05 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).

Purpose

Q7: It was clear what I could learn from the activity
Q9: The activity was pointless (reversed)
Q17: Feedback I was given was useful

	Q7	Q9	Q17
Q7	1.000	0.328(**)	0.301(**)
Q9		1.000	0.327(**)
Q17			1.000

** Correlation is significant at the 0.01 level (1-tailed).