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.