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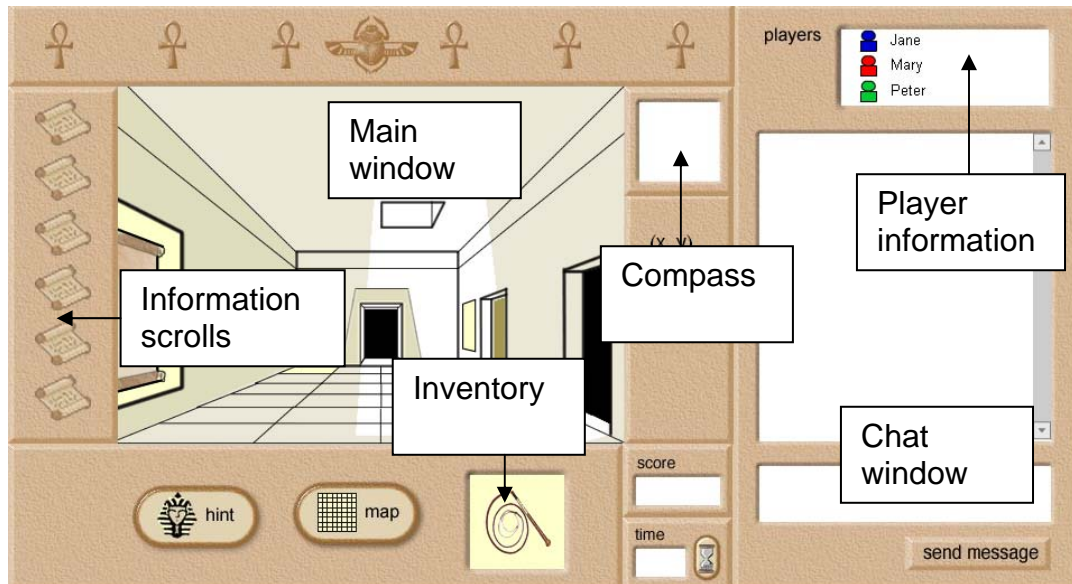
Figure 7-1: Initial interface for the Pharaoh's Tomb

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).
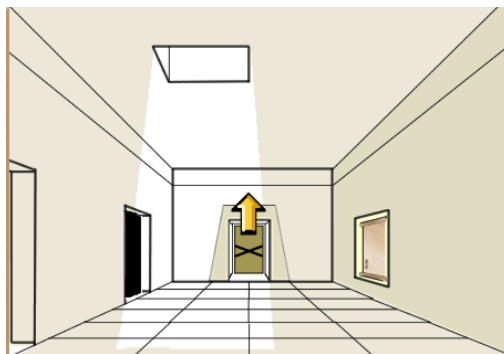

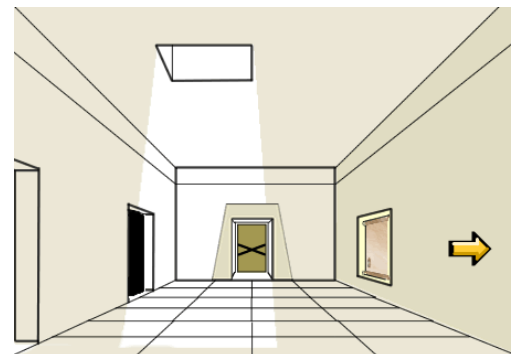Figure 7-2: Forward navigation in the Pharaoh's Tomb

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).
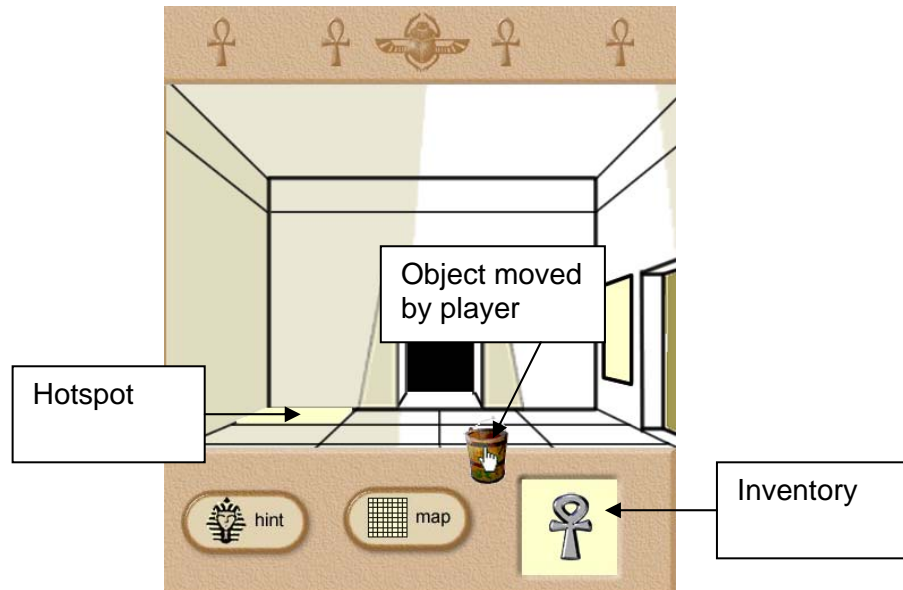
Figure 7-4: Moving a bucket to the inventory

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).
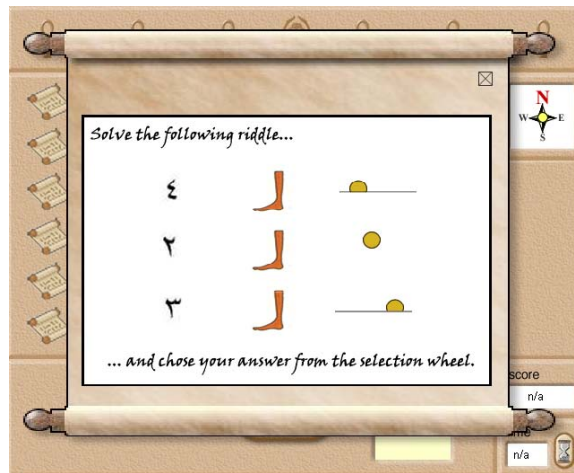

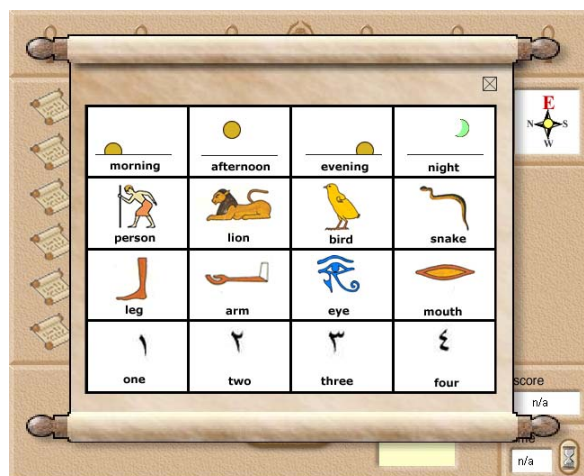Figure 7-5: The Pharaoh's Tomb riddle presented in code form

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).
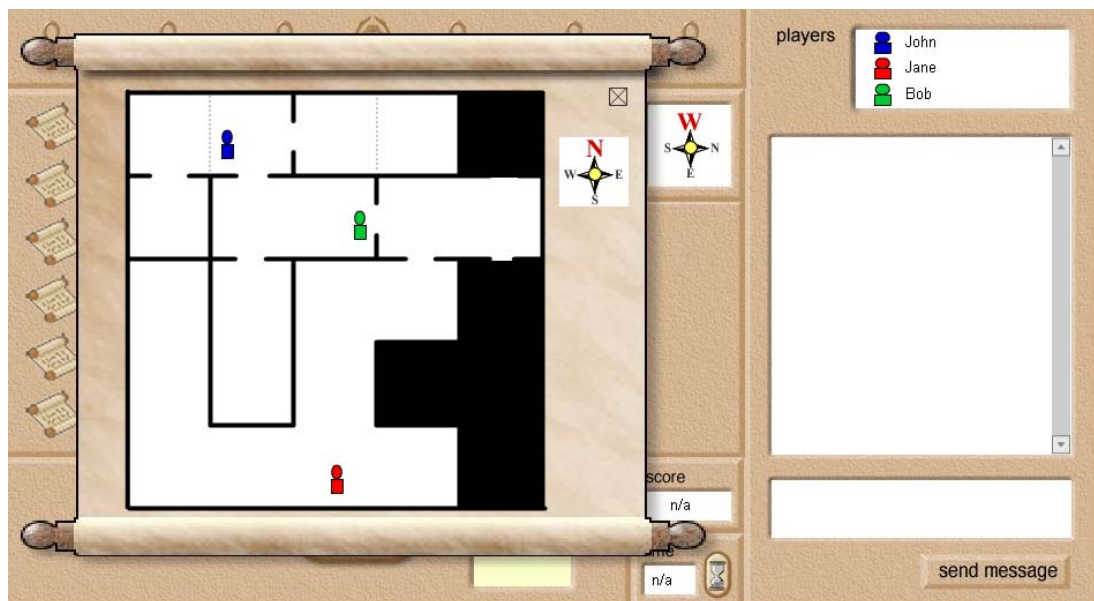

Figure 7-7: Using the map in the Pharaoh's Tomb

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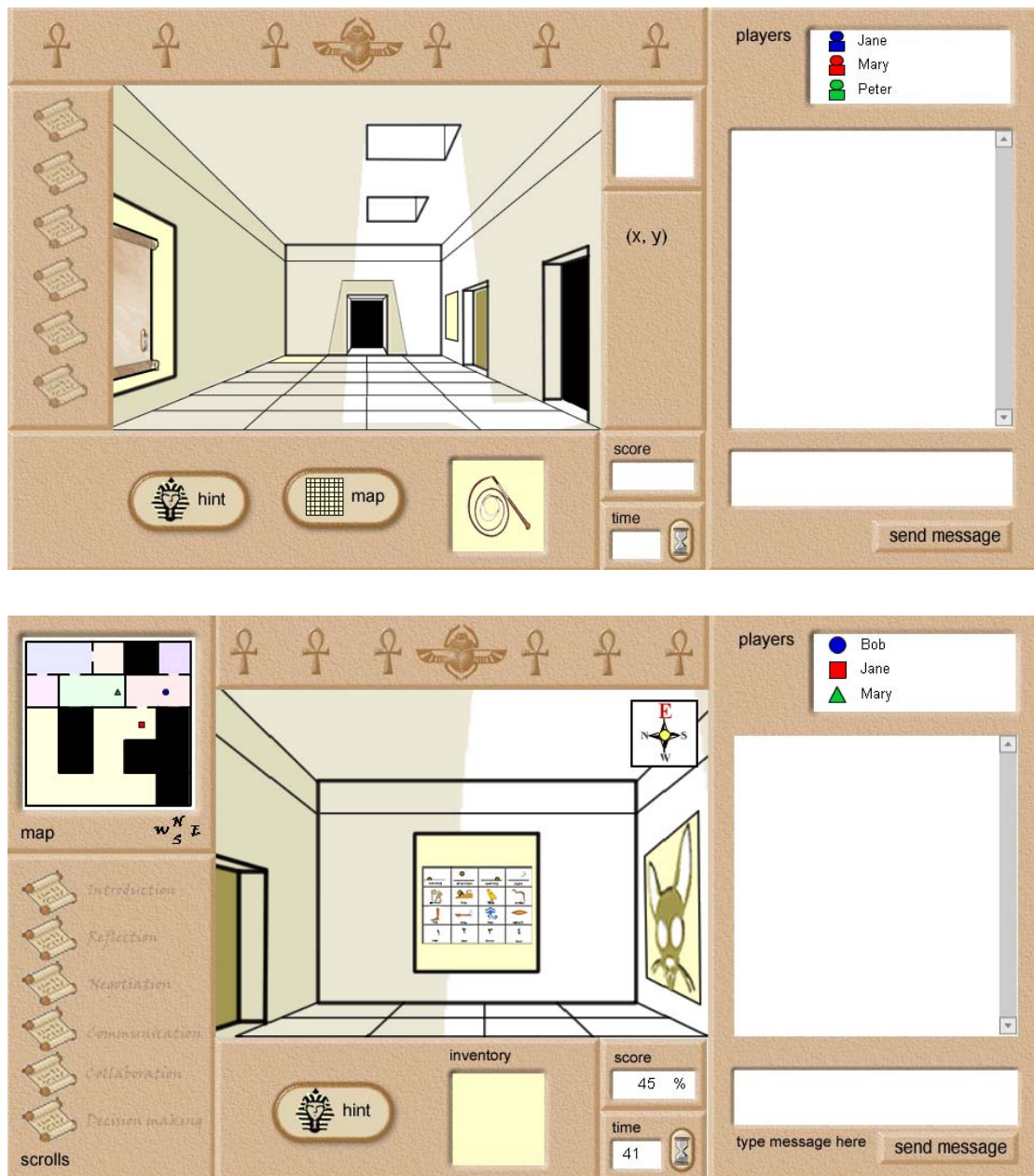
Figure 7-8: Version 1 (top) and version 2 (bottom) of the Pharaoh's Tomb interface

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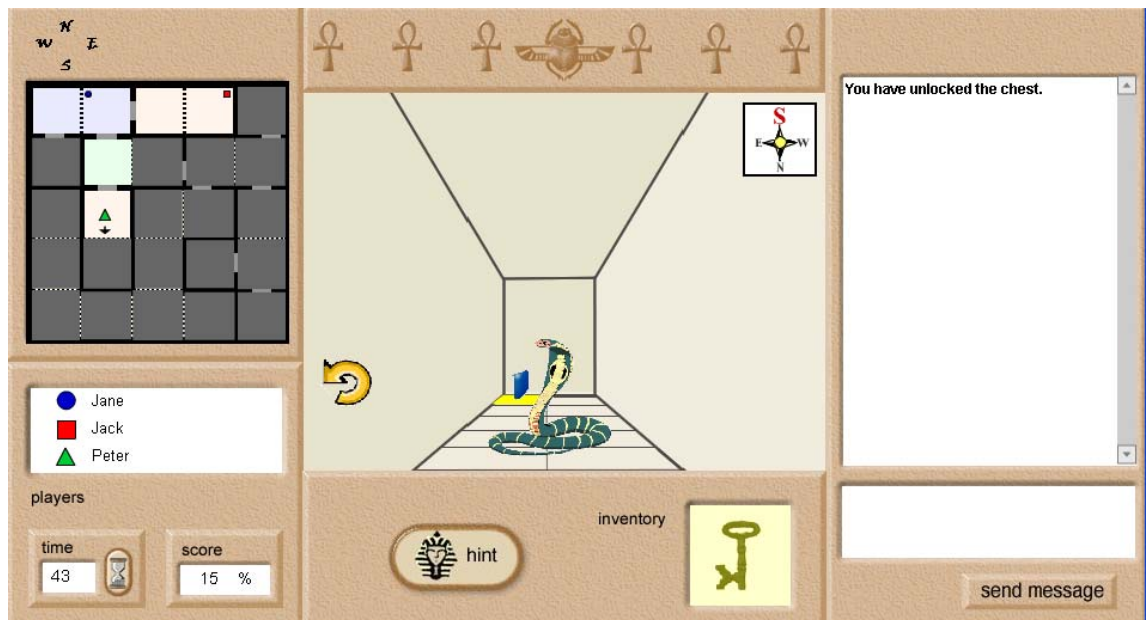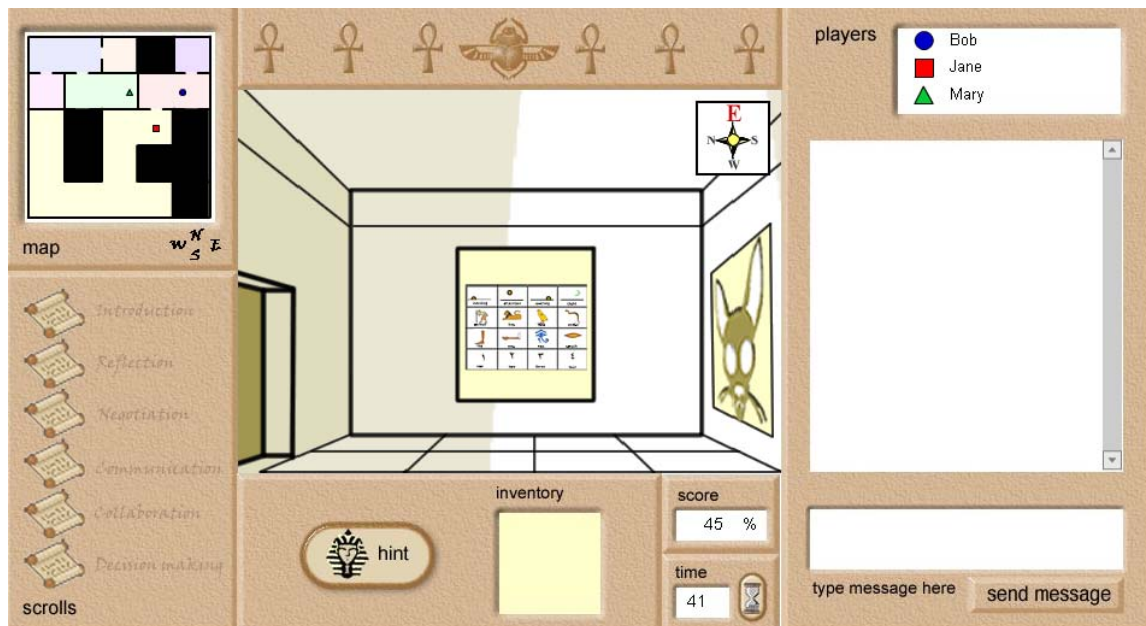
Figure 7-9: The second (top) and final (bottom) versions of the Pharaoh's Tomb interface

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.