EVALUATION
OF
THE USABILITY
OF
THE VIRTUAL LEARNING SPACES GAME
USER INTERFACE

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ABSTRACT

This thesis reports on a usability study conducted on the Virtual Learning Spaces (VLS) computer-based educational adventure game. The aim of the game is to improve the acquisition of knowledge through play in an interactive, entertaining and intrinsically motivating computer-based environment. The objective of this study centred on assessing the quality of the VLS game user interface, and determining faults and problems that may hinder implementation

Literature on usability of virtual reality educational game systems and related phenomenon of usability of other types of computer application systems was reviewed, including, to a lesser extent, literature on usability of web pages. The major issues of interest included, usability issues concerning principles of good user interface design, factors that influence how a user interface promotes user satisfaction and the objectives of playing the game, from player, game and the game as medium of learning perspectives. These principles provided a set of usability requirements for the VLS game user interface on which the evaluation was based.

A series of data collection methods comprising a cognitive walkthrough, heuristic evaluation, usability testing and post-test questionnaire, were used in this study. Despite some usability problems, results indicate that the VLS user interface design conformed, extensively, to the principles of good user interface design in appearance, interaction and user help. It was also found to be engaging, comprehensible and unbiased (in terms of gender and variable computer skills).

DECLARATION

I hereby declare that this study represents original work by the author and has not been submitted to another university. Where use has been made of work of others, this has been duly acknowledged.

Signed by

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Stephen Kigundu

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I would like to thank all persons who contributed towards the completion of this study. First and foremost, I convey my sincere appreciation to Ms. P. Clarke, my supervisor, under whose guidance and professionalism this work was completed. Her supervision was not only proficient and academic, but also provided for an extensive educational interaction, an open exchange of ideas and a brilliant learning experience. I appreciate the interest shown in my work and the encouragement given. I owe her my sincere gratitude.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 BASIS FOR THE STUDY

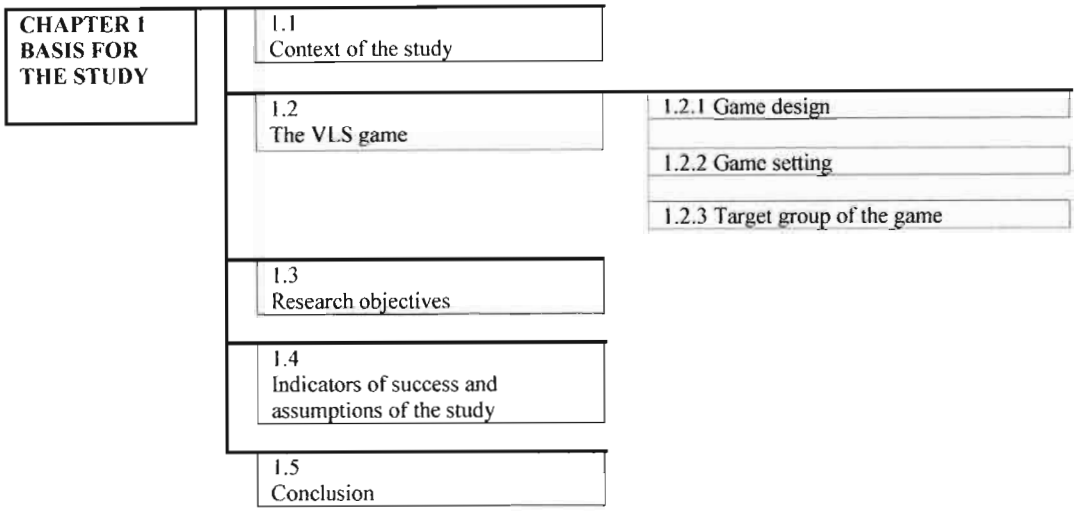


Figure1.1 Outline of chapter 1

1.1 Context of the study

This thesis reports on a usability study conducted on the Virtual Learning Spaces (VLS) computer-based educational game. The game was developed at the University of KwaZulu-Natal under the directorship of Professor Alan Amory. The usability study was part of Task 4 of a six-phase project that included the following tasks:

Task 1: Hardware and software development.

Task 2: Story development.

Task 3: Software and resource development.

Task 4: Software and User interface evaluation.

Task 5: Evaluation of the VLS game as viable educational tool.

Tasks 6: Development and evaluation of the VLS game to teach specific content (Amory, 2000).

Computer-based games and on-line gaming as educational tools, form one of the emerging areas of interest currently under study all over the world (Amory, 2000). This field involves the use of game technology associated with modern communication systems to develop interactive games as educationally viable tools. It is based on the observation that most humans process information better visually than they do textually and that more learning takes place and at a faster pace through seeing things whole and in context (Cooper 1995: 41).

Moreover, games have the potential to meet most, if not all, of the characteristics of intrinsic motivation (that is, challenge, curiosity, fantasy, and control (Malone, 1981: cited in Rieber, 1996)). Furthermore, computer games can also instil feelings of engagement (the connection between player's intrinsic knowledge and external stimuli) in a player that promote the initial interest in the game and continued play (Jones, 1998). Accordingly, interactive games can be used to communicate abstract ideas, concepts, and processes more easily and pleasantly than text or static visuals. Hence the objectives of the VLS project were to:

- Use interactive computer games as an educational tool.
- Provide an effective means of promoting the use of computers in a learning environment.
- Facilitate learning through an interactive, entertaining, intrinsically motivating computer-based environment in the form of a "Virtual Reality" game (Amory, 2000).

The anticipated end result of the project was a game where learning about a specific domain of knowledge might be achieved through exploration, discovery and problem solving.

This study took place while the game was still under development. It therefore involved primarily formative and predictive evaluation assessing the quality of the game user interface during development and determining imperfections and problems. The scope of this project covers the evaluation of the VLS game interface from the game user's perspective.

1.2 The VLS game

The VLS Game is an educational adventure game, designed to improve the acquisition of knowledge through play. The game combines modern game, computer and graphics technologies to produce interactive virtual learning spaces. The aim of the VLS game designers was to develop a game with the potential to empower young people to face the future with insight and confidence (Amory, 2000; Amory, 2001).

The VLS game was designed for the following target group:

Gender:	Male and female.
Age:	17 to 20 years.
Back ground:	From any race group.
Training:	Final year of school or first year university
Input skills:	Basic mouse control and typing.
Linguistic ability:	Good command of English language.
Task experience:	None required.
Product experience:	None required.
Physical attributes:	Normal visual and aural acuity.

The focus of the game is South African arts, culture, science and technological disciplines. From a general perspective, the game aims to:

- show how South African history and the functioning of South Africa's political, social and economical democracy fit together,
- provide a better understanding of communication technologies involved in the information revolution. (Amory, 2000).

1.2.1 Game design

The game design consists of an *Inner City* with portals radiating outwards from it. The technology used includes point-and-click and 360^{o} panoramic environments that use either first or third person views.

In the first-person perspective, the player is transported into a virtual learning environment (portal) that focuses on a specific discipline. A portal is where the player, through exploration and discovery, learns about a specific domain of knowledge. A portal consists of acts, scenes and puzzles. An act is a combination a number of scenes. Each scene represents a single geographical location in the virtual world.

In the first-person perspective the player interacts directly with the game space, which gives the player a feeling of unlimited 3D world. The player can move freely around the environment and also interact with virtual characters and other objects in the game space. According to Aykut and Erkut (2000) skyboxes are used to create this 3D environment. A *skybox* (figure 1.1) is a cube made of six images that surround the player. Each skybox is a scene, which comprises six camera views covering a field of view. The field of view of each camera view was 90^{O} so as to match up all the images seamlessly, when they were put together to form the six sides of a *skybox*.

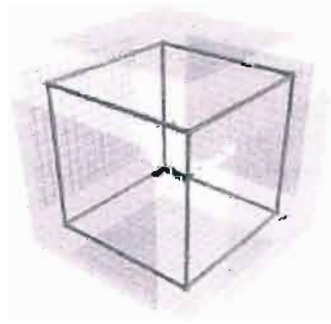


Figure 1.1 Illustration of the skybox
(Aykut and Erkut, 2000)

The edges were joined together, as shown in Figure 1.2 and realistically rendered with the help of the game engine to give a 3D impression. The images were created through modelling, lighting and rendering using the software program *Discreet 3D Max 3.1*. Texture and image manipulation was done with *Adobe Photoshop 6* software.

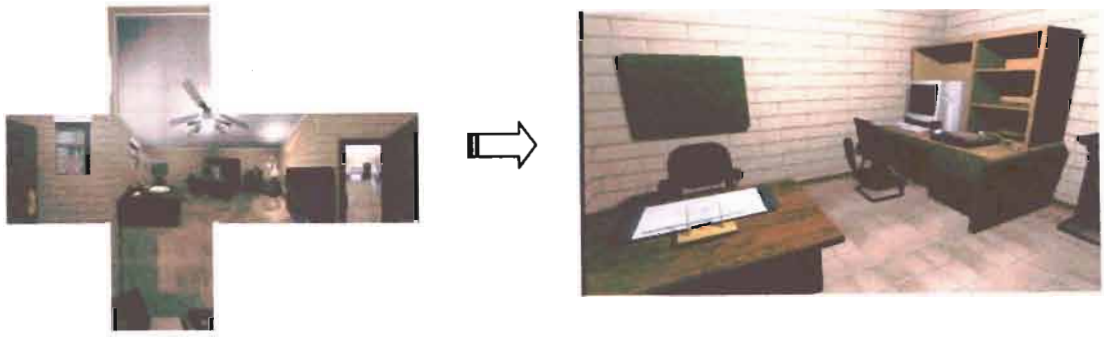


Figure 1.2 Net of the skybox and the 3D office created from it

When the game is played, the mouse is used for all navigation and interaction with the game. In each scene a player is able to move forward or backwards, or is able to turn right or left. While investigating the game space the player finds collectable objects, and solves puzzles to gain additional information or to progress to other game areas. The non-linear gameplay enables the player to go anywhere, at any time. However, the path that the player follows through the game is represented by a number of active nodes that the player navigates by means of mouse point-and-click actions. Visual changes such as zooms, dissolves, and fades show the player the effect of his or her actions, such as moving to a new place within the game.

In the third-person view the player becomes part of the virtual space and assumes a particular role. Here interaction with other players, represented as avatars (which are 3D representations in virtual space) is possible. This view is made up of two main components, the *Character Editor* and the *Inner City*.

The *Character Editor* (Figure 1.3) provides a means for the player to select the appearance of their character, as it will appear in the game scenarios. This editor enables the following characteristics to be set: gender, skin tone, hairstyle, clothing (tops, bottoms and shoes), and the colour of the clothing and hair.

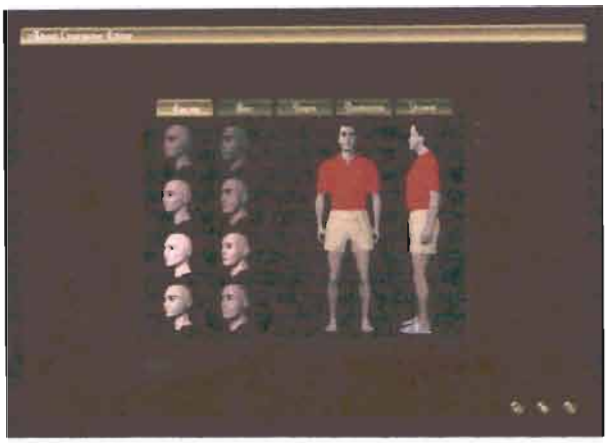


Figure 1.3 The Character Editor

These characteristics can be changed at any time during the game. The player is also capable of saving a set of characteristics to be reused at any time during a game or subsequent sessions.

At the start of play, the game places the player in the virtual world of the *Inner City*, in the form of an animated character (avatar) that he/she controls (Figure 1.4). The *Inner City* is that part of the game in which the 'built-up' characters interact.

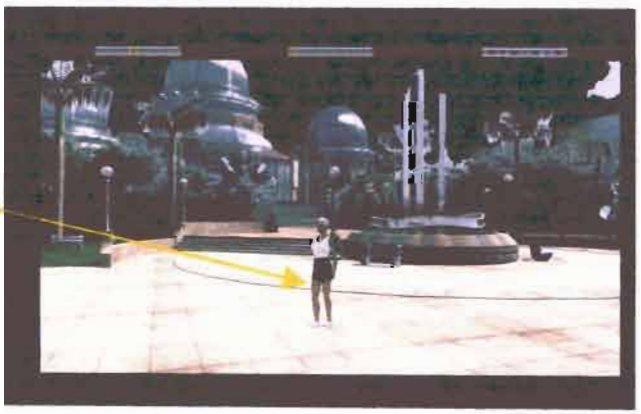


Figure 1.4 The Inner City

Information is provided through a number of different mediums such as artwork and posters found in the scenes; for example, the design of buildings provides knowledge about traditional South African architecture. Another source of information is envisioned to be through interaction with other players, networked into the virtual world, as well as computer generated characters. Some of the computer characters in the game are built-in to provide information to the player on specific subjects. These characters are also known as *virtual actors*.

The different places of interest that can be visited, within the Inner City are:

- *City Hall*: This is the starting point of the game. It contains information relating to environmental issues, history of the city and art.
- The *Waterfront*: This is an area that provides opportunity for interaction with other characters by visiting the restaurant and music shop which are located there.
- The *Trading Area*: The focus of this area is information regarding the products and trading activities in African culture. It also contains the docks, which is the only way to the ePort.
- The *ePort*: This is where the main functionality of the game is initiated.
- The *Apartment Complex*: This is the player's accommodation. The level of luxury of an apartment increases depending on the player's income from completing a virtual job or task.

1.2.2 Game setting

The fundamental objective of the game is for the player to earn as much income as possible from jobs he or she is contracted to do. The player acquires the job and necessary equipment from a secretary at the *ePort*. Then the player is sent out into one of the portals to carry out a mission. The mission is launched from the *ePort* where the player receives orders and information about the mission. Then the game transports the player from the *Inner City* environment (third-person

view) to the portal environment (first-person view). The mission is to explore this place by seeking clues and information. The *In the Service of Humanity* portal, evaluated in this study, exposes the player to information on the nature and transmission of diseases, namely, Tuberculosis, Malaria and AIDS. This study took place when the *Inner City* and one portal (titled *In the Service of Humanity*) of the VLS game was sufficiently developed and programmed with content to be in an operational form similar to the anticipated final version of the game. The evaluation of the usability of the VLS game user interface was therefore conducted on these two sections.

1.2.3 VLS game user interface structure

The VLS game user interface is made up of four parts as indicated in Figure1.5

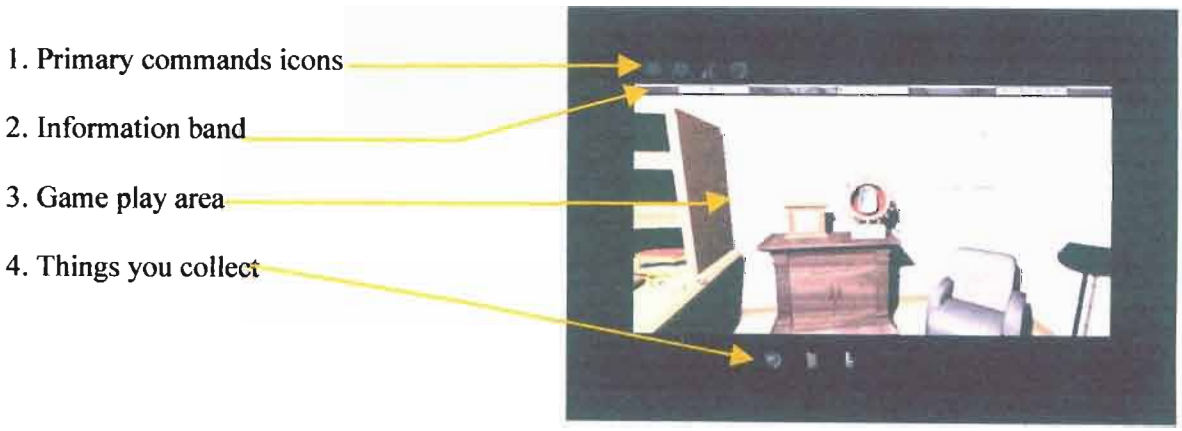


Figure 1.5 VLS user interface structure

1. Primary commands icons are Exit, Help Agent, and Personal Options
2. Information band, which displays the player's position, point gained and Persona
3. Game play area is where the action takes place.
4. Things you collect for example, *Personal digital assistant* and *Cellophone icons*

The player explores the game play area by navigating using the mouse. The player can point at an object and left-mouse-click on it in order to manipulate it. If nothing happens, then nothing can be done with this object (unless he or she failed to click on the correct part).

Virtual actors are presented by embedded quick time videos.

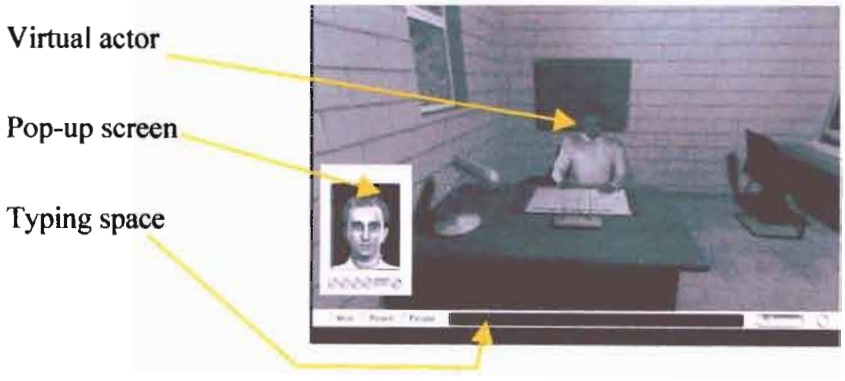
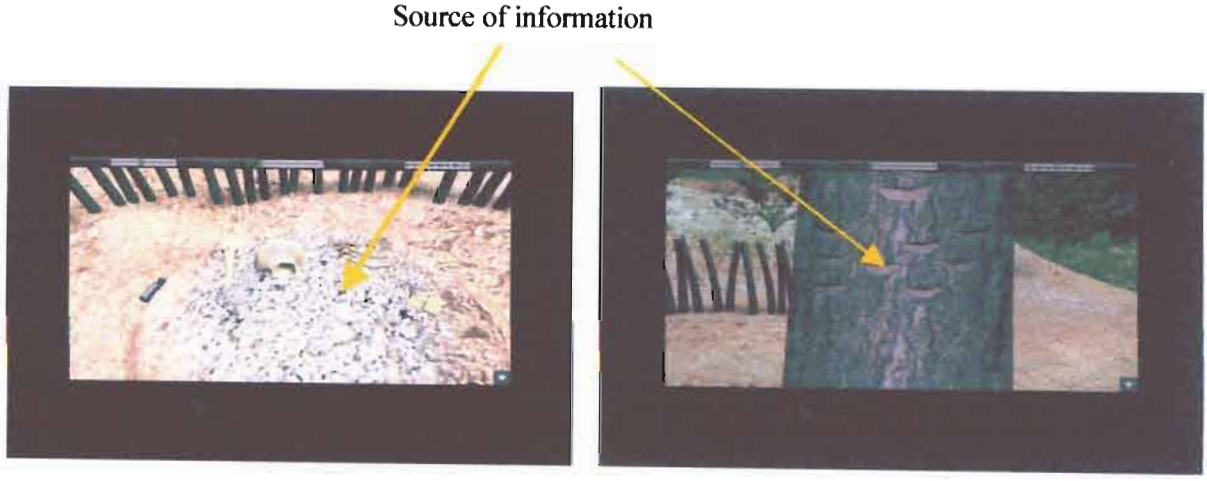


Figure 1.6 Example of a Virtual Actor

Communication with these actors is through a pop-up screen (Figure 1.6), which has a space at the bottom for typing in questions. The virtual actor's response is both text and sound.

In addition there are embedded close up (pop-up) pictures (Figure 1.7) of sources of information that require special attention.



The *fireplace*

The *tree carvings*

Figure 1.7 Examples of a source of information

1.3 Research objectives

The objective of this study was to assess the quality of the VLS game user interface prior to use by finding answers to the key research questions presented in Table 1.2.

Table 1.2 Research questions

Usability Issue		
Interface Design	Appearance	To what extent does the VLS game user interface appearance (colour, graphics and metaphor) facilitate the acquisition of correct information through ▪ visually appealing graphics, ▪ not displaying irrelevant information, ▪ using objects, features and concepts that are familiar to the player ▪ consistent display format across displays?
	Interaction style	To what extent does the VLS game interface interaction style facilitate and enhance ▪ fast response to player input actions, ▪ reduction of errors, ▪ recovery from errors, ▪ player control?
	User Help	To what extent is the VLS game interface help ▪ accessible to players, ▪ easy to use, ▪ flexible, ▪ unobtrusive?
Player satisfaction	Engaging	To what extent can the VLS game interface provide players with extrinsic motivation in form of: ▪ challenging tasks, ▪ interesting tasks, ▪ levels of player control, ▪ clear consistent feedback, ▪ enjoyable experience? (Quinn, 1998; Jones, 1998)
	Comprehensible	How fast can a user, who has never seen the VLS game user interface before, learn it sufficiently well to accomplish basic tasks?
		Once a player has learned to use the VLS user interface, how fast can he or she accomplish a specified task?
	Equitable	To what extent does the VLS game interface accommodate ▪ gender preferences, ▪ disparities in experience of players in computer-use, ▪ disparities in experience of players in computer games, ▪ disparities in player educational background and ▪ differences in cultural backgrounds?
Objectives	Player objectives	To what extent does the VLS game interface provide ▪ an enjoyable experience ▪ clear goals, so that a player can keep track of progress during play
	Game objectives	To what extent does the VLS game interface provide ▪ different levels of challenge, so that players can continue playing as their skills increase, ▪ context, characters, and a story that are appealing to the player, ▪ variety, so that a player can be play repeatedly without becoming bored,
	Learning objectives	How effective is the VLS game interface in enhancing the learning experience? Does it ▪ stimulate curiosity, ▪ provide meaningful contexts, ▪ combine fun with instruction, ▪ provide mentally stimulating activities?.

In the design and implementation of any software there is a need to carry out an evaluation of the software in order to determine faults and problems, which may hinder implementation (Squires,

1997). Recommendations from this study were to be used to improve on the VLS game user interface. Consequently, the aim of this study was to evaluate the quality of a user's experience when interacting with the VLS game.

To answer the key research questions, the following objectives were set:

1. To design and develop appropriate tools and processes to evaluate the usability of an educational computer game.
2. To implement these tools and processes to evaluate the usability of an educational computer game.
3. To evaluate whether the of the VLS game user interface is functional in practice for the intended player (Sutcliffe, 1995).
4. To assess whether of the VLS game user interface design satisfies specified usability requirements (Sutcliffe, 1995).
5. To monitor and evaluate the quality of the user's experience when playing with the VLS game.
6. To determine the engagement capacity of the game. (Jones, 1997; Redmond-Pyle and Moore, 1995)
7. To identify and facilitate the elimination of usability problems for player of the VLS game (Sutcliffe, 1995).
8. To find out whether there are any differences in the problems encountered, when playing the game, between novice and experienced computer users (Shneiderman, 1998).
9. To find out whether there are any differences in the problems encountered, when playing the game, between male and female players.
10. To lay the foundation for the construction of usability specifications for the game.

A secondary objective was to assess the reliability and validity of the processes and instruments used in the study. This assessment was necessary in order to draw justifiable conclusions about the suitability of the instruments in measuring the intended variables and ensuring reasonable subsequent use in other evaluations of the game as it is developed.

1.4 Indicators of success and assumptions of the study

Given the above objectives, the following milestones were set as indicators of success of the study:

- The construction of usability requirements for the VLS game user interface.
- Use of these requirements to test the game.
- Identification of problem areas.
- Suggestions as to how to eliminate these problems.

The objectives were set based on the assumption that the conditions under which the research was carried out would not be significantly different from those in the real world where the game will be played. Hence as a result of the findings and recommendations from this study, the final version of the VLS game could be improved in terms of be efficiency, effectiveness, engagement and meeting game objectives.

1.5 Conclusion

In this chapter the setting for the Virtual Learning Spaces (VLS) project under development at the University of KwaZulu-Natal was presented. This study ensued from the need to carry out formative and predictive evaluation of the usability of the game user interface in order to determine faults and problems, which may hinder implementation. Based on this interpretation the aims and objectives of the study were stipulated. The study was focused by means of key issues; VLS user interface design, user engagement and game objectives. Hence the aim of the next chapter is to discuss some of the major models and theories of computer game usability and related educational theories, and how these relate to the evaluation of the VLS game user interface and its support for educational objectives.

An outline of the remaining chapters of this thesis follows.

- Chapter 2 offers a review of the literature on the theories and principles of user interface design, the construction of usability requirements for the VLS game user interface and the theoretical setting for usability methods is also reviewed.
- Chapter 3 is a description of the research approach used in this study.
- Chapter 4 deals with an analysis and discussion of results. It included a description of the pilot test conducted to check the effectiveness of the evaluation tools and techniques developed or adapted for this study and to determine where revisions were needed.
- Chapter 5 presents conclusions drawn from the results of the study and recommendations to inform the developers of the VLS game as well as for further research.

CHAPTER 2 LITERATURE REVIEW

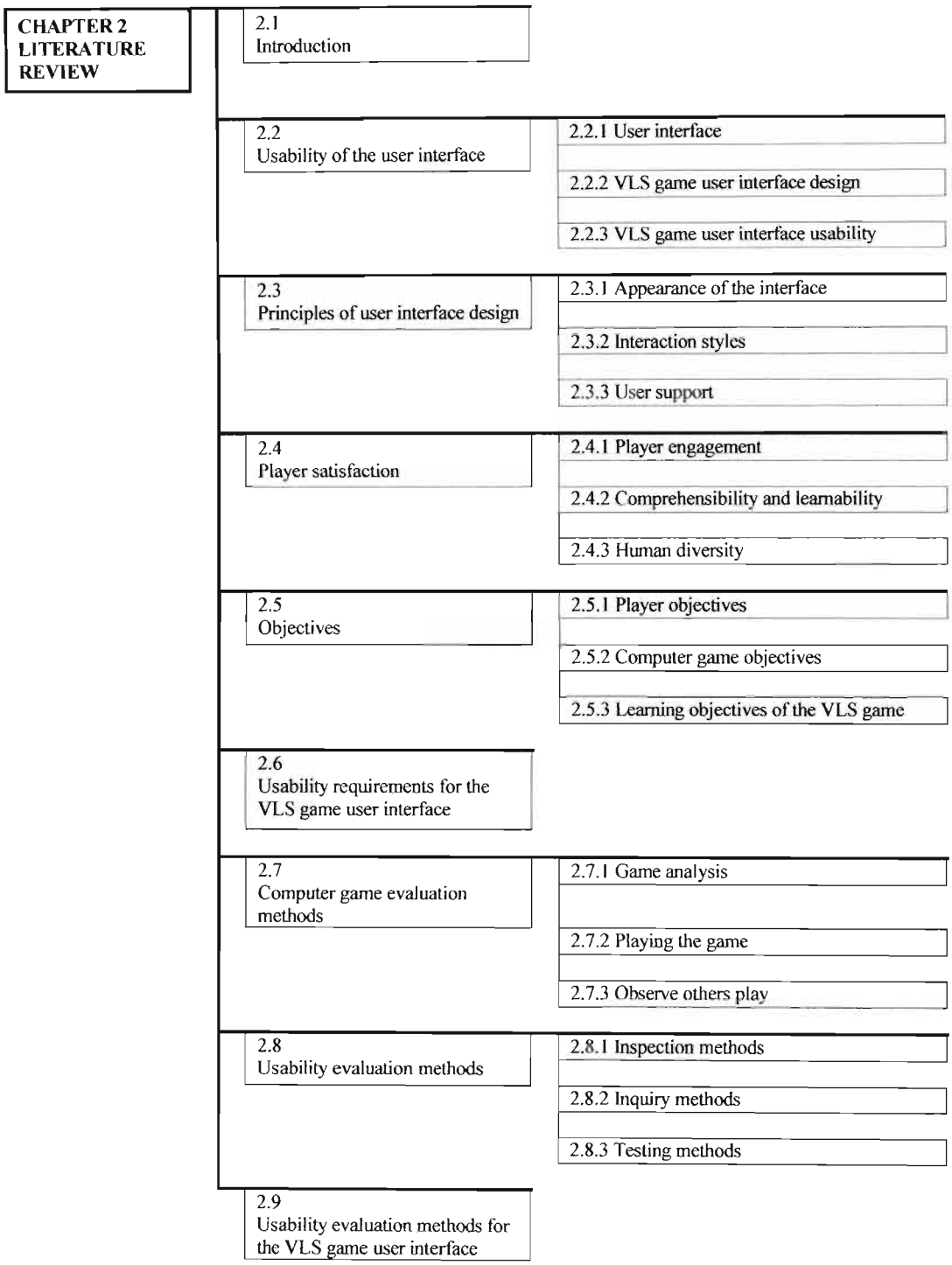


Figure 2.1 Outline of chapter 2

2.1 Introduction

The research literature on the topic of usability of virtual reality educational game systems is limited. Hence literature on related phenomenon of usability of other types of computer application systems and to a lesser extent, literature on usability of web pages was also reviewed. Materials referred to include:

- Books written by established professionals on interface design/evaluation.
- Selected university-based research reports and conference papers.
- Articles from recognized journals.
- Recognized on-line journals.
- On-line materials for which the credentials of the writer were provided.

The major issues of interest in this literature review include usability issues concerning user interface design, and evaluation of how user interface promotes user satisfaction and game objectives.

2.2 Usability of user interface

2.2.1 User interface

User interface is "an information channel that conveys information between computer and user" Harold (1990: 18). In essence user interface portrays how humans interact with what they see on the computer screen. This includes aspects of a computer system that can be perceived by the user, the commands (input information) and mechanisms used to control its operation. Computer games make use of graphics, animation and sound to convey information to the user. The objective is to enable the user to make mental comparison between something new and previous knowledge. Hence in the computer game user interface, the metaphor paradigm is used:

- To relay the structure of a group or system (using Organisational Metaphors).

- Relate tasks that can be done on the site with tasks that can be done in another environment (Functional metaphors).
- To rely information based on common graphic elements familiar to most people (Visual Metaphors).

(Cooper, 1995: 54).

The next section explores the VLS game user interface design and how it incorporates these metaphors.

2.2.2 VLS game user interface design

The VLS game design was based on the Game Object Model (GOM) (Amory, Naicker, Vincent, Adams, 1999). The GOM provides an abstract framework for the analysis, design and implementation of an educational game. It includes components that promote educational objectives (abstract) and those that allow for the realization of such objectives (concrete) (Amory, 2003). Amory (2003) further elaborates that, the basic story in computer games, just as in a play or film, is made up of a number of acts. In the game design, acts implement the story-line interface of the Visualization Space (an expression of how the game is seen) and define specific objectives that need to be realized. Each act needs to achieve specific objectives, tell a part of the story through one or more scenes. Scenes are defined as individual geographic locations within the game that are scripted with appropriate puzzles and objects to realise the game objectives. Therefore, a scene implements the concrete interfaces of the visualization space of the GOM. This means that evaluation of the usability of the VLS game user interface can be realized through the evaluation of the concrete interfaces in a scene, specifically:

- Graphics, sound and technology interfaces (elements space).
- Visual, logic, mathematical, computer interfaces (literacy space).
- Reading, writing, speaking interfaces (communication space).

- Short term, long term memory interfaces (memory space).
- Manipulation and reflex interfaces (motor space). (Amory and Seagram, 2003)

This study sought to evaluate the usability of the VLS game user interface through manifestations of these concrete interfaces in each scene. The usability evaluation requirements were based on the VLS game user interface definition discussed in the following section.

2.2.3 VLS game user interface usability

Usability of the user interface addresses the question of how well users can interact with the user interface. It applies to all aspects of the user interface with which the user might interact. Hence Nielsen (1993: 26) recommends the definition of the abstract concept, usability of user interface, in terms of more precise observable or measurable components. This enables the achievement of a systematic way of evaluating usability.

In order to redefine usability of the VLS user interface the following criteria was set:

- Use internationally recognized sources of usability definitions,
- Express usability in terms of measurable quantities,
- Incorporate usability engineering (use usability specifications as basis for evaluation) and contextual usability (define context of use) principles in the definition to make it more comprehensive.

Based on these criteria, ISO 9241 and Jakob Nielsen were considered appropriate sources of definitions for use in the present study. ISO stands for International Organization for Standardization and the ISO 9241 part refers to the ergonomic requirements for visual display terminals. It has seventeen parts addressing hardware issues ranging from requirements for visual display to no-keyboard input devices, and software issues ranging from general dialogue principles to direct manipulation dialogues. Usability is defined by ISO 9241-11 standard as "the

effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments" (Dix, Finlay, Abowd and Beale, 1997: 192).

This definition can be expanded, and made more comprehensive, in concurrence with Nielsen's (1993: 26) definition, by including five attributes, which must be met for the users of a product. It must be effective, efficient, engaging, error tolerant and easy to learn (Quesenbery, 2001);

- Effective: Effectiveness is the completeness and accuracy with which users achieve specified goals.
- Efficiency: Efficiency is concerned primarily with how quickly a task can be completed. The system should be efficient to use, such that once a user has learned the system, a high level of productivity is possible.
- Engaging: An interface is engaging if it is pleasant to use such that users are subjectively satisfied with using it.
- Error tolerant: The system should have a low error rate, so that the users make few errors during the use of the system. However, if they do make errors they can easily recover from them. Catastrophic errors should not occur.
- Learnability and memorability: The system should be easy to learn so that the user can rapidly start getting some work done with the system. Moreover the system should be easy to remember, such that a casual user is able to use to the system after a period of absence, without having to learn everything afresh.

  (Quesenbery, 2001; Nielsen 1993: 26)

Using the ISO 9241 and Jakob Nielsen's definitions as a basis, the usability of the VLS game user interface is defined as; the extent to which the VLS game user interface functioning can be learnt with ease and used with efficiency, effectiveness and low error rate to achieve the specified objectives, resulting in a high level of player satisfaction, where:

- Learning with ease of refers to how fast a player, who has never seen the VLS game user interface before, can learn it sufficiently well to accomplish basic tasks.
- Efficiency refers to ease of use. That is how fast a player who has learned to use the VLS user interface can accomplish a given set of tasks.
- Effectiveness refers to the extent to which a player gets the correct information or generates the right outputs from interactions with the VLS game user interface.
- Player satisfaction refers to the extent to which the VLS game user interface is pleasant to use.

The definition exposes three issues, which need additional clarification, in the context of this study, in order to facilitate the application of the definition to the evaluation of the usability of the VLS game user interface:

1. The VLS game user interface. Here, the principles of good user interface design with respect to appearance, interaction and user support need clarification.
2. Player satisfaction. Here, the factors that influence how users respond to the VLS game user interface design and functioning require illumination.
3. Specified objectives. Here attention is given to the objectives of playing the game, from player, game and the game as medium of learning perspectives.

2.3 Principles of User interface design

2.3.1 Appearance of the interface

One of the fundamental principles advocated by Tognazzini (2003) is that effective interfaces must be visually clear so that users quickly see the breadth of their options, grasp how to achieve their goals, and do their work. This refers to:

- Aesthetic appearance, which plays a big role in the first impression of the user and his or her subsequent attitude towards the system (Kurosu and Kashimura, 1995; Tractinsky, 1997).
- Visual appeal, which results in a harmonious visual experience, pleasing to the eye (Mayhew 1999: 223).
- An engaging overall design which does not display irrelevant information (Nielsen, 1994).
- Facilitation of information acquisition and processing (Tractinsky, 1997).
- Enhanced readability of the text-based communication through the use of high contrast of text and font sizes that are large enough to be readable on standard monitors (Ray and Ray 1999; Tognazzini, 2003; Matthews, 1999).

The power of modern graphics software (e.g. Discreet 3D Max 3.1 and Adobe Photoshop 6 used in the development of the VLS game user interface) gives designers the capacity to take care of colour, graphics, typography, layout, icons, and coherency to a photo-realistic finish. Therefore, one area of interest in this study was extent to which the users perceived the VLS game user interface appearance to be realistic and how the appearance facilitates the dissemination of correct information.

The user interface visual representation (interface metaphor) and direct manipulation of the world of action (Shneiderman, 1998: 229) provides the means by which a game user interface presents information. According to Tognazzini (2003) metaphors enable users to grasp the finest details of the conceptual model through:

- using concepts, features and objects that are closer or familiar to the user's world, and
- appealing to peoples' perceptions of sight, sound, touch, and kinaesthesia.

Erickson (1990: 73) argues that the main purpose of user interface is to facilitate effective communication between computer and user and make acquisition of information, by the user, easy. In support of this view, Tognazzini (2003) contends that metaphors must be compatible with the users' previous knowledge in order to enable them to correctly interpret the information and meaning behind the metaphor, for example, using common actions or tasks that are similar to those done in daily life, such as walking along a path and not across a field. In other words objects must be consistent with their behaviour and objects that act differently must look different.

However, Cooper, (1995) noted that some metaphors only express one or a few dimensions of a multidimensional phenomenon or may have more than one meaning. Consequently, metaphors can sometimes be quite difficult to interpret. Hence, in the VLS game user interface design, how to facilitate information dissemination, acquisition and processing, might be more problematic than giving the player a visually pleasing experience.

2.3.2 Interaction styles

Many interaction styles exist that can be used for navigation of the software interface (Shneiderman, 1998: 72). The VLS game user interface environment utilizes the direct manipulation style. With direct manipulation tasks and concepts are presented visually. User actions are made explicit through manipulation of objects on the screen. Thus a direct manipulation system has the following features:

- visibility of objects of interest,
- rapid, reversible and incremental actions,
- explicity of actions through manipulation of objects on the screen,
- immediate feed back,
- reversibility of all actions, and
- syntactic correctness of all actions. (Sutcliffe, 1995: 115; Preece et al, 1995: 270)

Shneiderman, (1998: 205) contends that direct manipulation makes a user interface remarkably powerful due to the following merits:

- Novices (users with no previous computer experience) can learn basic functionality quickly, through a demonstration by a more experienced player (learnability).
- Actions can be undone; hence error messages are rarely needed.
- Players can see immediately if their actions are fostering their goals (quick system response).
- Players can gain confidence and mastery because they are the initiators of actions, are in control and can predict the system responses.

2.3.3 User help

User help refers to strategies for offering assistance to players when they are having difficulties. These may include manuals, help files, in-built tutorials, web pages, web tutorials or phone lines to real people. It also involves activities designed to enable players to learn and use systems tools efficiently and effectively in the performance of their work. Hence Dix, et al (1997: 445) emphasises that, whatever form it takes, user help must possess the following requirements:

- Availability: the user needs to be able to access help any time during his interaction with the system (readily available).
- Consistency: users require different types of help for different purposes. This implies that the help system may incorporate a number of parts. The help provided by each of these parts must be consistent with all the others.
- Flexibility: a flexible help system allows each user to interact with it in a way appropriate to his/her needs.
- Unobtrusiveness: the help system should not prevent the user from continuing with normal work nor interfere with a user's application.

However, computer games in general and educational computer games in particular are supposed to be challenging and to have a certain level of difficulty by nature. Therefore, user support, though readily available, must have some degree of controlled access such that it responds only when the player truly needs help.

2.4 Player satisfaction

A system may be technically well organized and extremely effective. However, the way the user reacts to it is equally important. This is particularly true for computer games where, as Jones (1998) observed, the amount of time involved, the obscurity of game patterns, and the difficulty in attaining the end make computer games tedious to some people. Therefore, players need to have an entertaining or moving experience so as not to stop playing the game due lack of motivation. Hence Nielsen (1993: 33) identified subjective satisfaction (a measure of how enjoyable it is to use the system) as especially important for systems (such as computer games) that are used on a discretional basis (i.e. by choice), in a non-work environment.

In an educational computer game environment, motivation may also be due to interest in the content. The interest provides the player with intrinsic motivation to work within the environment. If, however, the player is not motivated by interest in content, then the environment may need to offer greater motivational features to promote the initial interest and also keep the player interested. The factors that have an effect on subjective satisfaction (discussed in the following sections) include feeling of engagement, learnability and comprehensibility, and human diversity.

2.4.1 Player engagement

According to Jones (1998) computer games have the capacity to make the player totally engrossed in the game (engagement). This engagement promotes the initial interest of a player (intrinsic motivation) in the game and continued play. Engagement is defined and described by

Csikszentmihalyi as "flow". According to Rieber (1996), Csikszentmihalyi's Flow Theory of Optimal Experience provides an important framework for adult motivation for learning. Csikszentmihalyi (1990: cited in Rieber, 1996: 52) defines flow as " the state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will do it even at great cost, for the sheer sake of doing it." Accordingly, flow occurs when adults become extremely engaged and absorbed by certain activities and spontaneously 'go with the flow' which is accompanied by a sense of satisfaction (Rieber, 1996).

Rieber asserts that learning activities are more likely to elicit flow if the individual is actively involved in a task and the activities meet one or more of the following:

- Challenge is optimised (the task must be difficult enough to be interesting but not totally frustrating).
- The individual is completely engrossed in the task.
- Clear goals are embedded in the material.
- Clear and consistent feedback is provided as to whether one is attaining the goals.
- The individual feels completely in control.
- All feelings of self-consciousness disappear.
- Time is transformed during the activity (e.g. hours pass without noticing).

According to Jones (1998) components of flow are manifested in computer games through a variety of strategies. These include, among other things, the use of levels of difficulty to optimise challenge. Levels of difficulty provide progressively difficult but not frustrating tasks. Tasks like gathering objects or information or solving puzzles present clear goals that provide players with means of gauging progress. This requires clear and consistent feedback, which is provided by changes in state (for example, zooms, dissolves, fades, opening a door etc) of the game (Jones and Okey, 1995). Attention of the player is absorbed through mastering the controls of the game (such

as mouse movements), which makes the player feel completely in charge, without feelings of reserve.

2.4.2 Learnability and comprehensibility

Learnability refers to ease of learning how to play the game. Nielsen (1993: 27) identified learnability, as 'the most fundamental usability attribute' because the first experience most people get with a new system is that of learning to use it. Hence most systems need to be easy to learn. A system is easy to learn if a user, who has never seen the user interface before (novice user), can quickly learn to sufficiently carry out basic tasks. The ideal novice users are those without any prior computer experience. Nielsen (1993: 30) also observed that users tend to 'to jump right in and start using a system' on their own with out any initial training. Hence on top of being easy to learn, the system must also be easy to use. In practical terms, a system is easy to use if users make few errors while using it. If errors are made, it is be easy to recover from them or undo the action that caused the error. A computer game user interface that is easy to learn and use enables the player to enjoy the game and thus contribute to the subjective satisfaction of the player.

2.4.3 Human diversity

Shneiderman (1998: 67) observed that the understanding of the intended users is one of the fundamental principles of user–engineering. The average user communities are expected to have various combinations of knowledge, skills or experience and usage patterns, in addition to differences in age, gender, personality, culture, disabilities, cognitive, and perceptual abilities (Shneiderman, 1998: 18). Therefore the users' individual characteristics and differences are important issues of usability (Nielsen 1993: 43). This is especially true in South Africa, which has a large cultural diversity and multi-linguistic user base (Murrell, 1998).

One of the basic differences among users stem from their experience or skills with computers (computer literacy)(Nielsen 1993: 43). The experiences users have with computers have two

dimensions, knowledge of general use of computers and knowledge of the task domain addressed by the system (Nielsen 1993: 44).

Computer literacy (in this study) refers to the level of expertise and familiarity someone has with computers. The following levels of computer literacy, identified by Sutcliffe (1995) are used:

- Naïve user with no previous computer experience.
- Novice user with some previous computer experience.
- Skilled user with considerable computer experience.
- Expert user with knowledge of system structure.

In a computer game environment, the players' level of computer literacy is likely to play a significant role in the way the player perceives and benefits from the game. For example the naïve player will have to learn to use the input devices (mouse and keyboard) before learning to play the game.

The task domain that is addressed by the VLS computer interface includes interpretations of graphics (visual literacy). Visual literacy is often dependent on culture, experience and exposure to a specific medium (Amory and Mars, 1994). Also certain graphics and images may be offensive to some players due to cultural or religious grounds (Murrell, 1998). Ideally, the usability evaluation of the VLS game user interface should involve a culturally diverse sample of users. Moreover, as Murrell (1998) noted 'graphics and iconic representations are not universally understood but are culturally learnt'. Hence, graphics and icon symbols should have corresponding labels in order to eliminate ambiguity. Furthermore, one must not presume equal understanding of English (the language used in the VLS game) from all users, especially second language users. Hence the use of idiomatic English and jargon must be avoided (Murrell, 1998).

Another aspect of human diversity is learning style. Kliman, (1999) observed that "Some learners enjoy being presented with problems, others like to pose their own problems; some like to design and invent, others prefer to extend and adapt what others have created; some are motivated by time pressure, others find it distressing". Alternatively, from Gardner's (Gardner, Komhaber, and Wake, 1996: 205) theory of 'multiple intelligences' the following learning styles and their corresponding activities are obtained. Learning through reading (print), through listening (aural), through discussions with fellow students in small groups or on a one to one basis (interactive), through looking at demonstrations, pictures, slides, and graphs (visual), through touching or "hands-on " approach (haptic), through moving or movement (kinesthetic), and through using sense of smell whilst learning (olfactory). The use of multimedia and graphic user interfaces gives developers the potential to include most of these learning styles in the VLS game user interface design (with the exception of the olfactory). Hence the study needs to evaluate the extent to which the VLS game user interface accommodates player differences and preferences discussed above.

2.5 Objectives

2.5.1 Player objectives

One of the main objectives of playing any game is to provide an enjoyable experience to make the player want to play again and again. According to Kliman, (1999) characteristics that good games share include:

- clear goals and rules;
- ease of keeping track of players' progress as they play;
- provide a variety of strategies that the game can be played with (i.e. players can make different choices).

These characteristics were of particular concern in the evaluation of the VLS game user interface because they are required for the game to provide the player with a pleasurable experience.

2.5.2 Computer game objectives

Computer games must also offer an appropriate challenge in addition to the general characteristics of games mentioned above, in order to provide the player with an enjoyable experience. Appropriate challenge refers to tasks that are difficult enough to be interesting but not totally frustrating. For example, action games (e.g. Doom II) require quick reactions to situations in order to keep on playing and win the game. It is keeping up the quick reactions to the game that present a challenging experience. Strategy games (e.g. War Craft II), involve the use of higher order thinking and problem solving skills to continue playing and win the game. The challenge comes from looking at the larger problem, and planning a strategy to solve the problem. Conversely, fantasy games (e.g. Myst) require cognitive effort and are not generally dependent on rapid response. The emphasis is on exploration discovery and the challenge is in acquisition and use of information.

Many computer games available today offer attention-getting graphics, sound, and other special effects, yet these can become tiresome if the game itself is not well structured and appropriately challenging (Kliman, 1999). Hence the objective of computer games is to provide:

- different levels of challenge, so that a player can continue playing as their skills increase
- context, characters, and a story that are appealing to the player
- variety, so that a player can be play repeatedly without getting bored
- clear goals, so that a player can keep track of progress during play.

In educational computer games, the fulfilling of the game objectives does not only present the player with an entertaining and enriching experience, it also provides the motivation for the player to continue playing the game long enough to achieve the desired learning objectives.

2.5.3 Motivation for learning objectives of the VLS game

In order to get insight into the perceived use of educational software, its educational objectives, among other things, have to be looked at (De Paz, Pilo, and Pastorino, 1999). However, as Squires (1997) noted, it is not possible to evaluate an educational software package as an object in its own right; it is only possible to evaluate the actual or perceived use of a package. The learning objectives of the VLS game are rooted in modern educational theories and principles, which are based on constructivist theories (Amory, 2000). Constructivism is a philosophy of learning founded on the assertion that, individuals comprehend the world they live in by reflecting on past experiences. Each individual generates distinctive mental models, which are used to make sense of their experiences (Scott, Dyson and Gater, 1987: 7; Fosnot; 1996: 10).

Constructivists describe learning as the process of adjusting mental models to accommodate new experiences and it takes place through interactions with one's environment. Learning involves individual constructions of knowledge, ability to interact with and adapt to his or her environment (Fosnot, 1996; Rieber, 1996). Rieber (1996) noted that this learning is accomplished through two mechanisms, assimilation and accommodation. Fosnot (1996:13) describes assimilation as the organisation of experience with one's own logical structures or understanding. This refers to the transformation of new information so that it makes sense within the existing knowledge base. Conversely, accommodation comprises reflective integrative behaviour that serves to change one's cognitive structure in an attempt to understand new information. However, Vygotsky (1978) contends that learning occurs in a social context, where an individual learns through problem solving experiences shared with others, for example, family members, educators or peers. The interaction with these social agents exposes the learner to alternative viewpoints. Constructivists contend that all the above aspects of learning are essential for the facilitation and acquisition of knowledge. Hence, constructivists recommend that (among other things) educators should adapt their teaching strategies to accommodate the following objectives::

- promote curricula customized to the students' prior knowledge,
- encourage students to analyze, interpret and predict information, and
- emphasize hands-on problem solving. (Fosnot, 1996: 29).

In order to achieve the above objectives, Rieber (1996) advocates the use of computer-based microworlds or virtual learning environment, such as the VLS game. These have the capacity to provide meaningful learning environments pertaining to the real word through co-operative and individualized environments. The learning contexts should be based on a framework of challenging activities that stimulate curiosity and simultaneously combine fun and instruction (Malone, 1981: cited in Rieber, 1996). Amory (2000: 10) asserts that in the VLS game interface, the principles of constructivism above are accomplished through the creation of virtual learning spaces where, through play, students identify and solve problems through the use of critical and creative thinking. Consequently the motivational objectives of the VLS game, are to provide a learning environment, which is mentally stimulating, stimulate curiosity, combine fun with instruction, provide meaningful contexts, and involve tasks difficult enough to be interesting but not totally frustrating.

2.6 Usability requirements for the VLS game user interface

The principles and theories of user interface design and evaluation discussed in this chapter provided a set of usability requirements for the VLS game user interface. These requirements relate to usability issues of user interface design, and evaluation of how user interface promotes user satisfaction and game objectives as shown in Table 2.1.

Table 2.1 Usability requirements for the VLS game user interface

Usability Issue	Usability Parameters	Usability requirements
User Interface Design	Appearance	Visually appealing
		Aesthetic appearance
		Readable text-based communication
		Does not display irrelevant information
		Use objects, features and concepts familiar to player
	Interaction style	Reversible actions
		Low error rate
		Ease of navigation
		Efficient interface response
		Effective player control
	User support/Help	Readily available help
		Easy to use
		Flexible system
		Unobtrusive to play
Player satisfaction	Engaging	Challenging tasks
		Player in control
		Interesting tasks
		Clear and consistent feedback
	Comprehensible	Easy to learn
		Easy to use
	Equitable	Accommodate gender preferences
		Accommodate both novice and experienced users
		Use simple language
		Use culturally and religiously inoffensive graphics
		Label icon symbols
		Accommodate different learning styles
Objectives	Player objectives	Enjoyable experience
		Clear goals, so that a player can keep track of progress during play
		Keeping track of progress should be easy
	Game objectives	Different levels of challenge, so that players can continue playing as their skills increase
		Context, characters, and a story that are appealing to the player
		Variety, to enable player to play repeatedly without becoming bored
	Motivation for learning objectives	Stimulate curiosity
		Combine fun with instruction
		Provide meaningful contexts
		Provide mentally stimulating activities

These requirements were used to

- extend the scope of the three main research issues upon which the research questions were based, by defining the usability parameters of the VLS game user interfaces in terms their respective requirements.
- design and develop tools and processes to evaluate of the usability of the VLS game user interface.

In addition, these usability requirements were taken into account in the planning and execution of the evaluation of the usability of the VLS game user interface with respect to:

- usability evaluation of game user interface, and
- data reduction and analysis procedures.

Hence, the usability requirements formed the foundation for the choice of research methods outlined in Chapter 3.

2.7 Computer game evaluation methods

2.7.1 Game analysis

Game analysis involved the study of the design, rules and mechanics of a computer-based game. The information was obtained through interviewing the developers (scriptwriters, portal developer, programmer, graphical designer, project manager and project head) of the VLS game and reading the developer's documentation. The game analysis was based on a framework for analysing games proposed by Konzack (2002). This framework is made up seven different layers of a computer game, namely:

1. Hardware refers to the physical nature of the playground (the computer and its components, wires, signals etc) and the computer as a tool, medium, or toy. This was used to describe the minimum system requirements for the VLS game.
2. Program code determines the computers' responses to user actions. It instructs the computer what to do. It is therefore, essential to the understanding of computer games. However, it was not relevant to this study to analyse the VLS game program code since main area of interest of the study was the VLS game user interface.
3. Functionality refers to what the computer application does and its response to user actions or input. According to Konzack (2002) functionality analysis focuses on 'the behaviour of the computer and the computers interface reactions to user input'. Aarseth (1997: cited in

Konzack, 2002) described the functionalities any application may have, as dynamics, determinability, transiency, perspective, access, linking, and user function. Though Aarseth's descriptions to a large extent refer to text-based applications, it is believed in this study that they can be adapted to offer a fair description of a game user interface. Table 2.2 illustrates the (adopted and adapted) version of the functionalities and their variations, which were used to describe VLS game user interface.

Table 2.2 Game user Interface functionalities

	Functionality	**Variations**	
1	Dynamics	*Static* Game user interface arrangement constant	*Intratextonic* Game user interface arrangement change
2	Determinability	*Determinate* Game user interface action always follows another on command	*Indeterminate* Game user interface action do not follow another on command
3	Transiency	*Transient* Mere passing of cursor causes actions to occur	*Intransient* Need to point-and-click for actions to occur
4	Perspective	*Personal* Player performs a premeditated role	*Impersonal* Player performs a spontaneous role
5	Access	*Random access* Readily available to the player all the time	*Controlled access* Not readily available to the player all the time
6	Linking	*Explicit* Links for the player to follow unconditionally	*Conditional* Links active only if certain conditions are met
7	Player function	*Interpretive* Find the semantic meaning of the computer game	*Explorative* Player chooses between different paths through the game

(Aarseth, 1997: cited in Konzack, 2002)

4. Gameplay refers to game structure (positions, resources, space and time, goal, sub-goals, obstacles, knowledge, rewards or penalties) of the computer software application. Konzack (2002) used ludology (the study of games) to document different game factors, which were adopted to describe the VLS game interface structure as follows:
   - Positions: There are two positions from which the VLS game can be observed: audience or players. In this study the researcher took the position of the audience and the participants were the players.

- Resources: Resources refer to means by which the players influenced the game. The resources of the VLS game user interface were images on the screen and the mechanisms (e.g. mouse) of manipulating these images.
- Space: The space was divided into the space of the game, (virtual space) and the playground, space of the real world of the players (for example a computer laboratory).
- Time: This refers to the duration set for the VLS game, the time taken to attain a preconceived goal in the game.
- Goal and sub-goals: The goal refers to objective to be met before proceeding. Sub-goals are stages needed to partially reach the main goal.
- Obstacles: The obstacles are the challenges that prevent players from reaching their goal(s). The evaluation of the VLS game user interface considered how the obstacles built into the game and also the unintended, undesirable obstacles (due problems of design) affected the usability of the interface.
- Knowledge: There were two kinds of knowledge considered in the VLS game. The first is the open knowledge, which is required to use the computer (computer literacy). And the hidden knowledge, which involves the strategies the players use to play the game or the players' own understanding or interpretation of the game.
- Rewards or penalties: Rewards or penalties are the resources, which can be won or lost during the game. In the VLS game, rewards were in the form of information that the player needs to solve puzzles etc.

5. Meaning refers to the semantic meaning of the computer game. It involves the analysis of how signs and narratives (such as pictures, sounds and text) in the VLS game user interface convey different meanings of what happens within the game during play.

6. Referentiality refers to characteristics (signs, ornaments and structures) of the VLS game user interface setting, originally used in other media or games, and which have been incorporated into the VLS game.
7. Social culture refers to the interaction between the VLS game user interface and player(s)

2.7.2 Playing the game

Aarseth (2003) recommended playing the game as a useful method of evaluation of the user interface, because it facilitated:

- understanding of the game mechanics,
- mental interpretation of game design,
- exploration of game rules and
- comprehension of distinctions between functional and decorative design elements in the game.

This method was used in this study to identify areas of the VLS game user interface that cause usability problems for the player. This information was used as basis for the observation of a sample group of players and the problems they encountered.

2.7.3 Observe others play

While gameplay analysis and playing the game are two valid methods of computer game evaluation, Aarseth (2003) argues that for thorough game analysis, drawing on the experience generated by others is crucial, not merely useful. Hence, observing others play was used also as a key method of evaluation of the VLS game user interface, in addition to gameplay analysis and playing the game. This method was very useful in exposing problems and determining their gravity.

2.8 Usability evaluation methods

According to Nielsen (1993) there are three categories of strategies of evaluation, from which selection of appropriate and effective methodologies usability evaluation can be made. These are testing, inspection and inquiry methods. For the evaluation of the VLS game user interface, the following methods were selected on the basis of cost effectiveness, ease of implementation and ability to identify user interface problems:

- Inspection Methods: Heuristic Evaluation,
- Inquiry Methods: Questionnaires and
- Testing Methods: Laboratory Testing

Descriptions of these methods follow in the following sections. Each description involves the theory of the method presented, its positive and negative aspects, as well as a typical form of reporting the results.

2.8.1 Inspection methods

Inspection Methods are methods that rely upon judgment of inspectors (Albion, 1999). Preece, Rogers, Sharp, Benyon, Holland and Carey, (1994: 672) describe usability inspection as a set of highly cost-effective methods for finding usability problems and improving the usability of the user interface design. Usability specialists, software developers, users and other professionals use inspection to examine usability-related aspects of a user interface. The main goal of all inspection methods is to generate a list of usability problems. Various inspection techniques have been described, such as cognitive walkthroughs, feature inspection, heuristic evaluation, and expert reviews (Preece et al, 1995: 672; Nielsen, 1993). For the evaluation of the VLS game user interface, the cognitive walkthrough and heuristic evaluation were used.

2.8.1.1 The cognitive walkthrough

Cognitive walkthrough involves inspection of a user interface by going through a set of tasks and evaluating its ease of learning and comprehensibility. It is 'an effective method for revealing

problems that affect users' overall performance, and it can capture cognitive processes of both novice and expert users' (Reeves and Hedberg, 2003:160). Therefore, the cognitive walkthrough was used to acquaint the researcher with how the game is played. The focus was on uncovering problems that users may have when they first use the VLS game user interface.

The walkthrough was limited to a representative selection of tasks (Appendix VI) based on the results of context of use analysis. The input to the walkthrough included the following features of achievement:

- Learnability: How players know "what effect to achieve":
- Visibility: How players know "an action is available":
- Comprehensibility: How players know "an action is appropriate":
- System feedback: How players know "things are going OK" after an action.

The results of the cognitive walkthrough were given in the form of a cognitive walkthrough evaluation report.

2.8.1.2 The heuristic evaluation

The heuristic evaluation method was selected as its benefits include:

- cheaper and less time consuming than performing actual user tests.
- relatively good at finding most of the serious usability problems.
- easy to learn
- results in problem reports that are better predictors of end-user problems

(Mäki, 2003; 45; Albion, 1999).

However Nielsen (1993) observed that one of the problems with heuristic evaluation is that it is not easy to execute; the evaluator needs to be aware of various factors including human memory capabilities, aesthetics, psychology and so on. Therefore to aid the evaluator in discovering usability problems, a list of heuristics, which can be used to generate ideas while evaluating the

system, was provided. The heuristics used were the interface design heuristics (Nielsen 1994), for the evaluation of basic requirements for usability and educational design heuristics (Quinn, 1996: cited in Albion, 1999). Also, a single evaluator is likely to miss problems in a design, even when using the criteria. In order to avoid this problem, a small team of five evaluators was used to assess the design independently (Nielsen 1993; Virzi 1992; Lewis 1994).

According to Nielsen (1994: cited in Riihiaho, 2000: 32) the procedure for heuristic evaluation has the following steps:

- A pre-evaluation training session, where evaluators are given a brief description of the heuristics and the terminology used.
- Individual evaluations, where each evaluator goes through and inspects the user interface elements. The observer may assist the evaluators in operating the interface.
- A debriefing session if needed.
- Combination of the results of the evaluations and usability problems encountered.
- After the problems are combined the evaluators estimate the severity of each problem.

The heuristic evaluation was used in this study to compile an evaluation report, in the form of a list of usability problems, severity rating for each problem and the heuristics that the VLS user interface violates.

2.8.2 Inquiry methods

Inquiry methods are tools that help us have a deeper understanding of the users' impression of the system. In a usability inquiry, usability evaluators obtain information about users' likes, dislikes, needs, and understanding of the system by talking to them, or allowing them to answer questions verbally or in written form. Examples of inquiry methods include, field observation, focus groups, interviews, logging actual use, proactive field study, questionnaires and interviews (Nielsen, 1993: 207). For the evaluation of the VLS game user interface, questionnaires and interviews were

selected on the basis of cost effectiveness, ease of implementation and ability to identify user interface problems.

2.8.2.1 Questionnaires

Kirakowski (2000) describes a questionnaire as a method for the elicitation, collecting and recording of information. Questionnaires are made up of items to which the user supplies answers or reactions. A questionnaire (the Post test questionnaire, Appendix VII) was used to measure satisfaction of the VLS game user interface. It was used as a part of a usability test (Mäki, 2003: 32). Two types of question structures were used:

- Closed questions; in which the respondents were asked to select an answer from a choice of alternative replies.
- Open questions; in which the respondent was free to provide his/her own answer.

The questionnaire included three different types of questions:

- Demographic questions, for example age, education or working experience etc.
- Opinion-type questions (no right or wrong answers) were used to ask the respondents what they thought about the VLS game user interface.
- Attitude questions which focused on respondent's likes and dislikes. (Mäki, 2003: 32)

Advantages of a questionnaire (considered relevant in this study) include the fact that it is quick to administer, to score and to gather a quantity of data. It is therefore cost effective. Also the users' point of view is very important in determining user satisfaction.

The following methods were used to analyse the results of questionnaires:

- Quantitative analysis, for closed-ended questions and
- Qualitative analysis of comments and explanations.

The questionnaire results, in the form of a tabulated and graphical representation of the quantitative summaries and a summary of the main points found in the qualitative analysis, were presented in a questionnaire report.

2.8.2.2 Interviews

According to Percival and Ellington (1984: 121), interviews are a verbal form of questionnaire. However interviews are used to explore specific areas of interest identified from the written questionnaire. Interviews allow the questioning of users about their preferences and opinions concerning the product, according to a predetermined plan. They are useful in identifying areas that need more detailed analysis; hence they are used in conjunction with other usability engineering methods, such as usability tests (Mäki, 2003: 30). Usability issues covered by interviews are effectiveness and satisfaction (Nielsen, 1993; Fowler and Mangione, 1990).

The interview method was beneficial in this study as it was used to enable the VLS project staff to voice their expectations from the VLS game user interface. Thus, it was used to obtain detailed information about the VLS game structure features and characteristics of the VLS game user interface. In order to avoid asking leading questions, which are a major limitation of interviewing (Mäki, 2003: 31), a predetermined set of questions (Appendix I) was used.

2.8.3 Testing methods

Testing strategies are techniques that can be used to obtain quantitative data about test participants' performances. The quantitative data can be used for comparative testing or testing against predefined benchmarks. Examples include, coaching method, co-discovery learning, performance measurement, question-asking protocol, remote testing, laboratory testing, retrospective testing, shadowing method, teaching method, and thinking aloud protocol (Nielsen, 1993). For the evaluation of the VLS game user interface, laboratory testing was selected because of the following benefits:

- Laboratory testing allows for evaluation of number of usability attributes, including: learnability, comprehensibility and ease of use, efficiency, and user satisfaction.
- Detailed player feedback could be obtained quickly and at little expense.
- The method involved the experiences of actual players, working on the game to accomplish realistic tasks.

2.8.3.1 Laboratory testing

Laboratory testing is used to obtain the quantitative data for comparison against predefined requirements. It is conducted in a formal setting (in a usability laboratory or otherwise) so that the data can be collected accurately and possible unexpected interference minimized. Representative users work on typical tasks using the system (or the prototype) and the evaluators use the results to see how the user interface supports the users to do their tasks. (Nielsen, 1993; Rubin, 1994: 50)

According to Nielsen (1993) and Rubin (1994: 213) the procedure of conducting a formal usability laboratory test has three main steps:

1) Define the goals for the usability testing in terms of usability attributes. The various parts of the goals must be balanced and ordered according to their relative importance.
2) Conduct the test in a usability laboratory. The environment is controlled in such way that chances of unexpected interruption during the test are minimised. When possible, the test should be video-recorded to support data collection and verification after the test by reviewing the video recording.
3) Analyse the data and draw conclusions. To compare with a benchmark value, mean or median can be calculated, together with standard deviation, standard error of the mean, and the confidence intervals.

2.8.3.2 Qualitative analysis of usability problems

The quantitative analysis of the results can also be supplemented by a qualitative analysis of the usability problems that have been found. Riihiaho (2000: 33, citing Nielsen, 1994) noted that the analysis of a usability problem must take into account a combination of three factors:

- Frequency at which the problem occurs (can it be regarded as common or rare?).
- Impact of the problem (will it be easy or difficult for the users to overcome?).
- Persistence of the problem (is it a one-time problem that users can overcome once they know about it or will users repeatedly be bothered by the problem?).

In addition, Reeves and Hedberg (2003: 284) recommend the use of the scales below to determine the extensiveness and severity of each problem.

Extensiveness Scale:

1. A single case problem.
2. Problem occurs in several places.
3. Problem is widely spread.

Severity scale:

1. Cosmetic problem: need not be fixed.
2. Minor problem: fixing it is given low priority.
3. Major problem: important to fix.
4. Usability catastrophe: imperative to fix

2.8.3.3 Number of test users

According to Nielsen and Landauer (1993: cited in Nielsen, 2000) the number of usability problems found in a usability test vary exponentially with the number of users tested. Nielsen and Landauer also demonstrated that five is the optimal number of test users. Similarly, Basson (2001), and Kunjavski (1998) explain that the first five test users expose most of the problems, which are to be seen. Another point demonstrated by Nielsen and Landauer is that, at least fifteen users (from a single group) are needed to discover all the usability problems in the design. Therefore, thirty players were considered suitable to cover the categories, novice vs. expert users and male vs. female, of test participants.

2.9 Usability evaluation methods for the VLS game user interface

The usability evaluation methods discussed above were matched with the usability requirements for the VLS game user interface to form a matrix of research questions and methods in Table 2.3.

Table 2.3 Matrix of research questions and methods

Usability Issue	Research questions	Methods				
		Usability context analysis **Appendix I**	Cognitive walk through **Appendix II**	Heuristic evaluation **Appendix III**	Usability test **Appendix IV ,V &VI**	Post-test questionnaire **Appendix VII**
Interface Design	To what extent does the VLS game user interface colour, graphics and metaphor facilitate the acquisition of correct information through • visually appealing graphics, • not displaying irrelevant information, • using objects, features and concepts familiar to the player, and • consistent display format across displays?		✓	✓		✓
	To what extent does the VLS game user interface interaction style facilitate • fast response to player input actions, • reduction of errors, • recovery from errors, and • player control?		✓	✓	✓	
	To what extent is the VLS game interface help • accessible to players? • easy to use? • flexible? • unobtrusive?		✓	✓	✓	
Player satisfaction	To what extent the VLS game interface provide players with extrinsic motivation in form of: • challenging tasks, • interesting tasks, • levels of player control, • clear consistent feedback and • an enjoyable experience?			✓	✓	✓
	How fast can a user, who has never seen the VLS game user interface before, learn it sufficiently well to accomplish basic tasks?		✓	✓	✓	
	Once a player has learned to use the VLS user interface, how fast can he or she accomplish a specified task?		✓	✓	✓	
	To what extent does the VLS game interface accommodate • gender preferences? • experiences of players in computer-use? • experiences of players in computer games? • disparities in player educational background?			✓	✓	✓
Objectives	To what extent does the VLS game interface provide the player with • an enjoyable experience? • clear goals, to enable tracking of progress during play? • easy means of keeping track of progress?.	✓		✓	✓	✓
	To what extent does the VLS game interface, present players with • various levels of challenge, to enable continued playing as skills increase? • context, characters, and a story that are appealing to the player? • variety, to enable player to play repeatedly without getting bore?	✓		✓		✓
	How effective is the VLS game interface in enhancing the learning experience? • Does it stimulate curiosity? • Does it provide meaningful contexts? • Does it combine fun with instruction? • Does it provide mentally stimulating activities?	✓		✓	✓	✓

This matrix formed the basis for the design and structure of the research methods. These methods are presented in more detail in chapter 3.

CHAPTER 3 RESEARCH METHODOLOGY

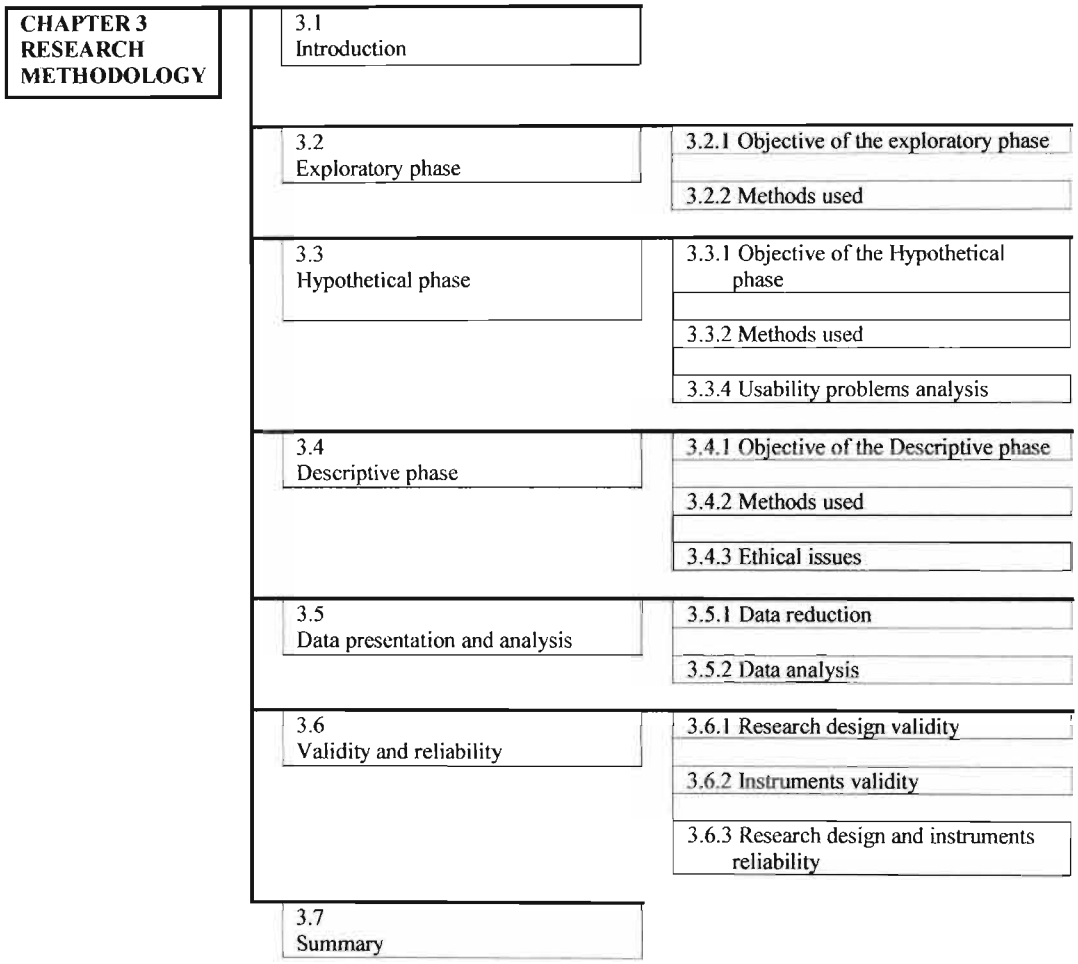


Figure 3.1 Outline of chapter 3

3.1 Introduction

The evaluation of the VLS game involved a variety of methods carried out in three phases (Table 3.1), namely exploratory, hypothetical and descriptive, based on the computer game evaluation methods described in Chapter 2.

Table 3.1 Summary of data collection procedures and instruments

	Phase	Objective	People	Method	Instruments
1	Exploratory **Game analysis**	Identify and define: •Target users •Tasks •Equipment and environment of use	VLS project staff: Programmer, graphical designers, and project head.	Context of use analysis	Semi-structured Interview **(Appendix I)** Design documents analysis
2	Hypothetical **Play the game**	Acquaint the researcher with: •How the game is played Problems that 1st time players may have •Visibility of system status •System feedback •Learnability •Comprehensibility	Researcher	Cognitive walkthrough	Cognitive walkthrough **(Appendix II)**
		Identify potential usability problems: •Compile a list of usability problems. •Severity rating for each problem. •Heuristics that the VLS user interface violates.	Researcher and five other experts	Heuristic evaluation	Heuristic evaluation **(Appendix III)**
3	Descriptive **Observe others play**	Get data about test players' performance: •Task time •Usability problems •Impact of the problem •Persistence of the problem Evaluate usability attributes including: •Learnability •Comprehensibility (ease of use) •Player satisfaction.	Sample from target group	Usability testing	Background questionnaire **(Appendix IV** Observation instrument **(Appendix V)** Test tasks **(Appendix VI)**
		Determine usability problems from user point of view	Test participants	Post-test questionnaire	Post-test questionnaire **(Appendix VII)**

More details about these methods are given in the following sections.

3.2 Exploratory phase

3.2.1 Objective of the exploratory phase

The objective of this phase was to obtain detailed information about the VLS game structure. The areas of interest included the features and characteristics of the VLS game user interface, the goal(s) of the game, tasks to be done, and actions that need to be taken in order to achieve these goals. This information was necessary to ensure that the circumstances under which the game was evaluated, matched the intended circumstances of eventual use. The sources of information were documentation on the design of VLS game and the developers of the VLS game. This included the VLS project staff; i.e. programmer, graphical designers, and project head.

3.2.2 Methods used

In order to achieve the objectives of this phase, the researcher spent a week with VLS project staff, at the project laboratory. During this time, the researcher studied documents used in the planning and designing of the VLS user interface. This included a paper-based analysis of the documents (deconstructed story) on design of *In the Service of humanity* portal, the portal evaluated in this study. This phase also involved a semi-structured interview (Appendix I) with designers and game developers for their opinions and understanding of the VLS game user interface.

A simplified Usability Context Analysis (UCA) (Bevan, 1997) was used to examine the findings from this phase. UCA was used to determine the key features of the VLS game user interface. Results of this preliminary study, in the form of a context of use description, were used to define the parameters of the game, namely:

- goal(s) of the game,
- tasks to be done, and
- actions needed to play the game.

3.3 Hypothetical phase

3.3.1 Objective of the Hypothetical phase

The hypothetical phase was used to acquaint the researcher with how the VLS game user interface is used and to understand game mechanics and explore game rules. The objective was to find out areas that may present usability problems of the game user interface. This phase involved the examination of usability related aspects of the game interface with respect to functionality and gameplay.

3.3.2 Methods used

For the evaluation of the VLS game user interface, the following inspection methods were used:

- Cognitive walkthrough (as described in section 2.8.1.1), and
- Heuristic evaluation (as described in section 2.8.1.2) of the VLS game user interface.

The walkthrough was limited to a representative selection of tasks (Appendix VI) based on the results of context of use analysis. The key features of the walkthrough were, visibility, learnability, comprehensibility and feedback of the VLS game user interface. In addition, the cognitive walkthrough of the VLS user interface was used to evaluate gameplay using game analysis described in section 2.7.1.

The Heuristic evaluation was used to carry out a systematic inspection of the VLS game user interface. During the inspection, five evaluators, individually, went through selected tasks (Appendix VI) as they inspected the user interface elements. The researcher assisted the evaluators in operating the interface. Each evaluator was then requested to use a paper-based Heuristic evaluation questionnaire (Appendix III) to scrutinize the VLS game interface and to identify potential usability problems. The chosen evaluators were:

- Mature (25 years and above)
- Good background in user interface design (digital media students or graduates)
- Skilled computer users
- Experienced in playing computer games

The results of this phase were a Cognitive walkthrough evaluation report and a Heuristic evaluation report (see chapter 4). These results were used to compile a list of potential usability problems with which the usability test results were compared.

3.4 Descriptive phase

3.4.1 Objective of the descriptive phase

In the descriptive phase, the focus was on how a sample group of members from the target group do a representative selection of tasks (Appendix VI). The objective of this phase was to observe how players from the target group interact with the VLS game user interface and note any faults or problems, which may hinder proper functioning of the VLS game user interface. This was done in an experimental setting, where observational sessions were held (Nielsen, 1993).

3.4.2 Methods used

This phase had two sections, the usability test, followed by a post-test questionnaire (Appendix VII). The usability testing was used to obtain the quantitative data for comparison against predefined requirements. It is conducted in a formal setting (preferably in a usability laboratory) so that the data can be collected accurately and possible unexpected interference minimized. According to Rubin (1994), an ideal testing laboratory requires the following equipment and resources:

- Stand-alone computers or computer network on which the game is installed.
- Application software that enables the tester to view the participant's screen during the test.
- A video camera to record the participant's actions and facial expressions.
- Application that can record, and replay the recorded screen series.
- Speaker telephone for the participant to communicate with the tester.
- Voice recording to record the verbal activities during the test.
- Journal software to guide and log the usability test session.

In this study due to limited resources and the need for portability of equipment, a simpler portable laboratory was set up as shown in Figure 3.2 and Figure 3.3

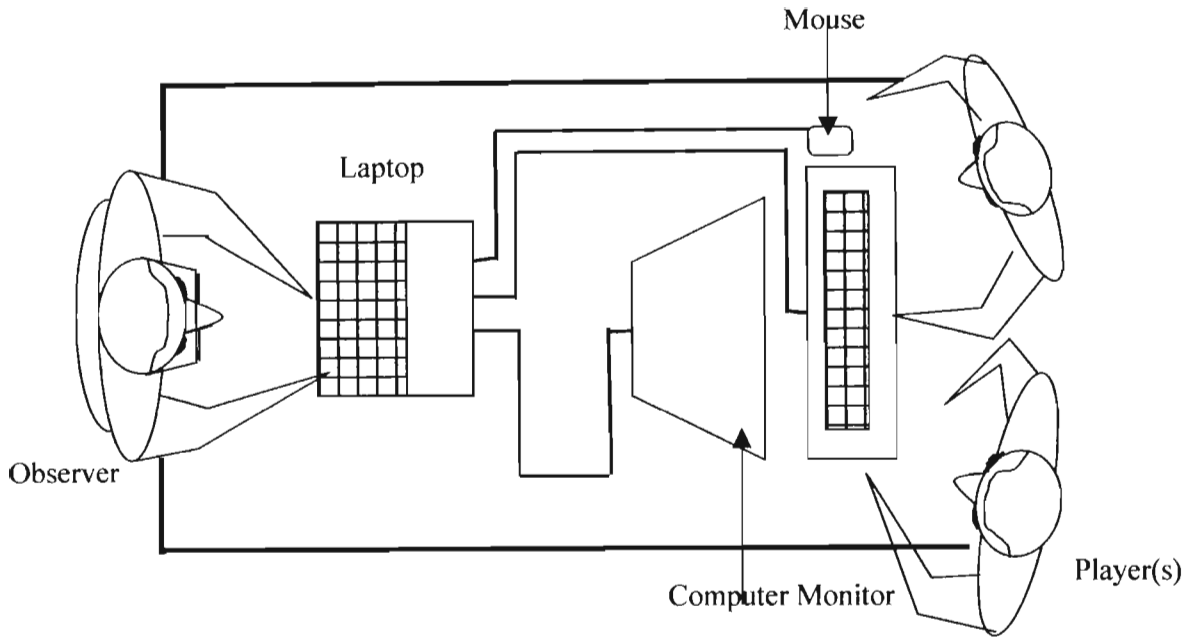


Figure 3.2 Mobile Laboratory set up and equipment

The mobile laboratory consisted of the following equipment:

- The game was installed on a stand-alone computer, Acer Aspire 1600 Laptop. Its specifications were: 512 MB of RAM, Intel Pentium 4 CPU (2. 66MHZ), with multi-tasking capability, which enabled the game to be played and at the same time record the audio activities of the players through a USB microphone.
- Extra external USB mouse, USB keyboard and monitor were connected to the computer for the players to use. This arrangement enabled the observer to see what was happening on the player's screen (external monitor) during the test by looking at his own (laptop) screen, which displayed the same information. Unfortunately, it could not record and replay the participant's screen series because the graphics resources of the computer could not be shared between the game and screen capture software.
- It was not necessary to install a speaker telephone for the players to communicate with the observer since they were sitting close to each other (Figure 3.3).

- A working space (table) of 1m by 2m was found to be adequate to accommodate all the equipment.

Figure 3.3 Mobile Laboratory equipment in use

The usability test was conducted using the mobile laboratory described above. The mobile laboratory was set up in a classes specially requested from the principals of the two schools involved in the study. Only the test participants were allowed into the classroom so as to minimise the chances of unexpected interruption during the test. The test schedule (Table 3.2) was used to make the testing orderly. The test participants worked together two at a time to make it more natural for them to talk during the test, as suggested by Nielsen (1993: 198). They were asked to work through a set of test tasks (Appendix VI). The researcher made observations and used the observation instrument (Appendix V) to note down problems encountered by the participants and duration of each task.

Table 3.2 Test schedule and materials

	Test activity	Test materials
1	Reception of the participant, introduction of the observer, and the test background.	
2	Introduction of the test procedure and informal browsing of the game	Background questionnaire (Appendix IV)
3	Test	Observation instrument (Appendix V) Test tasks (Appendix VI)
4	Post-test questionnaire	Post-test questionnaire (Appendix VII)

The target population of the VLS game was the youth in first the year of university or final year of high school. A two-stage purposive sampling was used to choose the students who participated in the usability test. In the first stage, two high schools in East London, Eastern Cape province were chosen. These schools were chosen because they were accessible to the researcher in that the researcher was a staff member of the first school and a parent in the second school while they served scholars from the same geographical area. They were also useful features for comparing and contrasting. For example, the first school had no computer laboratory and the students had little or no computer experience. Therefore the students from this school were considered a good baseline sample. The second school had a fully equipped computer laboratory and the students learn to use computers from their first year of secondary school thus all were skilled computer users. Hence this school was chosen to include, in the sample, students with computer expertise. The students from the schools were considered useful in the investigation of similarities or differences in the way the naïve and skilled computer users would respond the VLS game. In addition, the schools together provided a heterogeneous sample with characteristics (age, gender, academic training and background) similar to those described in the VLS game evaluation criteria guidelines. In the second stage, volunteer sampling was used to select students from each school when the researcher offered them a chance to test the VLS game. The target number was thirty participants (fifteen from each school), but due to problems of absenteeism on the days the test was conducted, the final number of participant was twenty-six.

A debriefing session followed each usability test to facilitate clarity of problem areas. The objective was to collect more detailed, in-depth information to clarify activities observed (Nielsen, 1993). The debriefing took place after the usability test, when participants were given a post-test questionnaire (Appendix VII) to complete.

The results of this phase was given in two reports (see chapter 4):

1. The usability test report which included:
    - Description of the test, including descriptions of participants, tasks and methods used as well as the goals of the tests.
    - Summary of the results of the data collected from the test observations.
2. The post-test questionnaires report, which included
    - quantitative summaries of results,
    - supported by qualitative comments from the participants.

3.4.3 Ethical issues

Ethical issues concern the right for all the people involved to be fully aware of the reasons for the project and the part they play. The following ethical issues were given special attention in this study to ensure smooth running of the tests.

The researcher had to:

- Obtain informed consent from all participants.
- Ensure that all participants participated voluntarily, and may withdraw at any time.
- Be open and honest in dealing with other researchers and participants.
- Fully explain the research in advance, and 'de-brief' participants afterwards.
- Maintain confidentiality at all times. (Rubin, 1994:169; Nielsen, 1993: 182)

3.5. Data presentation and analysis

3.5.1 Data reduction

The compiling and summarizing of results was done concurrently with the test session. According to Rubin (1994: 259) this technique can be used to

- speed up overall analysis process,
- check that data, matching problem statements was collected,
- see if something important had been missed,
- understand what was collected before moving on,
- record events that happened during the test while still fresh in one's mind.

This technique was used to compile the summaries of:

- Demographics (from background questionnaire),
- Task timings, and
- Problems; nature, extent and frequency. (Rubin, 1994: 259)

These are outlined in chapter 4.

Quantitative and qualitative data reduction was done according to recommendations given by Rubin (1994: 265).

- Limited choice items; answers were collated to show the number (frequency) of participants who selected each possible choice.
- Explanations and comments were carefully analysed to determine the nature of the participants' experiences.

3.5.2 Data analysis

SPSS 12.01 (2004) software was used to determine the minimum, maximum and mean values of the participants' age and task timings. It was also used to analyse the participants' responses to each item of the post-test questionnaire in terms of frequencies, percentages and the Mean Likert value (Lv) of each post-test questionnaire item response. These were used:

- To analyse the responses for each of the six usability requirements; appearance, interaction style, user help, engagement, comprehensibility, equitability, player objectives, game objectives and motivation for learning objectives.
- To compare how (differences or similarities) each group (i.e. female-male; naïve-novice-skilled computer user; and computer game experience) answered each question by comparing their Mean Likert values.

The analysis of the qualitative data was performed by triangulation through comparison of the multiple data collected through heuristic evaluation, observations made during the usability testing, explanations/comments from the post-test questionnaire. The focus was on:

- Tasks that did not meet the criterion that 70% of participants successfully complete a task.
- Post-test questionnaire items that did not meet the criterion that 70% of participants gave a positive response.
- User difficulties that caused poor performance.
- Type of error and its source.
- Differences between performances of players from the following groups: male and female, naïve, novice and skilled (as defined on page 26) in computer use. (Rubin, 1994: 272)

3.6 Validity and reliability

As in most research, it was considered necessary to do a validity and reliability assessment in order to draw justifiable conclusions about the suitability of the research design and instruments in measuring the intended variables and ensuring reasonable subsequent use. In this study:

- Validity refers to how well a research design or instrument measures what it is intended to measure (Hargis, 1995: 150; Percival and Ellington, 1984: 101).
- Reliability refers to stability or consistency of measure over time, under different but comparable conditions (Mouton, 1996: 111; Percival and Ellington, 1984: 101).

3.6.1 Research design validity

Imenda and Muyangwa (1996: 99) stress that, in order to make the results of the research study reliable and easy to generalise, the researcher should always take cognisance of the following major aspects of research design:

- Internal Validity, which implies the extent to which extraneous variables have been prevented from affecting the outcome of a study.
- Ecological Validity, which implies the extent to which findings of the study can be generalised from the set of environmental conditions created in the study to other environmental conditions.
- External Validity, which implies the extent to which the findings of a study can be generalised to related areas of study within the same field.
- Population Validity, which refers to the extent to which the findings of a study can be generalised from a specific sample to a larger population. This is used only if probability-sampling technique is used. Therefore was not appropriate for this study.

In this study research design validity was achieved through the controls shown Table 3.3

Table 3.3 Research design validity (Imenda and Muyangwa, 1996: 99)

	Aspect	Factors	Control
1	Internal Validity	Expertise	Variety of sample group including naïve, novice and skilled computer users.
2	Ecological Validity	Disruptions	Controlled laboratory environment
3	External Validity	Population	Representative sample in terms of age, educational back ground and gender.

3.6.2 Instruments validity

Instruments Validity seeks to ascertain the extent to which a given instrument addresses the idea and construct the researcher wishes to measure (Imenda and Muyangwa, 1996: 129). In this study, content and construct validity was aimed at. Content validity; refers to the extent to which the content of interest is covered by a particular measurement instrument (Imenda and Muyangwa, 1996: 129). Whereas construct validity concerns the degree to which an instrument relates with particular theoretical concepts (Imenda and Muyangwa, 1996: 132). In this study instruments validity was achieved by adopting the style and structure of other already standardized instruments, which included Nielsen's heuristics, System Usability Scale (SUS) questionnaire and System Usability Measurement Instrument (SUMI). The resultant instrument (Post-test questionnaire, Appendix VII) was also given to experts for appraisal. Another approach used to augment validity, was a pilot test. The pilot test was conducted with ten participants. Its purpose was to make sure that the tools and the techniques for data collection worked well and to determine where revisions were needed. In addition, the pilot test was used to assess the test tasks with respect to clarity of instructions and duration of each task (Riihiaho 2000; 21). In order to enhance external validity, the pilot test sample included both male (6) and female (4) players with different computer experiences (naïve, novice and skilled) in addition to the twenty-six used in the full test. Also, usability reports (presented in chapter 4) include a detailed description of a context of evaluation, listing the types of users, the tasks performed and the environment in which the evaluations took place. This information allows other people to assess the validity of the measurements. This gives

them the opportunity to use the results of this study in future usability evaluations of the game as it develops (Thomas and Bevan, 1996).

3.6.3 Research design and instruments reliability

Research design reliability was enhanced by triangulation of results from the heuristic evaluation, laboratory testing and post-test questionnaire (Mouton, 1996: 156).

Hargis (1995: 143) contends that there are three ways of looking at instruments reliability:

- Test-retest reliability: This denotes the degree of confidence that can be placed in a test to give the same results for the same sample participants, if the test is administered more than once.
- Interrater reliability: This signifies the confidence that can be placed on the judgment of test scorers to be consistent.
- Internal consistency: This indicates the confidence that can be placed on a test's items to be measures of the same thing.

The test-retest reliability was not appropriate in this study because only one test was done. Hence it was difficult to satisfy the time-span between the two administrations of the test requirement. The interrater reliability involves instruments that require examiner judgement, such as educational tests. Therefore, it was not relevant in this study. The computation of internal consistency reliability, which is a done when only one administration of a questionnaire is possible and the scale used is a rating scale, was appropriate for this study. But the sample size ($n = 26$) was not sufficient to permit a proper statistical analysis. Despite this limitation, instruments reliability was enhanced through raising only one issue at a time in each questionnaire item (Percival and Ellington, 1984: 102). For example, under User Interface design, the parameter "appearance" has five usability requirements (see Table 2.1). From each of these requirements one item was created

in the post-test questionnaire (Hargis, 1995: 146). Hence the final post-test questionnaire had a total of thirty-six items.

3.7 Summary

A series of data collection methods comprising, a Cognitive walkthrough, Heuristic evaluation, Usability testing and Post-test questionnaire, were used in this study. The results generated by the research methods outlined above are presented in Chapter 4.

CHAPTER 4 RESULTS OF THE STUDY

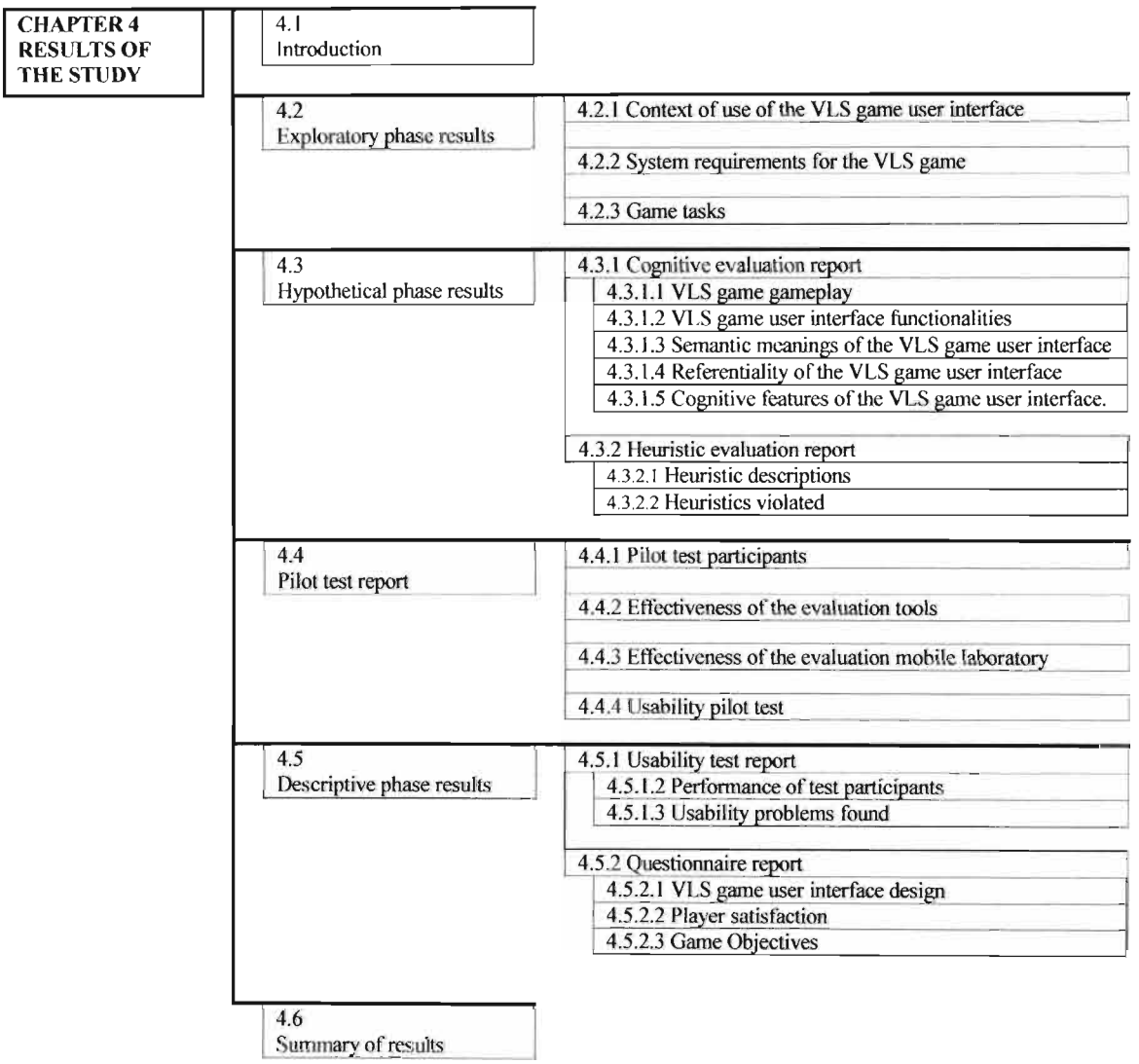


Figure 4.1 Outline of chapter 4

4.1 Introduction

This study involved the evaluation of the usability of VLS game user interface and its support for educational objectives. The evaluation involves a description of the anticipated context or circumstance of use of the VLS game user interface. This is followed by qualitative analysis and interpretation of the results from the cognitive walk through and heuristic evaluations. Using these as a foundation, the findings of the usability test are presented.

4.2 Exploratory phase results

The objective of this phase was to obtain detailed information about the VLS game user interface characteristic that included, tasks to be done and actions that need to be taken in order to accomplish tasks.

4.2.1 Context of use of the VLS game user interface

The proposed title of the VLS game is GammaKhozi. The purpose of GammaKhozi is to enhance learning about a specific domain of knowledge through personal exploration and discovery. The emphasis is on knowledge acquisition and not action. Therefore, the player needs careful observation and understanding of the scenarios presented by the game.

This section describes the features and characteristics (tasks and actions) of the VLS game user interface at the time of evaluation. It is a comprehensive portrayal of the stage of development of the VLS game user interface as described by the members (described in Table 4.1) of the VLS project.

Table 4.1 Participant profiles

	Gender	Age	Academic	Position	Computer use experience	Computer game experience
1	Male	55	Professor Digital media	Project head	Expert	Expert
2	Male	29	Postgraduate student Masters of science	Programmer	Expert	Experienced
3	Male	30	Postgraduate student Masters of science	Graphic artist	Expert	Experienced
4	Male	27	Postgraduate student Masters of science	Story line developer	Expert	Experienced

4.2.2 System requirements for the VLS game

According to observations of the VLS staff, the computer system requirements for the optimal operation of the VLS game are as shown in Table 4.2

Table 4.2 System requirements for the VLS game

	Components	Requirements	
		Minimum	Preferred
1	Memory	128Mb	256Mb
2	Processor	Pentium III	
3	Processing speed	1.5Mhz	
4	Operating platform	Win98	WinXP
5	Driver	Directrix 8	
6	Graphics	3D	
7	Storage space of tested version	16.0 KB	

The game is to be played in a single machine mode, where the players play independently or in a networked mode in a university or school computer laboratory, where there could be some interaction with other players.

4.2.3 Game tasks

From the descriptions of player activities by the VLS project personnel; five types of tasks were identified. These are shown in Table 4.3 together with their corresponding subtasks and actions that need to be taken in order to accomplish tasks.

Table 4.3 Game tasks

	Task s	Sub tasks	Actions
1	Creating a persona	Dressing and saving a persona.	Point and click
2	Navigation	Move persona from one place to another (*Inner City*).	Moving the cursor
		Explore and navigate the virtual environment (*Portal*)	Point and click
3	Interact with virtual actor and *Help Agent*	Communication with the virtual actor	Typing
4	Solving a puzzle	Complete or fill in puzzle	Point and click
5	Identify sources of information	Observation	

These tasks were used to design the test tasks (Appendix VI), on which the Cognitive walk through, the Heuristic evaluation and the Usability test were based. The task of creating a persona had been tested before, since there was no improvement on this aspect, it was not included in the Usability test. Aspects of the test tasks of the VLS game were evaluated using usability measures and requirements in Table 2.1 (page 31)

4.3 Hypothetical phase

The hypothetical phase was used to acquaint the researcher with how the VLS game user interface is used and to understand game mechanics and explore game rules. The objective was to find out areas that may present usability problems during the use of the game user interface.

4.3.1 Cognitive evaluation report

The Cognitive walkthrough involved the inspection, by the researcher (Table 4.4), of the VLS game user interface to evaluate its visibility, learnability, comprehensibility and feedback mechanisms. The aim was to identify areas of the VLS game user interface that may present usability problems to a player.

Table 4.4 Researcher's profile

	Gender	Age	Academic	Computer experience	Computer game experience
	Male	49	Masters student (Digital media)	Experienced	Average

The walkthrough was based on a framework for analysing games proposed by Konzack (2002) (see section 2.1, page 32). This involved analysis of the VLS game user interface with respect to:

- Gameplay,
- User interface functionalities,
- Semantic meanings (of signs and texts) and
- Referentiality

It was however limited to a representative selection of tasks as given in Appendix II.

4.3.1.1 VLS game gameplay

The main task required during gameplay is to explore and navigate the virtual environment. This requires the player to move the cursor by moving the mouse and using mouse point-and-click at hot spots to move forward. The player manipulates the game or images on the screen through mouse point-and-mouse click actions. However, the only means to communicate with the virtual

actors and *Help Agent* is through typing on the keyboard. Hence problems may arise due lack of the three kinds of skills required to play the game:

- cursor (mouse) movement and control,
- recognizing the hot spot, and
- typing.

The player is also the judge of his own success and sets his or her own pace. Therefore game duration (time) is dependent on the user. This implies that the VLS game user interface does not contain any time-constrained actions.

The goal, in terms of what is needed to win the game, was not clear because the game was not complete. Nevertheless, it was noted that the sub-goals, needed to partially meet the main goal, were to find clues, which are used to solve the puzzle. These clues are the rewards of the game; hence they are a form of measurement of success. Possible source of problems are:

- failing to identify an object as a possible clue or source of information, and
- navigation.

Hence in order to investigate these problems, the usability test included a task, which required searching for objects that may provide clues or sources of information (see Appendix VI, task 3).

4.3.1.2 The VLS game user interface functionalities

Study of the VLS game user interface responses to player actions or input revealed the interface reactions or functionalities to player input as shown in Table 4.5.

Table 4.5 The VLS game user interface functionalities

	Functionality	Observation	Deduction
1	**Dynamics**: Game user interface arrangement: - *Constant* = Static, Change = *Intratextonic*	VLS game user interface structure (see Figure 1.5) does not change during play	VLS game user interface is Static (though the game itself is dynamic) therefore it is easy to learn.
2	**Determinability** Game user interface action follows another on command = *Determinate* Or without command= *Indeterminate*	VLS game user interface actions respond to player input in the form of mouse movement or mouse clicks.	VLS game user interface actions are determinate, therefore player is in control
3	**Transiency** Mere passing of cursor causes actions to occur = *Transient* Need to point-and-click for actions to occur = *Intransient*	The player has to move the mouse to "look" around or to mouse point-and-click at a hot spot to move forward/choose an object (in portal) or to move avatar (in Inner City).	VLS game user interface is Intransient; therefore results player's actions/input are clearly visible.
4	**Perspective** Player performs a premeditated role = *Personal* spontaneous role = *Impersonal*	Player performs a premeditated role as the explorer	VLS game user interface perspective is Personal
5	**Access** Readily available = *Random* access Not readily available = *Controlled* access	There is no controlled access to the VLS game user interface.	VLS game user interface accessibility is Random
6	**Linking** Links for the player to follow unconditionally = *Explicit* Links active only if certain conditions are met = *Conditional*	Links for the player to follow unconditionally	VLS game user interface linking is Explicit
7	**Player function** Find the semantic meaning of the computer game = *Interpretive* Player chooses between different paths through the game = *Explorative*	Player has a opportunity to investigate different paths or situations during the game	VLS game user interface player function is Explorative

The VLS game user interface metaphor is to mimic life as closely as possible such that the difference between fantasy and real life is blurred. However, the exploration function of the VLS game user interface requires a player to be patient and systematic. This might be problematic to regular computer game players who are used to fast action type games.

4.3.1.3 Semantic meanings of the VLS game user interface

The VLS game user interface contains a number of signs and texts that represent actions that are crucial to the usability of the VLS game user interface. Table 4.6 and shows the interface signs and text that were identified during the cognitive evaluation and their corresponding meanings.

Table 4.6 Semantic meanings of signs and text

Signs and Text	Meaning
▼ This is found in the close up pictures of sources of important information 	Return or move back Go out our the current interface (picture) into the main interface
✕ This is found in the communication with virtual actor interface 	Close Bring the communication with the virtual actor to an end
✕ This is found in the primary commands icons 	Exit Stop playing and go out of the game
? This is found in the primary commands icons 	*Help Agent* Meaning inquiring or questioning.
Send This is found in the communication with virtual actor interface 	Convey typed communication or massage to virtual actor

The player failing to ascribe the correct meaning to these signs and text may cause unnecessary delays as the player adopts a trial and error strategy. Therefore it was decided to investigate this further by observing whether or not players experience problems with these signs and text during the usability test (see section 4.5.1).

4.3.1.4. Referentiality of the VLS game user interface

The referentiality of the VLS game user interface refers to characteristics (concepts, structures, and signs) originally used in other media, games or settings, and which have been incorporated into the VLS game. For example, according the VLS project staff, the game model of *gathering information through exploring and following a non-linear story* is based on the fantasy game *Myst.* Also the VLS game user interface structure (Figure 1.5, page 8), and the signs and text (Table 4.6) are based on standard, universally accepted conventions and principles of Human Computer Interaction (HCI) design. The contention here lies in whether the target player (final year high school/first year university, 17 to 20 years old) is familiar with these concepts, structures and signs.

4.3.1.5 Cognitive features of the VLS game user interface

The inspection of the VLS game user interface while doing the test tasks revealed that the interaction between the player(s) and the VLS game user interface involve the following features of achievement:

- Learnability: Players know "what effect to achieve" through training on how to play the game.
- Visibility: Players know "an action is available" because the interface provides a prompt that connects the action to what player wants to do. For example, change of colour of cursor during navigation and pop-up screen, for communication with virtual actor.
- Comprehensibility: Players know "an action is appropriate" through visual effects that connect the action to what a player is doing and through experience, as the player learns the game.
- System feedback: Players know "things are going OK" after an action by visual changes such as zooms or pop-ups and fades that show the player the effect of his or her actions (e.g. moving forward). They also recognize a connection between the interface response and what the player was trying to do. For example, when doing the puzzle, the player chooses a letter by clicking on it, and the chosen letter changes colour to green.

4.3.2 Heuristic evaluation report

The Heuristic evaluation involved the inspection of the VLS game user interface to identify potential usability problems. A selection of five, postgraduate digital media students (Table 4.7) was used in the heuristic evaluation because they had a good background in user interface design from their training. An added advantage was that they were also skilled computer users and experienced (has played more than five types of computer games) in playing computer games.

Table 4.7 Participants profiles

	Gender	Age	Academic	Computer experience	Computer game experience
1	Male	42	Masters student (Digital media)	Skilled	Experienced
2	Female	39	Masters student (Digital media)	Skilled	Experienced
3	Male	26	Masters student (Digital media)	Skilled	Average
4	Male	26	Masters student (Digital media)	Skilled	Experienced
5	Male	45	Masters student (Digital media)	Skilled	Experienced

4.3.2.1 Heuristic descriptions

Heuristic descriptions were compiled from the observations made during the heuristic inspection of the VLS game user interface. The twelve descriptions were based on Nielsen's interface design heuristics (Appendix III) as follows:

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design

9. Error recognition, diagnosis, and recovery

10. VLS game Help

11. Constructivist principle

12. Educational principles

1. Visibility of system status

The player can see by means of the position of the cursor on the screen where he /she is all the time. The mouse movement and clicks results in clearly visible changes (in form of motion) on the screen. Hence the player can see clearly the change that takes place as a result of his/her actions. Therefore, the VLS game user interface gives the player clear feedback as to the system status. However

- When moving forward, there is a delay between the "mouse click" and the changes taking place on the screen. Therefore " the game is a little slow" one of the participants concluded.
- The player is not in total control because (in the 1st person) sometimes the screen keeps on turning without the player's input. As one participant observed, "It seems to have some momentum of its own".

2. Match between system and the real world

The terminology used in the VLS game (for example, *Exit*, *Help Agent*) is familiar to the player. At the same time the dialogue with the virtual actors (e.g. *Dr. Misner* and the *Help Agent*) is simple and natural. The Heuristic evaluators did not encounter any technical terms used in all communications.

The *Inner City* is rendered in such way that one can see that it is a city. However there is a conspicuous lack of signs, advertisements etc, whereas these are supposed to be one of the

sources of information. Conversely, *In the service of humanity portal* is set in a forested area. The rendering in this case shows the different parts (trees, grass, paths and river) of the forest. Therefore, the VLS game user interface appearance, background and landscape are natural. Hence the user interface appearance closely matches its metaphor, which is to mimic life as closely as possible such that the difference between fantasy and real life is blurred. The exception was the tree near the fireplace, which has unnatural (geometric) looking leaves (Figure 4.2).

Figure 4. 2 Tree with unnatural leaves

3. User control and freedom

The two actions (point and click, and typing) needed to play the game, are simple enough to be redone if a mistake is made. Therefore the VLS game user interface supports undo and redo. However the player options are not free from restrictions, for example:

- There are some things that a player cannot zoom in, in the portal (e.g. the certificate on the wall in *Dr. Misner's* office, see Figure 4.3).
- Only a proportion of the buildings or places (i.e. *City Hall, Waterfront, Trading Area, ePort* and *Apartment Complex*) in the *Inner City* are accessible to the avatar.

Moreover, as one participant noted, "Players path is predefined and as indicated by flashing of cursor". Therefore, "player is restricted in movement."

4. Consistency and standards

The button ( ) in the zoom pictures (Table 4.6 and Figure 1.7) is a conventional user interface symbol used to represent a return or go back function. However it is not a common symbol in the players lives and it does not have a pop-up label to clarify its function. Another button without a label was , which closes the communication with the virtual actors. This indicates that the VLS game user interface is inconsistent in the labeling respect. This inconsistency was investigated during the usability test to see whether it affects a player's reaction to the user interface.

However, as one participant observed, "There are no dramatic or illogical shifts in scenery or landscape". Therefore, the VLS game user interface appearance (background, landscape) is relatively consistent from scene to scene and interface functionality is the same throughout.

5. Error prevention

The VLS game user interface allows only valid actions to have effect (as indicated by flashing cursor). The design prevents error problems from occurring. Hence the participants of the heuristic evaluation encountered no error messages or did not make mistakes that generated error messages.

6. Recognition rather than recall

The heuristic evaluation participants observed that the VLS user interface input actions (mouse point and click and typing) were uncomplicated and hence easy to execute. Therefore training the player requires minimal instructions and should not take a long time. Challenges of the game are cognitive in nature and are in the form of puzzles and problem solving. Moreover the player has to remember information from one part of the VLS game to another in order to be able to solve the puzzles. Additionally, the important sources of information are placed in areas likely to attract the

player's attention. For example, a participant noted, "the Aids virus structure (Figure 4.3) cannot be missed in *Dr. Misner*'s room (study)".

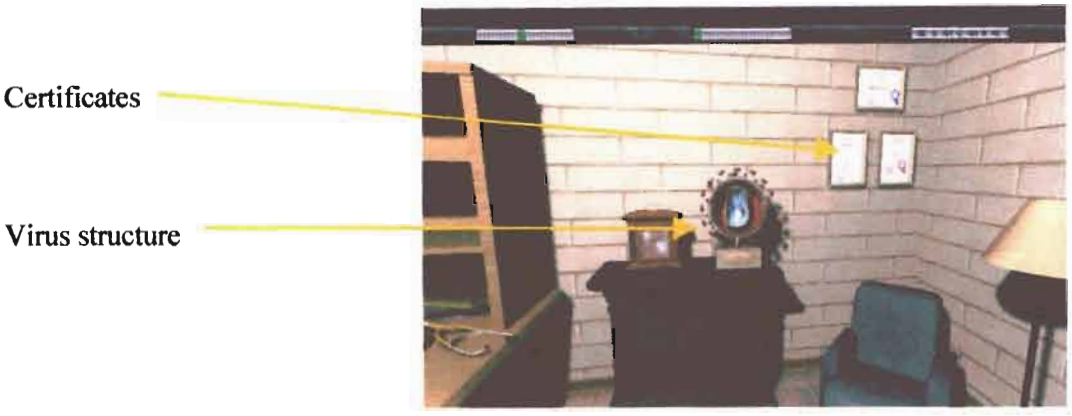


Figure 4.3 The virus structure in *Dr Misner's* office

However, the tree carvings hot spot is likely to be missed by the player, because of its close proximity to another hot spot, the fireplace (Figure 4.4).

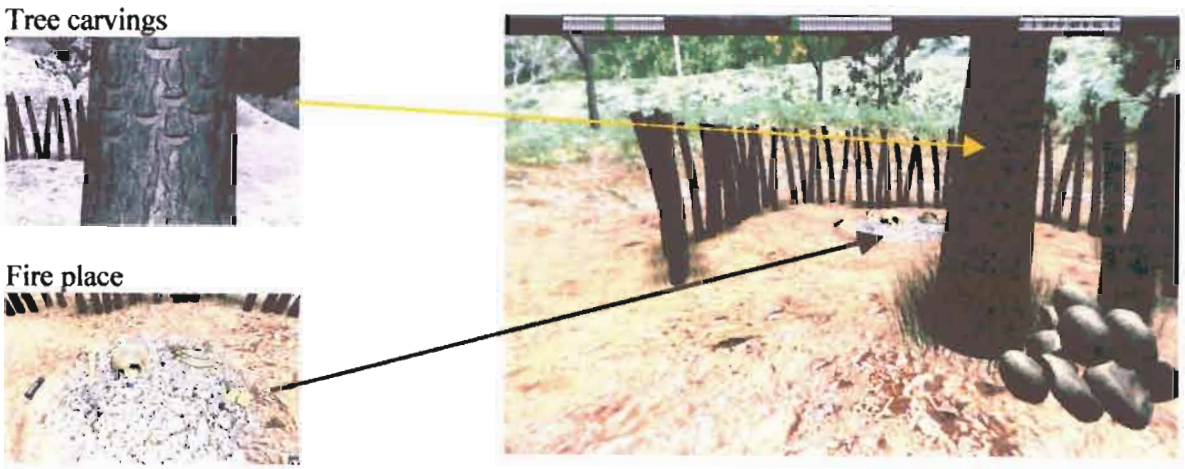


Figure 4.4 The *tree carvings* and the *fire place*

7. Flexibility and efficiency of use

The stage of development of the VLS game user interface that was evaluated did not have any indications of design features designed to speed up interactions for experience players (for example keyboard shortcuts).

8. Aesthetic and minimalist design

The VLS game user interface choice of text font sizes and colors is consistent with good screen design recommendations. However the choice of colors for the primary commands icons is poor because they are "not visible on the dark background", observed one participant. They only became visible (see Table 4.10) when the cursor passes over them.

The VLS game scenarios do not contain information that is irrelevant. However the VLS game dialogues (with *Dr. Misner* and *Help Agent*) are not coherent all the time. For example when *Dr. Misner* was asked, "How old are you?" he replied that, "55% you lost me".

9. Error recognition, diagnosis, and recovery

The stage of development of the VLS game user interface that was evaluated did not have any indications of error messages. This suggests that either the error recognition capacity is not yet applicable in this version or stage of development of the game or it is has a high error tolerant capacity

10. VLS game Help

The VLS game help, called the *Help Agent,* is accessible by means of mouse clicking on an icon. The only means of communication with the *Help Agent* is by typing. The heuristic evaluation participants considered typing a disadvantage to players with no typing experience. However, after interaction with the *Help Agent,* the participants felt that the players would be able to quickly grasp how to communicate with the *Help Agent.*

11. Constructivist principles

The observations made by the heuristic evaluation participants, about how the VLS game user interface (as a learning environment) fulfils constructivist principles are shown in Table 4.8. The question of whether the game provided meaningful learning contexts did not produce tangible

responses from the participants. At the level of development of the game the learning outcomes or objectives were not yet clear. Conversely the game design (exploratory in nature) prevents the learning outcomes or objectives to be revealed.

Table 4.8 Constructivist principles

	Principles	Observations
1	The VLS game stimulates curiosity.	"Yes, very much so. A user feels the need to explore within this design." "The cursor moves around the environment and it makes a player inquisitive about what to observe close." "Not really, it could be more dramatic – perhaps an introductory story or a mission."
2	The VLS game combines fun with learning	"Yes, a pleasant experience touring the scenery or building and walkways." "The game is fun to play."
3	The VLS game provides meaningful learning contexts	"Yes, objects included in the tour and in surrounding areas encourage learning." "The graphics were excellent and the interface presented 'real time' reactions to player input actions."
4	The VLS game require player to identify and solve problems related to learning objectives of the game	"Yes, For example the puzzle"
5	The VLS game require player to identify, collect, analyze, organize and critically evaluate information	"The close-up pictures that popup are an indication that they contain important information. Thus a player does not have to identify, but to analyse the pictures." "The game that I saw did not ask that much of the user."
6	The VLS game provides player with self-assessment opportunities that are aligned with its educational objectives	"Yes, for example the puzzle." "Yes, however, it does not seem that the players can save the self assessment results."
8	The VLS game provides a well-integrated media (reading, listening and pictures).	"No, I think this needs a lot more development." "Yes, but sound is not yet fully integrated."

12. Educational principles

The observations made by the heuristic evaluation participants, about how the VLS game user interface (as a learning environment) fulfils educational principles are shown in Table 4.9. The heuristic observations in Table 4.9 suggest that the exploratory nature of the game and the close-up pictures make it interesting, engaging and also provide constructive feedback and relevant information to the player. Additionally, the players' conceptual understandings are tested through the puzzle. Thus it satisfies some of the educational principles articulated by Amory (2000).

Table 4.9 Educational principles

	Educational principles	Observation
1.	The software makes it clear to the learner what is to be accomplished and what will be gained from its use.	The overall goal of the game is not evident in the version used because only part of the game was available
2.	The activities in the software will interest and engage a learner	The exploratory nature of the game, visual changes such as zooms, fades and colour change, and the puzzles interest and engage the player.
3.	The software supports learner preferences for different access pathways.	The VLS game user interface lacks input options. For example, Navigation limited to using mouse, arrow keys could be used as alternative
4.	The learner is able to find relevant information while engaged in an activity.	The close-up/popup pictures contain information or clues to puzzles
5.	The software provides support for learner activities to allow working within existing competence while encountering meaningful chunks of knowledge.	This is not yet evident in the version tested.
6.	The software requires learners to articulate their conceptual understandings as the basis for feedback.	The player's understanding of the learning content is tested through puzzles
7.	The software provides learners with constructive feedback on their endeavors.	The feedback is not helpful because when a player makes a mistake he/she is not told how to rectify it.
8.	The software produces clear and measurable outcomes that would support competency-based evaluation.	The puzzle has performance indication capability in the form of percentage points
9.	The software provides opportunities and support for learning through interaction with others through discussion or other collaborative activities.	This is not yet possible, but may be feasible when networked, or when the virtual cellphone (communication tool) became operational in the game.

4.3.2.2 Heuristics Violated

Analysis of the comments and observations by the heuristic evaluation participants exposed a number of heuristics violated by the VLS user interface.

- Match between system and the real world.
- Inconsistent display format.
- Visibility of icons.

These heuristics are illustrated in Table 4.10. Table 4.10 also presents the extensiveness and severity of each problem according to the respective scales on page 42.

Table 4.10 Heuristics Violated

	Heuristics violated	Extensiveness and severity
1.	Match between system and the real world. Tree has unnatural shaped leaves 	A single case problem: at *the burning place* Cosmetic problem: need not be fixed
2.	Inconsistent display format These buttons ▼ and ✕ have no pop-up labels.  	Problem occurs in three places: The close-up popup pictures (Figure 4.4) and interaction with *Dr. Misner* and *Help Agent* (Figure 1.7) Major problem: important to fix
3.	Icons not clearly visible on the dark background. Visible only when cursor is pointed at it. 	Single case problem: Primary command icons Major problem: important to fix

The observation that the tree has unnatural shaped leaves was considered to be a cosmetic problem since all the participants recognized it as a tree despite its geometric shaped leaves. The buttons ▼and ✕ not having popup labels was considered to be a major problem that need to be fixed because players with no computer experience need to know the functions of these buttons are. The lack of contrast between the primary command icons and the dark background was also considered a major problem that was important to fix because of the key nature of their functions. It was therefore necessary to observe how the two major heuristics violated affect the player's use and response to the VLS game user interface.

4.4 Pilot test report

A pilot test was conducted to check the effectiveness of the evaluation tools and to determine where revisions were required, as well as a test-run for the mobile laboratory set up and equipment. In addition, the pilot test was used to assess the test tasks with respect to clarity of instructions, feasibility and duration of each task.

4 4.1 Pilot test participants

The chosen participants were closely matched with the profiles described by the personnel of the VLS project (section 1.2.page 3). The sample included: male (N =6) and female (N = 4) players. A factor that distinguished between male and female participants was computer experience. The six male participants were volunteers from school 2 and were all experienced computer users. However, the four female participants were from school 1 and were novice computer users. All the participants were between 17 and 20 years old, in final year of school, with basic typing skills, an adequate command of English language and normal visual and aural acuity.

4.4.2 Effectiveness of the evaluation tools and mobile laboratory equipment

Some of the items in the post questionnaires required some explanatory help in order for the test participants to understand. In order to overcome this problem (in the main study), simpler words were added in brackets in order to give the required meaning. No technical problems in setting up and using the mobile laboratory were encountered. However all participants experienced problems of mouse control and hence cursor control. This resulted into the game area moving abnormally fast in using the mouse and keyboard. This was considered a major problem for investigation in the usability test.

4.4 3 Feasibility and duration of usability test tasks

In the test, the instructions, which had been given to the participants verbally, were forgotten during the testing. Therefore the final test included written instructions (Appendix VI) for the players to refer to.

Task 1 was a training task to demonstrate mouse control mouse clicking at a *hot spot*. It involved the exploration of the *Burning Place* and look for objects that may provide clues to the player. It ended with the *fireplace* (Figure 1.7) demonstrated as an example of a source of information. The researcher experienced no problems in this demonstration. Therefore no changes were necessary.

Task 2 was an outdoor navigation task where the players were requested to go back into the game play, from the *Fireplace* picture, look around for any other clues and then go back to the starting place in the first task. It was noted that the mouse clicking (at a *hot spot*) action required to navigate the gameplay area was well managed by the players. However they experienced the problem of mouse control and hence cursor control. This problem was identified as a usability problem. Thus Task 2 was a feasible task for exposing some usability problems.

Task 3 was an indoor navigation task where players had to explore *Dr. Misner*'s officer and look for objects that may provide clues to the player. The players did not experience any technical difficulties. However they still experienced the problem of mouse control and hence cursor control.

Task 4 involved doing the puzzle using the given answers. This required mouse pointing and clicking on the appropriate letters. The puzzle took the longest to find the thirteen answers. However, all the entries required the same action (mouse clicking). Therefore there was no need to do them all; four entries were considered enough to prove a player's ability do the puzzle.

Task 5 entailed communication with the virtual character (*Dr. Misner*). The input action needed is typing. Typing presented problems to naïve and novice computer users but the skilled had no problems.

Task 6 entailed finding and interacting with the *Help Agent*. Only two questions were required because it has the same communication structure as the virtual character.

The results in Table 4.11 indicate that the average total time taken to do the six test tasks was 33 minutes and forty seconds. Therefore, in order to accommodate all the activities (from reception of the participant to handing in of Post-test questionnaire), in the final test, one hour was set for each pair of participants.

Table 4.11 Duration of usability test tasks

Task	Description	Mean time (minutes and seconds)
1	Training task	5.7
2	General navigation	4.9
3	Identify possible clues in office	2.6
4	Interaction with puzzle	11.3
5	Communication with virtual character	6.7
6	Interaction with *Help Agent*	5.8
	TOTAL TEST TIME	**33.40**

It was also observed that the participants did not to talk aloud despite of the fact that they were working in pairs. This was attributed to the disjointed nature of the tasks. Consequently, it was decided that, at this stage of development of the VLS game, audio and video recording during the usability test was not necessary. It would be more appropriate to include them when testing the complete game.

4.5 Descriptive phase

The objective of this phase was to observe how players from the target group interact with the VLS game user interface. This was done in a controlled setting to avoid disruptions (see section 3.4.2). The researcher made notes of problems, which were experienced by the test participants that hindered proper functioning of the VLS game user interface.

4.5.1 Usability test report

The Usability test was conducted on volunteer participants (26) (Table 4.12) in final year of high school. There were two schools involved. School 1 was chosen for its naïve and novice learners and school 2 for its more computer literate learners. Thus, as Table 4.13 shows, the participants were a heterogeneous sample of both gender and with different levels of computer skills.

Table 4.12 Test participants demographics

	n	Minimum	Maximum	Mean
AGE	26	16	20	17.54

Table 4.13 Gender vs. Computer skills cross tabulation

Gender	Computer skills			Total
	Naive	Novice	Skilled	
Female	5	3	6	14
Male	2	4	6	12
Total	7	7	12	26

In school 1, those who had never used a computer before (naïve) described themselves as having no confidence when using a computer. Those participants with some previous computer experience (novice) expressed different levels of confidence when using the computer, ranging from comparatively lower confidence to very confident (see Table 4.14). All the participants at that school who had some experience in playing computer games had only played the onscreen card game *Solitaire*.

Table 4.14 Computer skills vs. confidence cross tabulation

Computer skills		Confidence					Total
		No confidence	Little confidence	Some confidence	Confident	Very confident	
School 1	Naive	7	0	0	0	0	7
School 1	Novice	0	1	2	2	2	7
School 2	Skilled	0	0	0	12	0	12
Total		7	1	2	14	2	26

In school 2 both male and female participants were skilled computer users. All described themselves as having confidence when using a computer (see Table 4.14). They also had experience in different types of computer games including action, sport and adventure games.

4.5.1.1 Performance of test participants

The participants were taken through a training task to show them how to navigate using the mouse. The way the cursor changes colour was also demonstrated. Lastly they were shown an example of pop up picture (the *fire place*, Figure 1.7) of a source of information. Then they were asked to carry on with tasks 2 to 6 as described in Appendix VI. Table 4.15 presents a summary view of time taken for each of the tasks.

Table 4.15. Test task timings

Task	**Description**	**Time** (minutes and seconds) (n = 26)		
		Minimum	Maximum	Mean
1	Training task: navigation	1.09	5.53	3.17
2	Out door navigation and identifying possible clues	0.26	5.09	2.30
3	In door navigation and identifying possible clues	1.20	8.04	2.56
4	Interaction with puzzle	2.17	12.09	5.29
5	Communication with virtual character	3.39	11.27	7.26
6	Identification of *Help Agent*	0.20	1.40	0.55
	TOTAL	**8.31**	**43.42**	**21.03**

The performances (in terms the time taken to do the tasks) of both the male and female test participants (Table 4.16) were comparable except when interacting with the virtual actor, where the female participants took much longer.

Table 4.16. Test task timings according to gender

Task	Description	Time (minutes and seconds)					
		Male (n = 12)			Female (n = 14)		
		Minimum	Maximum	Mean	Minimum	Maximum	Mean
1	Training task	1.09	5.53	3.23	2.44	5.10	3.51
2	General navigation	0.26	5.09	1.50	0.55	4.28	2.00
3	Identify possible clues	1.20	8.04	3.29	2.32	4.33	2.43
4	Interaction with puzzle	2.17	12.09	6.31	3.12	7.43	5.07
5	Communication with virtual character	3.39	11.03	5.18	6.54	11.27	8.54
6	Identification of *Help Agent*	0.50	1.01	0.58	0.20	1.40	0.51
	TOTAL	**9.41**	**43.19**	**21.29**	**16.37**	**35.01**	**23.06**

Conversely, a simple comparison of the performances of skilled and unskilled computer users, summarised in Table 4.17, reveals differences in their performances. It took the naïve (unskilled) participants approximately twice as long as the experienced participants in most tasks. This could be attributed to their lack of skills (e.g. cursor or mouse movement and control, typing) as predicted from the heuristic evaluation.

Table 4.17 Task timings according to computer experience

Task	Description	Time in minutes and seconds								
		Skilled (n = 12)			Novice (n = 7)			Naïve (n = 7)		
		Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
1	Training task	1.09	2.50	2.36	3.22	6.13	4.28	3.52	6.30	5.08
2	General navigation	0.26	2.00	1.22	0.34	5.09	3.12	0.30	6.09	4. 21
3	Identify possible clues	1.20	3.41	2.30	1.56	8.04	5.20	1.50	8. 40	6.26
4	Interaction with puzzle	3.37	12.09	8.38	2.17	3.49	3.23	3.17	5.39	3.23
5	Communication of virtual character	3.39	4.02	3.60	4.05	11.27	7.54	5.40	12. 17	8. 45
6	Identification of *Help Agent*	1.00	1.01	0.84	0.90	1.40	1.25	1.30	1.40	1.35
	TOTAL	**10.31**	**25.03**	**17.8**	**12.24**	**35.02**	**23.02**	**15.19**	**40.55**	**29.38**

4.5.1.2 Usability problems found.

As the test players interacted with the VLS game user interface, they experienced usability problems of navigation and mouse use. Presented in Table 4.18 are the problems observed during the test, the severity of each problem (in terms of the number of the observed number of people who experienced the problem and the ease with which it was overcome) and extent with which it occurs.

Table 4.18 Usability problems description

	Problem	**Severity**		**Extensiveness**
	Depiction and description	Frequency	Impact	Place(s) of occurrences
1.	Lack of mouse control	26	Easy	Occurs in several places;
2.	Missing the hot spot	8	Easy	Occurs in several places
3.	Failing to identify exit or close button.	4	Easy	Occurs in five places
4.	Failing to undo the puzzle entry	4	Easy	Single case problem
5.	Missing a clue (Notches on tree)	26	Difficult	Single case problem

1. Lack of mouse control

The observation of the participants' actions during the usability test revealed that all (26) participants (novice and experienced computer users) experienced the problem of mouse control and hence cursor control. This resulted into the game area moving abnormally fast. Consequently some of the players experienced navigation problem of confusing the directions of forwards and backwards motion. This was basically a navigation problem and occurred in the first, second third tasks. It was further observed that the problem was more pronounced during the first two navigation tasks but was controlled in the third task. This suggests that the problem is easy to overcome through as the player gains experience in the game.

2. Missing the hot spot

Another problem due to exaggerated movements was that the player kept on missing the hot spot. It resulted in the player moving around in circles without progress. It was also more pronounced during the first two navigation tasks and was controlled in the third task.

3. Failing to identify exit or close button

During task three, the participants had to look for three sources information in the *Dr. Misner*'s office. These sources popped up as pictures (see Figure 4.5).

Figure 4. 5 Example of a sources of information

In each of the three pictures, the player had to move back into the game play mode by clicking on return button (➧). Four naïve participants (three female and one male) failed to identify this button and had to ask for assistance from the researcher.

4. Failing to undo the puzzle entry

A puzzle entry was achieved through mouse clicking on the appropriate letter. The activated letter changed colour from brown to green (see Figure 4.6).

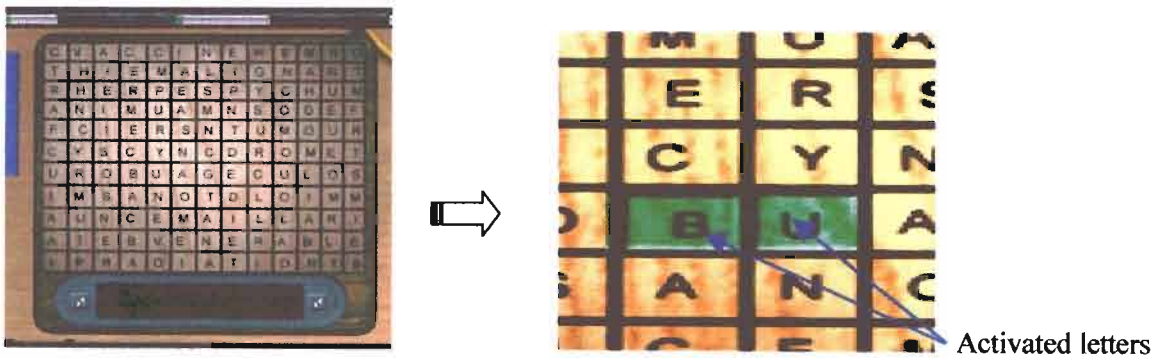


Figure 4. 6 Puzzle entries

Some of the participants failed to realise that clicking on the letter again deactivates a wrong choice. They recovered through unconventional means by closing the puzzle and starting again or

going on to the next question and the back again. Hence it was rated as an easy problem to overcome. Overall, the observation did not reveal any major differences in the problems encountered by male and female players.

4.5.2 Questionnaire Report

After each usability test, the participants were given a post-test questionnaire to complete. It was made up of three major sections:

- Interface design including appearance, interaction method and user help.
- Player satisfaction including engagement, comprehensibility and equitability.
- Game objectives including general game objectives and general educational objectives.

Although the sample size of participants was too small to run comparative tests between subgroups, the mean values of the Likert scale responses (Lv) were considered appropriate to give a descriptive sense of the general direction of the participants' responses.

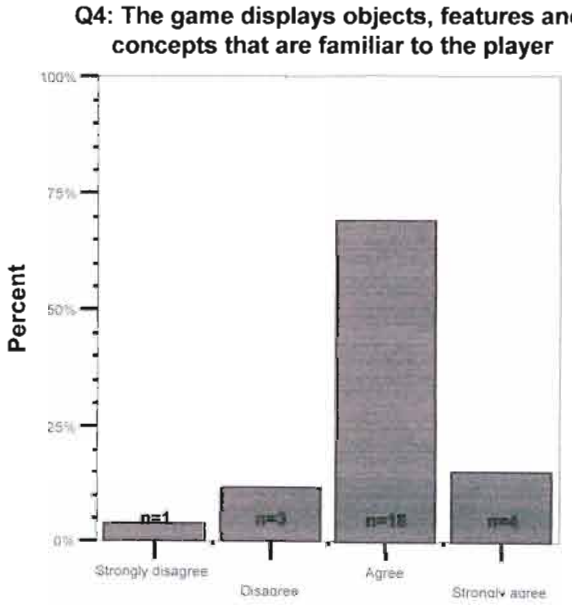


Figure 4.7 Bar-chart percentage responses to objects, features and concepts displayed by the VLS game user interface

Overall, the distribution of the participants' responses were skewed towards agree and strongly agree in most of the questionnaire items (for example see Figure 4.7). Where deviations from the general trend occurred, bar charts were used to illustrate these differences.

The Lvs were also used to compare the results of the questionnaire across different groups e.g. gender groups, and different computer literacy levels. Clustered bar charts were used to illustrate the variations that were found.

The weighting of the Likert scale used in the questionnaire was:

1 = Strongly disagree, 2 = Disagree, 3 = Agree; 4 = Strongly agree.

4.5.2.1 VLS game user interface design

Appearance

For the *Appearance* criterion of the post-test questionnaire the responses indicate that the respondents either agreed or strongly agreed with three (items 1, 2, and 3) of the five user interface criteria as illustrated in Table 4.19.

Table 4.19 VLS game user interface appearance

	Usability requirements	Mean Likert values (Lv)					
			Gender		Computer Skills		
	Item	Overall	Female	Male	Naïve	Novice	Skilled
		n = 26	n = 14	n = 12	n = 7	n = 7	n = 12
1.	The general appearance of the game is visually appealing.	3.35	3.29	3.42	3.14	3.43	3.42
2.	The colour of the game display is pleasing.	3.27	3.43	3.08	3.29	3.29	3.25
3.	The icons are clear and easy to see	3.15	3.36	2.92	3.57	3.29	2.83
4.	The game displays objects, features and concepts that are familiar to the player.	2.96	3.14	2.75	2.86	3.14	2.93
5.	Text based communication is easy to read.	2.88	3.21	2.50	3.14	3.00	2.67

1. The general appearance of the game is visually app000ealing

The participants found the general appearance of the VLS user interface to be visually appealing (Lv = 3.35) as they all selected a level of agreement with this statement as shown in Figure 4.8. This positive feeling about the appearance section is revealed in the participants' remarks such as,

"It is appealing because it is almost life-like" (male participant), and

"...very realistic, such as trees and *Dr. Misner*" (male participant)

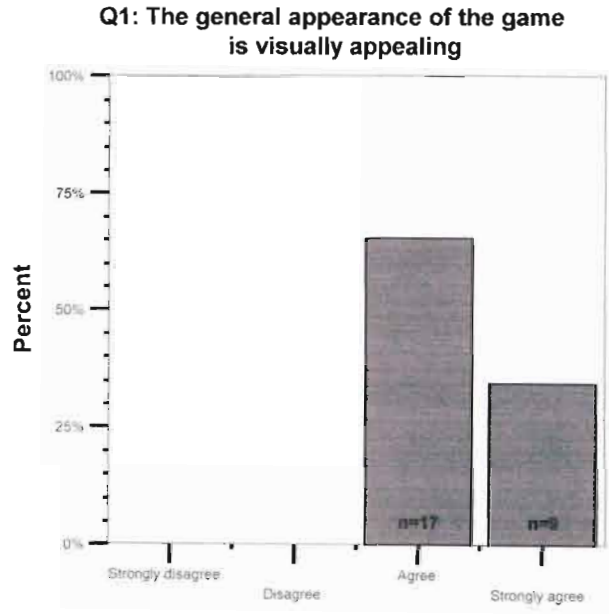


Figure 4.8 Bar-chart of percentage responses to the VLS game user interface visual appeal

2. The colour of the game display is pleasing

The colour was also found to be pleasing (Lv = 3.27) for both female (Lv=3.34) and male (Lv= 3.02) participants. As a male participant said "The colours are attractive to the eye and are not dull." It " is clear and bright colour" (female participant) and "very pleasing" (female participant).

The participants' responses to items 1 and 2 above indicate that the VLS game user interface made a good first impression on the participants in terms of appearance and visual appeal. Hence the appearance facilitated positive attitude towards the VLS game user interface (Kurosu and Kashimura, 1995; Tractinsky, 1997)

3. The icons are clear and easy to see

The VLS game user interface icons were found to be visible (Lv = 3.15). However, 15.4 % (4) of the participants felt that there was not enough contrast between the icons and the dark background. This supports the Heuristic evaluation results (Table 4.10) where it was observed that the visibility of the icons could be problematic to some players. Nevertheless, results of the usability test indicate that this did not prevent the test participants from locating and using the primary command icons, *Exit* and *Help Agent* (Table 4.6). For example, the usability test participants were quick to locate the *Help Agent* (minimum = 20 seconds, maximum = 100 seconds, mean = 55 seconds).

4. The game displays objects, features and concepts that are familiar to the player

One of the fundamental objectives of a virtual learning environment, like the VLS game, is to mimic life as closely as possible such that the difference between fantasy and real life is blurred. Thus, in the design of the VLS game user interface, this objective was achieved by displaying objects, features and concepts that were intended to be familiar to the players. Results indicate that 84,6% (22) of the test participants concur with this statement. The comments given in support of this feature include:

"Associates with every day life." (male participant).

"There are things that we normally see in our every day life and at home" (female participant)

"Puzzle is something familiar" (female participant)

"Games nowadays have similar concepts" (male participant)

However, a comparatively lower Mean Likert value for item 4 indicate that the some participants experienced or noticed some problems with the VLS user interface display of objects, features and concepts. It seems that one of the problems experienced were related to the intransient nature of the VLS game user interface (i.e. need to point-and-click for changes to occur). A male participant, experienced in computer games expressed dissatisfaction; "Movement is new and

slow" (referring to using the mouse to navigate). This is due to the delay between the "mouse click" and the changes taking place on the screen observed during the heuristic evaluation.

5. Text based communication is easy to read

As Figure 4.9 indicates, 73% (19) of the participants agreed that the text was easy to read. However, a comparatively lower Mean Likert value for item 5 indicates that some participants experienced or noticed some problems with the text-based communication.

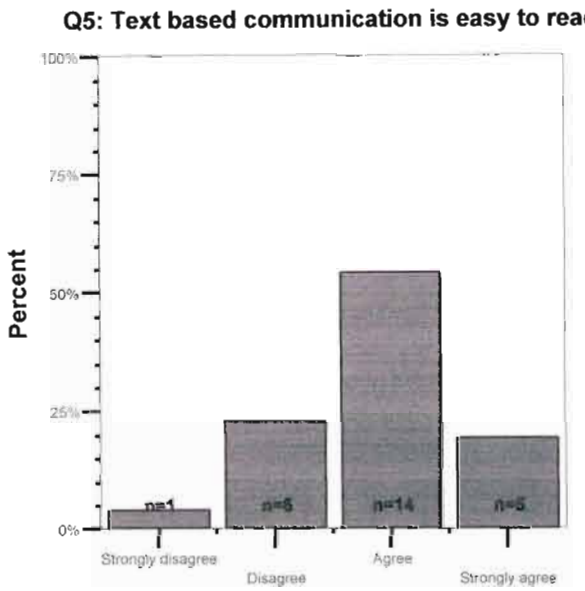


Figure 4.9 Bar-chart responses to text based communication of the VLS game user interface

Although observation during the usability test revealed that the participants were able to communicate with *Dr. Misner* (the virtual actor), 27%, (7) of the participants expressed dissatisfaction with the size of the text in the communication with virtual characters (*Dr. Misner* and *Help Agent*) interface. They said, "the text is small" (female participant) and "seem to be faint" (female participant). Hence others (2) suggested that the text should be "written in a slightly larger font" (male participant). Therefore, there is a need to improve readability of the VLS game user interface text-based communication through the use of high contrast and large font as Tognazzini (2003) recommends.

6. The display format of the game is consistent across displays

Almost all the participants did not understand this statement and requested some explanation. Despite this no responses to this item were obtained.

Interaction method

The VLS game user interface environment utilizes the direct manipulation style. This interaction method involves manipulation of objects on the screen.

For the *Interaction method* criterion of the post-test questionnaire the, responses indicate that the majority of the respondents either agreed or strongly agreed with six (items 7, 8, 9, 10, 11, and 12) of the seven user interface criteria (Table 4.20).

Table 4.20 Interaction method

	Usability requirements	Mean Likert values (Lv)					
			Gender		Computer skills		
		Over all	Female	Male	Naive	Novice	Skilled
	Item	n = 26	n = 14	n = 12	n = 7	n = 7	n = 12
7	The response to player input actions were fast enough (quick system response).	3.08	3.14	3.00	3.43	2.43	3.25
8	It is easy to play the game such that the making of errors is minimal	3.00	2.93	3.08	3.14	3.29	2.75
9	When the player makes an error it is easy to undo it. (recover from the error).	3.00	2.86	3.17	3.14	2.43	3.25
10	The player is in control of at all times.	3.00	3.07	3.00	3.14	2.86	3.00
11	Player control of the mouse is compatible with cursor movement.	3.08	3.00	3.17	3.14	3.43	3.00
12	The player can establish (see) where he/she has been, is and is going.	3.23	3.36	3.08	3.57	3.00	2.43
13	The game response (feedback) to player actions is clearly visible.	2.73	2.71	2.75	2.75	3.25	2.75

7. The response to player input actions were fast enough (quick system response).

The VLS game user interface responses to player input actions were perceived to be quick (Lv = 3.08). 80.7 % (21) of the participants were in agreement that the VLS game user interface response was fast enough. The comments given in support of this feature include:

"I asked the question and I got the answer straight away" (female participant).

"Not too slow not too fast. Straight after input a response is acquired" (male participant).

"The reaction, if I should call it that, was not waited for" (male participant).

The other (5) participants were aware of the delay between the "mouse click" and the changes taking place on the screen, which was also observed during the heuristic evaluation. Hence the conclusion of a male participant that " The game is a little slow".

8. It is easy to play the game such that the making of errors is minimal

Most participants, 84.6% (22) were of the opinion that it was easy to play the game such that the chances of making errors were minimal. As one of the participants observed, "one rarely makes mistakes" (male participant). Other comments given in support of this feature include:

"It does not require a lot of effort which makes it easy to play" (male participant)

"The change of colour on the pointer makes choice easier" (female participant)

However one participant (who was experienced in computer games) observed " It is easy to make an error if you do not understand the concept" (male participant).

9. When the player makes an error it is easy to undo it (recover from the error).

77% (20) of the participants felt that it was easy to undo or reverse errors that a player may make during VLS game play. For example, when communicating with the virtual actor by typing, a participant said, "spelling errors can be deleted and retyped." Another area where errors occurred and were easily undone was the puzzle. The common mistake was to choose a wrong letter. It

was observed during the usability test that clicking on the letter again could reverse this mistake. But some of the participants recovered through unconventional means by:

- Closing the puzzle and starting again.
- Going on to the next question and then back again.

10. The player is in control of at all times.

80,8% (21) of the participants agreed that the player was in control at all times. The comments given in support of this feature include:

"Control is totally yours" (male participant) and

"It is all in your hand" (male participant)

However, some participants (19,2%, 5) experienced problems of lack of control " when cursor is moved too quickly" (noted one of the participants). A participant who experienced an acute mouse control problem, observed, "sometimes the cursor moved too fast and I got confused".

11. Player control of the mouse is compatible with cursor movement.

Player control of the mouse was perceived to be compatible with cursor movement by 76.9% (20) of the participants. The other 23.1% (6) experienced problems such as:

"The mouse moved but cursor didn't" (male participant)

"It is a bit slow, needs faster response" (male participant)

"Only when cursor movement is done too quickly does compatibility shaky" (male participant)

This suggests that player control, which was predicted in the Cognitive walkthrough (see Table 4.5(2)), is compromised when the mouse is moved quickly.

12. The player can establish (see) where he/she has been, is and is going.

76.9% (20) of the participants shared the opinion that a player could determine his or her position all the time. The reasons given in support of this feature include:

"Because I can go back where I came from" (female participant).

"Because there is a pointer which is helping me" (female participant).

"The player can see himself/herself by seeing a pointer" (male participant).

"Clear pictures and noticeable surroundings" (male participant).

"The pointer is helping me to go anywhere I want to" (female participant).

"Because it is like you are there you can see where you are what you are doing" (female participant).

"It was easy to trace back my stapes (steps), the 360 degree movement aids in that area" (male participant).

This ability for the player to establish his or her position enhances navigation and helps the player to realize that the actions are in support of his or her goals.

13. The game response (feedback) to player actions is clearly visible.

The VLS game user interface response or feedback to player actions is clearly visible (65.4%, 17). "This is especially evident when moving from place to place" (one participant observed). However, a comparatively lower Mean Likert value (Lv = 2.73) for item 13 indicates that a number of participants experienced some problems with game response. Some indicator comments given in support of this observation include:

"Because you do not know what you are looking for" (female participant).

"Game is a bit slow" (male participant).

"I did not know where the game was leading" (female participant).

User help

User help refers to strategies for offering assistance to players when they are having difficulties. In the VLS game user interface, it is in the form of an interactive virtual actor. For the *User help* criterion of the post-test questionnaire the responses indicate that the respondents either agreed or strongly agree with two (items 14, and 15) of the four user interface criteria (Table 4.21).

14. The player is able to access help at any time when playing the game (help is readily available / accessible).

The user help (the *Help Agent*) was found to be readily accessible by 80.8% (21) of the participants. Positive aspects that were referred to by participants included:

"The help is within reach and in standby responsive" (male participant)

"Because I saw the question mark, I know where to go for help" (male participant)

15. The game help is easy to use.

The user help (the *Help Agent*) was found to be easy to use by 84% (22) of the participants. Only the naïve players (with no previous computer experience) experienced minor typing problems. They did not know how to capitalise letters at the beginning of a sentence or how to insert a question mark at the end of a question.

Table 4.21 User help

	Usability requirements	**Mean Likert values (Lv)**					
			Gender		**Computer skills**		
		Over all	**Female**	**Male**	**Naive**	**Novice**	**Skilled**
	Item	**n = 26**	**n = 14**	**n = 12**	**n = 7**	**n = 7**	**n = 12**
14.	The player is able to access help at any time when playing the game (help is readily available / accessible).	3.00	2.79	3.25	2.86	3.00	3.08
15.	The game help is easy to use.	3.31	3.14	3.50	3.43	3.14	3.33
17.	The game help does not prevent the player from continuing with normal play (is unobtrusive).	2.54	2.50	2.58	2.29	2.14	2.92

16. The game help allows each player to use it in a way appropriate to his/her needs (is flexible)

Almost all the participants did not understand this statement and requested some explanation. Only sixteen participants responded to it and none of their comments said something substantially constructive. For example

"Does not have all the answers" (female participant).

"You can be flexible if you can. But if you are not, don't try to be" (male participant).

"It's easy" (female participant)

"The game gives each and every player the same roles" (male participant).

"You have to play by the rules of the game or you will go wrong on the game" (male participant).

"I'm sure that's right because each and every player has her or his needs" (male participant).

Therefore this item was considered inappropriate for further analysis.

17. The game help does not prevent the player from continuing with normal play (is unobtrusive).

There were mixed feelings 65. 4% (17) agreed and 34.6% (9) disagreed that the game help prevent the player from continuing with normal play. Observations indicated that the *Help Agent* pop-up makes the game play area inactive (see Figure 4.10). However as one participant noted, "exiting help is no problem therefore to continue is no problem" (female participant).

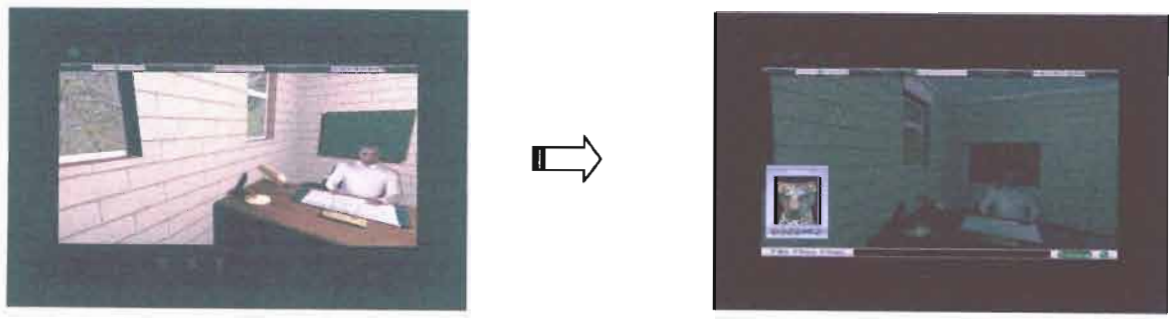


Figure 4.10 Game play area in normal view and with *Help Agent* pop up

The participants' responses to items 14,15 and 17 suggest that the VLS game user interface help is accessible and easy to use. However it interferes game play since it makes the game play area inactive. Hence the player has to close the help interface in order to continue playing.

4.5.2.2 Player satisfaction

Engagement

Engagement was considered to be a very important aspect of player satisfaction because of its ability to stimulate the initial interest of a player (intrinsic motivation) in the game and to promote continuous play. For the *engaging* criterion (Table 4.22) of the post-test questionnaire, responses indicate that the respondents either agreed or strongly agreed with four (items 18, 19, 21 and 22) of the five user interface criteria.

Table 4.22 Engagement

	Usability requirements	Mean Likert values (Lv)					
			Gender		Computer skills		
		Over all	Female	Male	Naive	Novice	Skilled
	Item	n = 26	n = 14	n = 12	n = 7	n = 7	n = 12
18.	The game tasks are interesting.	3.19	3.43	2.92	3.86	3.57	2.58
19.	The game tasks are challenging.	3.12	3.14	3.08	3.43	3.14	2.92
20.	The game response or feedback to player actions is clear and consistent.	2.73	2.86	2.58	3.00	2.57	2.67
21.	Playing the game is an enjoyable experience.	3.38	3.50	3.25	3.86	3.57	3.00
22.	I felt very confident playing the game.	3.04	3.21	2.83	3.17	2.86	2.75

18. The game tasks are interesting.

The game tasks were found to be interesting (Lv = 3.12) by 76.9% (20) of the participants. This positive feeling is reflected in the participants' comments such as,

"Because you really want to know what will happen when you move to next stage" (male participant).

"There is always some thing new" (female participant).

"There is always something new and you can't help it but want to carry on" (female participant).

During the cognitive walkthrough, it was observed that the goal, in terms of what is needed to win the game, was not clear because the game was not complete. This left a vacuum, which the players felt. Hence one player (female participant) said: "I don't know what point the game is making".

19. The game tasks are challenging.

The game tasks were also found to be challenging (Lv =3.12) by 81.8% (21) of the participants. The comments given in support of this feature include:

"They (the tasks) really put your mind to work" (female participant).

"It tests your knowledge from time to time so one gets to use ones brain" (female participant)

"They need you to think" (male participant)

However some of the skilled computer users expressed reservations as indicated by a lower Lv (2.92) and the following comments:

"Very simple even a child can do them" (male participant).

"Only the puzzle was difficult" (male participant).

"It was not difficult to understand what was required and to do it" (male participant).

20. The game response or feedback to player actions is clear and consistent.

The VLS game user interface feedback was perceived to be clear and consistent by 69.2% (18) of the participants. These positive feelings are reflected in comments such as:

"Enjoyable in its simplicity" (the game) (male participant).

"The action is clear because it shows you that you moving left now" (female participant).

"You can normally see when it changes" (male participant).

However a lower Lv (2.73) indicates that some participants were not satisfied. Negative observations included:

"This is true with the puzzle but could be made better " (in other areas) (male participant).

"Yes it is clear but sometimes it is just the opposite if what the player had expected" (female participant).

21. Playing the game is an enjoyable experience.

96.2% (25) of the participants found the playing the game enjoyable. Figure 4.11 indicates almost half of them strongly agreed with the statement. The remarks given in support of this trait include:

"Some parts were really good, wouldn't have minded continuing" (female participant).

"Enjoyable in its simplicity" (female participant).

"Because it makes you forget about other things and make your mind concentrate on it" (female participant).

The last statement suggests that some participants experienced "flow". Hence the VLS game user interface has the capacity for player engagement (Jones, 1998). However one (male participant) felt that there is room for improvement and suggested that the game "needs more audio".

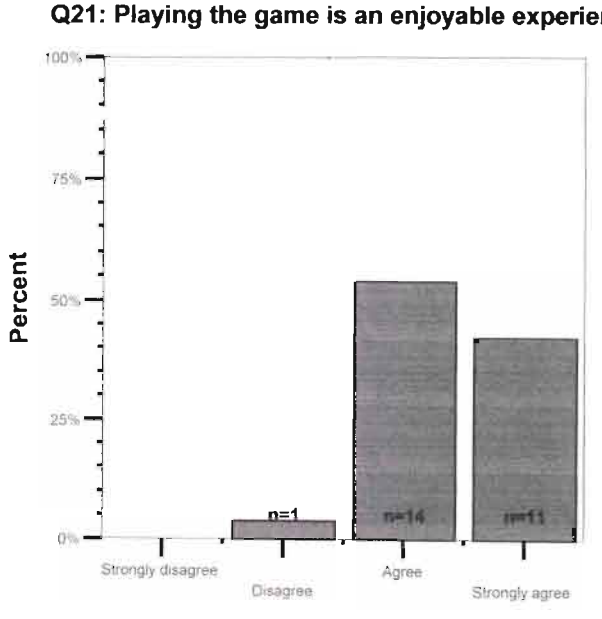


Figure 4.11 Bar-chart percentage responses to VLS game user interface enjoyment

22. I felt very confident playing the game.

73.1% (19) of the participants felt confident while playing the game. The comments given in support of this feature include:

"It was very easy" (male participant)

"The puzzle was confusing at first but improved with time" (female participant).

The others expressed the following reasons for lack of confidence:

"Gaming instructions were not given so I felt a little nervous" (male participant).

"Did not know what to expect" (male participant).

"I am not good at playing games so I wasn't that confident" (female participant).

"I am not sure of what I am supposed to do" (female participant).

Most of the participants who expressed lack of confidence (6 male and1 female) were first time computer users.

Despite reservations expressed by skilled computer users and some lack of confidence by naïve computer users, response to items 18,19, 20 and 21 indicate that the game tasks were interesting, challenging and enjoyable. Hence the VLS game user interface has the capacity for player engagement (Jones, 1998).

Comprehensibility

For the *comprehensibility* criterion (Table 4.23) of the post-test questionnaire, responses indicate that a high proportion of the respondents either agreed or strongly agreed with both items of the user interface criteria.

Table 4.23 Comprehensibility

	Usability requirements	Mean Likert values (Lv)					
			Gender		Computer skills		
		Over all	Female	Male	Naive	Novice	Skilled
	Item	n = 26	n = 14	n = 12	n = 7	n = 7	n = 12
23	I think that most people would learn to play this game very quickly.	3.27	3.29	3.25	3.57	3.29	3.00
24	I think the game was easy to play.	3.31	3.29	3.33	3.57	3.57	3.33

23. I think that most people would learn to play this game very quickly.

84.6% (22) of the participants felt that it was easy to learn to play game. The comments given in support of this feature include:

"Yes I learned to play very quickly and easy" (female participant).

"Because it is simple" (male participant).

"Easily understandable" (male participant).

"If you put your mind in it most people would learn quickly" (male participant).

Others observed:

"Firstly it is not easy cause you can think you are through with it but you just get the opposite" (male participant),

"If a person has never played computer game they might find it difficult to answer the tasks." (male participant),

"You can go quickly if you are used to a computer." (female participant)

24. I think the game was easy to play.

92.3% (24) of the participants felt that it was easy to play the game. The comments given in support of this feature include:

"Interaction is easy therefore making play easy." (male participant),

"Because you don't press so many buttons." (female participant)

"Because the arrow is showing us direction." (male participant),

"It is easy because you just push the mouse and click." (male participant).

The response to items to items 23 and 24 support the observations from the Heuristic evaluation that the simplicity of VLS user interface input actions make it easy to learn and use. Therefore it is comprehensible. However, these responses do not take into consideration the problem of mouse and cursor control, which was experienced by all the participants.

Equitability

Equitability of the VLS game user interface was defined as its ability to be used by female, male, naïve and skilled computer users. This characteristic was of particular concern in the evaluation of the VLS game user interface because it is important for the game to provide all the players with a pleasurable experience.

For the *equitability* criterion (Table 4.24) of the post-test questionnaire, the majority of the participants agreed on two (items 25 and 26) of the three items.

Table 4.24 Equitable

	Usability requirements	**Mean Likert values (Lv)**					
			Gender		**Computer skills**		
		Over all	**Female**	**Male**	**Naive**	**Novice**	**Skilled**
	Item	**n = 26**	**n = 14**	**n = 12**	**n = 7**	**n = 7**	**n = 12**
25.	The game does not have gender sensitive material.	3.12	3.14	3.08	3.14	2.71	3.33
26.	The game does not discriminate in experience of players in computer-use.	3.00	3.00	3.00	3.00	3.00	3.00
27.	The game does not distinguish disparities in experience of players in computer games.	2.50	2.50	2.50	3.00	2.29	2.33

25. The game does not have gender sensitive material

88,5% (23) of the participants felt that the game does not have gender sensitive material. However of the three who disagreed, only one participant expressed reservations concerning gender sensitive materials noting that:

"The skeleton in the fireplace might be shocking to females." (male participant),

26. The game does not discriminate in experience of players in computer-use.

76,9% (20) of the participants felt that the game does not discriminate in experience of players in computer-use. They argued that:

"The functions (actions) are basic and easy to grasp by any one." (male participant),

"Both experienced and inexperienced can play the game by learning and follow instruction." (female participant)

However a few (4) felt that the game would be difficult for novice computer users:

"Because playing the game requires some basic computer skills i.e. use mouse and keyboard." (female participant)

"The player is expected to know how to exit and start afresh." (female participant)

27. The game does not distinguish disparities in experience of players in computer games.

53,9% (14) of the participants felt that game does not distinguish disparities in experience of players in computer games: The comments given in support of this feature include:

"It looks like it could accommodate all players experienced and inexperienced." (male participant),

"Because you just follow the instructions and do it." (male participant),

"All functions can be grasped by any one." (female participant)

However the feelings of the other 46,1% (12) were well expressed by the following comment from one participant:

"Experience in computer games is advantageous." (female participant)

Frequency crosstabulations of the gender categories with all of the items (excluding 6 and 16) did not reveal any major differences between responses from male and female participants. Frequency crosstabulations of computer experience with all of the items (excluding 6 and 16) revealed major differences in responses to two items only, 29 (levels of challenge) and 35 (game is fun). These results indicate that to large extent, the VLS game user interface is unbiased with respect to gender and computer use experiences.

4.5.2.3 Game Objectives

General game objectives

For the *general game objectives* criterion (Table 4.25) of the post-test questionnaire, responses indicate that the majority of the respondents either agreed or strongly agreed with the four user interface criteria. The lower Mean Likert values for items 30, 31 and 32 are due to some participants who strongly disagreed with these items.

Table 4.25 General game objectives

	Usability requirements	Mean Likert values (Lv)					
			Gender		Computer skills		
		Over all	Female	Male	Naive	Novice	Skilled
	Item	n = 26	n = 14	n = 12	n = 7	n = 7	n = 12
29.	The game has different levels of challenge, so that players can continue playing as their skills increase	3.04	3.21	2.83	3.86	3.00	2.58
30.	The game context, characters and a story are appealing (interesting).	2.88	3.07	2.67	3.43	2.43	2.83
31.	The game has variety, so that a player can be play repeatedly without getting bored.	2.96	3.14	2.75	3.43	3.29	2.50
32.	A player can keep track of progress during play.	2.88	3.00	2.75	3.00	3.00	2.75

29. The game has different levels of challenge, so that players can continue playing as their skills increase

73.1% 1(19) of the participants felt that the game has different levels of challenge and variety. Table 4.25 and Figure 4.12 further indicate that the naive and novice players judged that game as having different levels of challenge whereas half of the skilled players considered that the game was not challenging enough. Their comments included the following:

"It is simple and does not challenge the users computer skills" (skilled, male participant).

"A good PC gamer will finish it quickly" (skilled, male participant).

"It needs common sense" (skilled, female participant).

"The game seems to be same level throughout" (skilled, male participant).

"Options of challenge are not many" (skilled, male participant)

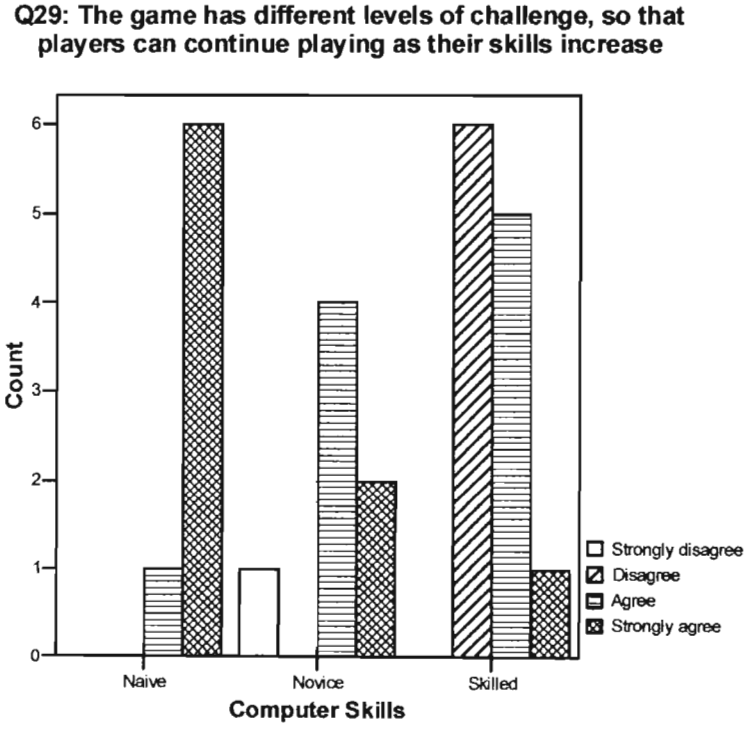


Figure 4.12 Computer skills vs. levels of challenge

30. The game context, and characters are appealing (interesting).

76.9% (19) of the participants found the game context and characters appealing because as one participant put it, "They provided the human touch" (female participant).

"For instance when chatting with *Dr. Misner* he appear on screen" (female participant).

However one participant noted that

"*Dr. Misner* has communication problems" (female participant)

These comments were in response to the erratic answers presented to some of the questions posed to the virtual character, *Dr. Misner*. The reason for this was that this character was not yet fully developed in the version of the game that was used in the evaluation.

31. The game has variety, so that a player can be play repeatedly without getting bored.

76.9%, (20) of the participants found the game context and characters to be appealing. Others were of the opinion that variety was not enough. These were mainly skilled computer users who observed that:

"Only two procedures exploring and puzzle" (male participant)

"The repetitive clicking to make something bigger (to navigate) is not very spell-binding" (male participant)

32. A player can keep track of progress during play.

The interface presented 'real time' reactions to player input actions. Hence many participants 76.9% (20) felt that the player could keep track of his or her progress.

The participants' response to items 29, 30, and 31 reveals the potential for the VLS game user interface to present different levels of challenge, to be interesting and provide variety so that a player can continue playing as their skills increase. However, skilled computer users found the present level of development of the game to lacking in levels of challenge and variety.

Motivation for learning objectives

The motivational objective of the VLS game user interface is to provide a learning environment, which is mentally stimulating, stimulate curiosity, combine fun with instruction, provide meaningful contexts, and involve tasks difficult enough to be interesting but not totally frustrating. For the *motivational for learning objectives* criterion (Table 4.26) of the post-test questionnaire, responses indicate that the majority of respondents either agreed or strongly agreed with all the four items of the user interface criteria. However the comparatively lower Lvs for items 34, 35 and 36, is an indication of some dissatisfaction.

Table 4.26 Motivational objectives

	Usability requirements	**Mean Likert values (Lv)**					
			Gender		**Computer skilss**		
		Over all	**Female**	**Male**	**Naive**	**Novice**	**Skilled**
	Item	**n = 26**	**n = 14**	**n = 12**	**n = 7**	**n = 7**	**n = 12**
33.	The game stimulates curiosity.	3.15	3.07	3.25	3.14	3.14	3.17
34.	The game provides meaningful contexts.	2.69	2.86	2.50	3.14	2.29	2.67
35.	The game is fun to play.	2.96	3.21	2.67	3.29	3.14	2.67
36.	The game is mentally stimulating.	2.92	2.79	3.08	2.57	3.29	2.92

33. The game stimulates curiosity.

92.4% (24) of the participants concurred that the game stimulates curiosity because as one "Want to know what is at the end." These positive feelings are reflected from comments such as:

"Because you became curious about what will happen next" (female participant).

"Users do not know what to expect so it keeps them interested" (male participant)

These comments reflect the observations made from the heuristic evaluation that "a user feels the need to explore within this design." However one of the heuristic evaluation participant suggested that curiosity could be further aroused by a dramatic introductory story or a mission statement.

34. The game provides meaningful contexts

73% (19) of the participants felt that the game context was meaningful. However most of the comments could not corroborate the expressed opinions. However one female participant seems to have got the correct idea about the game context when she observed that, "I can see the aim of the game to inform (us) about what we don't know about disease."

35. The game is fun to play.

A high number of participants (77.9%, 18) felt that the game was fun to play despite the fact that it was not a complete game.

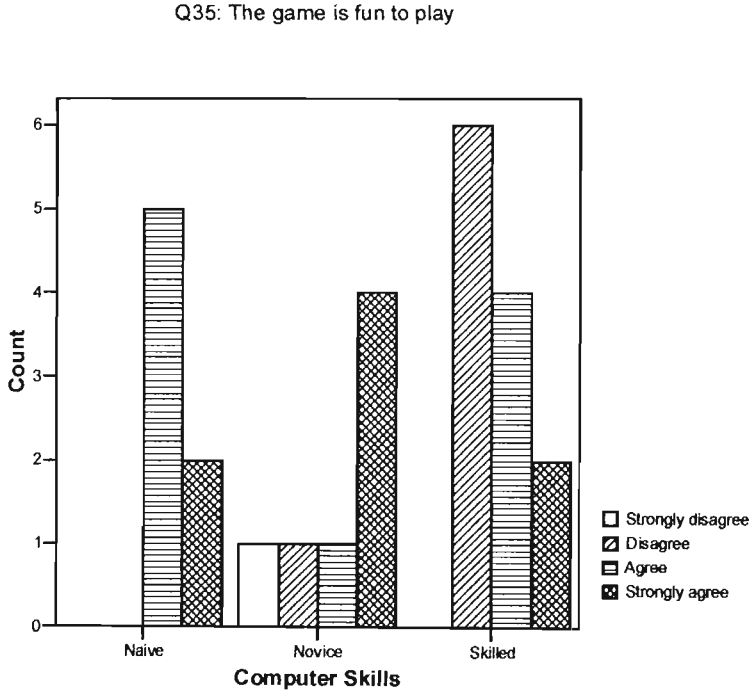


Figure 4.13 Computer skills vs. game is fun

Figure 4.13 indicates that all those who disagreed that the game was fun to play were from the group of skilled computer users who felt that:

"It is a slow-moving game" (skilled, male participant)

"Puzzle is difficult but every thing else is basic" (skilled, male participant)

"Needs more music and audio" (skilled, male participant)

36. The game is mentally stimulating.

A high number of participants (77.9%, 22) felt that the game was mentally stimulating because it makes one to "think about what do or not to do" (female participant) "especially the puzzle " (female participant). The positive responses from the majority participants suggest that the VLS game provide meaningful game contexts that have the potential to stimulate curiosity, to provide fun and are mentally stimulating. Hence it has the capacity to motivate players to play and learn.

4.6 Summary of results

The VLS game user interface player function is explorative in nature and involves four types of basic tasks, that is, navigation, interaction with the virtual character and the *Help Agent*, identification of information sources, and solving a puzzle. These tasks require three types of actions namely, moving the cursor, mouse point and click and typing. These actions resulted in visual changes (such as, colour change, zooms or pop-ups and fades) in the game play area that showed the players the effect of their actions. These changes enhanced the learnability, visibility, comprehensibility and system feedback of the VLS game user interface.

Results of the cognitive walkthrough predicted that although these actions seem to be simple, problems may arise due lack of cursor (mouse) control and typing skills required to play the game. The explorative functionality does not involve any time-constrained actions. This might be problematic to regular computer game players who are used to fast, action type games.

Results of the heuristic evaluations the VLS game user interface indicated that the three actions required to play the game were easy to learn and perform. However the problem of cursor control was also highlighted. Also the heuristic evaluation participants considered typing a disadvantage to players with no typing experience. The VLS game user interface appearance, background and landscape were considered natural and consistent with good screen design recommendations.

Hence the user interface appearance closely matches its metaphor, which is to mimic life as closely as possible. Only three heuristic violations were found:

1. Match between system and the real world, tree has unnatural shaped leaves.
2. These buttons ▼ and ✕ have no pop-up labels,
3. Primary icons not clearly visible on the dark background.

Results of the usability test and post-test questionnaire corroborated the findings from the cognitive walk through and heuristic evaluation. Results also indicate that, VLS game user interface design (appearance, interactivity and user help), player satisfaction (engagement, comprehensibility, and equitability) and objectives (player, game and motivation for learning objectives) were generally found to satisfy the usability requirements for the VLS game. However there were a few areas of dissatisfaction as shown in Table 4.27.

Table 4.27 Areas of participants' dissatisfaction

Usability Issue	Usability Parameters	Usability requirements	Areas of dissatisfaction
Interface design	Appearance	Clear and easy to see icons	Interface icons are not clearly visible on the dark background.
		Readable text-based communication	The text is small and faint.
	Interaction style	Effective player control	Lack of control when cursor is moved too quickly
Player satisfaction	Comprehensible	Easy to use	Game could be difficult for naïve computer users because it requires some basic computer skills i.e. use mouse and keyboard.
Specified objectives	Player objectives	Enjoyable experience	It is a slow-moving game. Needs more music and audio
	Game objectives	Different levels of challenge, so that players can continue playing as their skills increase	Puzzle is difficult but every thing else is basic.

Moreover, those who were computer skilled were not adequately challenged by the basic evaluation tasks that were extracted from the game. Once the development of the entire game is completed, the evaluation of the more fully integrated sections of the game will give a better indication of the extent of fun and challenge for players with a diverse range of computer skills.

Conclusions and recommendations arising from the results of this study are presented in Chapter 5.

CHAPTER 5 FINDINGS AND RECOMMENDATIONS`

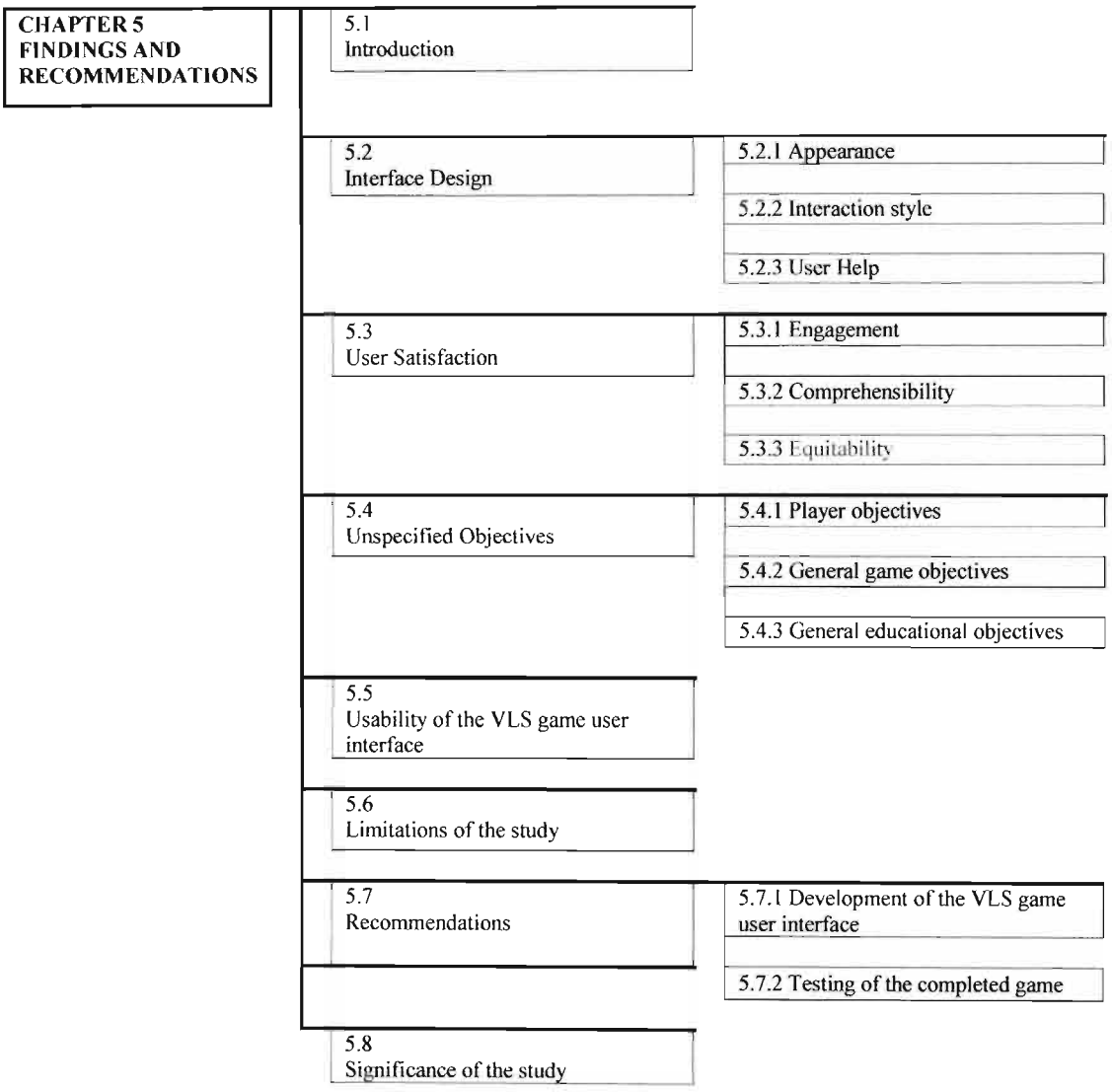


Figure 5.1 Outline of chapter 5

5.1. Introduction

In this study the usability of the VLS game user interface was assessed. The study was focused by means of key issues regarding the VLS game user interface design (its appearance, interaction style and user help), player satisfaction (engagement, comprehensibility and equitability) and specified

objectives (player objectives, game objectives and learning objectives). These issues provided the basis for the formulation the key research questions.

The study involved the construction of usability requirements for the game from a literature review of usability of virtual reality educational game systems, computer application systems and web pages. These requirements were used to design, develop and implement tools and processes used to evaluate the usability VLS game user interface and to assess whether of the VLS game user interface was functional and the extent it satisfied specified usability requirements.

A number of methods were used to evaluate the quality of the player's experience and identify usability problems. Of particular interest were differences (if any) in the problems encountered, by novice and experienced computer users, and male and female players. A cognitive walkthrough involved the examination of usability related aspects of the game interface with respect to functionality, gameplay, learnability, visibility, comprehensibility and system feedback. The objective was to uncover areas that may present usability problems. The heuristic evaluation involved a systematic inspection of the VLS game user interface by five evaluators, individually. Nielsen's heuristics were used to scrutinize the VLS game interface and to identify potential usability problems. The usability test involved observation how players from the target group interacted with the VLS game user interface. Problems that players encountered were noted. A debriefing took place after the usability test, where the test participants were given a post-test questionnaire to complete.

One of the objectives for a usability evaluation of a user interface is to assess whether the design satisfies specified usability requirements (Sutcliffe, 1995). Therefore the findings of the assessment of how the VLS game user interface satisfies it usability requirements, as well as recommendations for improvement are presented in the following sections.

5.2 Interface Design

5.2.1 Appearance

To what extent does the VLS game user interface appearance (colour, graphics and metaphor) facilitate the dissemination of information by not displaying irrelevant information, using objects, features and concepts that are familiar to the player and consistent display format across displays?

The heuristic evaluators observed that VLS game user interface choice of text font sizes and colors is consistent with good screen design recommendations. Similarly, the players perceived the VLS game user interface appearance to be realistic, almost life-like and colour, which is attractive to the eye and not dull. This indicates that the VLS game user interface is to large extent visually appealing. However the usability test participants' dissatisfaction with the visibility of the primary commands icons confirmed the findings of the heuristic evaluation that the contrast is poor hence the icons do not show clearly on the dark background.

One of the fundamental objectives of a virtual learning environment, like the VLS game, is to mimic life as closely as possible such that the difference between fantasy and real life is blurred. In the design of the VLS game user interface, this objective was achieved by displaying objects and features (e.g. forest, office, laboratory etc) that were associated with every day life of the target players.

In the usability testing, it was observed that the players recognized the concept of 'first person' representation of the player in the virtual world. "The player can see himself/herself by seeing a pointer" observed one player. Moreover, other computer games nowadays have similar concepts. However the navigation using the mouse was different and new to the players.

5.2.2 Interaction style

To what extent does the VLS game interface interaction style facilitates and enhances fast response to player input actions, reduction of errors, recovery from errors, and player control?

The VLS game user interface input actions are mouse movement, mouse point and click and typing. The interface responses to player input actions, for example the popup pictures, the puzzle entries and the communication with the virtual actors were quick. However, a delay between the "mouse click" and the changes taking place on the screen was observed during the heuristic evaluation and some of the usability test participants. This delay made navigation slow.

The VLS game user interface responds to player input in the form of mouse movement or mouse clicks. Hence the player should be in control, however most participants experienced the problem of mouse control. The actions (mouse point and click, and typing) needed to play the game, are simple enough to be redone if a mistake is made. Therefore the VLS game user interface supports undo and redo. However it took the unskilled participants approximately twice as long as the experienced participants in most tasks, this suggests that although the basic functionality of the VLS game user interface is easy to learn, it requires some practice to gain proficiency.

5.2.3 User Help

To what extent is the VLS game interface help accessible to players, easy to use, flexible, and unobtrusive?

Observations during the usability test indicate that the VLS game user interface help (the *Help Agent*) was readily accessible and easy to use. Moreover all the usability test participants were able to quickly grasp how to communicate with the *Help Agent.* Although the heuristic evaluation participants considered typing a disadvantage to players with no typing experience, the only

difference, observed, was the slightly slower typing speed of naïve players compared with the skilled players.

Observations indicated that the *Help Agent* pop-up makes the game play area inactive. Therefore *Help Agent* is obtrusive. However, it was further observed that in order to continue playing all a player needs to do is to close the help interface.

5.3 User Satisfaction

5.3.1 Engagement

To what extent can the VLS game interface provide players with extrinsic motivation in form of challenging tasks, interesting tasks, levels of player control, clear consistent feedback, and enjoyable experience?

The results from the usability test observations and comments from the posttest questionnaire, indicate that, during play, the players expressed enthusiasm to know what would happen in next the stage. Hence the players could not help it but want to carry on. This coupled with the observation " it (the game) makes you forget about other things and make your mind concentrate on it" by one of the usability test participants suggests that some participants experienced "flow" as defined by Csikszentmihalyi (1990: cited in Rieber, 1996). This suggests that the VLS game user interface has the capacity for player engagement (Jones, 1998). This is attributed to the exploratory nature of the game and the effects it provides that connects the action to what player wants to do. For example, it provides visual changes such as zooms, fades and colour change (of the cursor) that show the player the effect of his or her actions the during navigation. The pop-up screen, (Figure 1.6), for communication with virtual actor, suggests to the player the mode of interaction with the virtual actor.

5.3.2 Comprehensible

How fast can a user, who has never seen the VLS game user interface before, learn it sufficiently well to accomplish basic tasks?

Once a player has learned to use the VLS user interface, how fast can he or she accomplish a specified task?

The heuristic evaluation participants observed that the VLS user interface input actions (mouse point and click and typing) were uncomplicated and hence easy to execute. Therefore training the player requires minimal instructions and should not take a long time. This suggests that the VLS game user interface is easy to learn. This was confirmed by the observations made during the usability test where the longest time taken on the training task was only 6.13 minutes. However navigation was a problem due to lack of mouse control.

5.3.3 Equitable

To what extent does the VLS game interface accommodate, gender preferences, disparities in experience of players in computer-use, and disparities in experience of players in computer games?

The results and comments regarding *equitability*, suggests that the VLS user interface is unbiased as it accommodate all players regardless of their gender or computer use experience. This is due to the nature of the basic actions (moving the cursor and mouse point and click), which were found to be simple to carry out since the player uses only one button. In addition, the naïve player, despite having no computer skills, successfully managed to communicate with the virtual actor (*Dr. Misner*) although this required typing, using the computer keyboard.

5.4 Specified Objectives

5.4.1 Player objectives

To what extent does the VLS game interface provide an enjoyable experience and clear goals so that a player can keep track of progress during play?

As observed in section 5.3.1, the VLS game user interface has the capacity for player engagement. However according to the feedback, the enjoyment level of the game could be improved with the addition of more music and audio. Also some players would have liked the game to move faster.

The overall goal for successful completion of the game was not evident in the version used for this study, as only a subsection was available at this stage of evaluation. However sub-goals, that involved finding and using clues to solve puzzles that would lead to the final completion, did enable a player to keep track of progress during play.

5.4.2 Game objectives

To what extent does the VLS game interface provide different levels of challenge, so that players can continue playing as their skills increase; context, characters, and a story that are appealing to the player; variety, so that a player can be play repeatedly without becoming bored?

In educational computer games, the fulfilling of the game objectives does not only present the player with an entertaining and enriching experience. It also provides the motivation for the player to continue playing the game long enough to generate distinctive mental models, which are used to make sense of their experiences (Scott, Dyson and Gater, 1987: 7; Fosnot; 1996: 10). At the stage of development of the VLS game, showed a potential for the VLS game user interface to present different levels of challenge, so that a player can continue playing as their skills increase. Making the virtual world as close as possible to reality made it appealing to the player in terms of context and the virtual characters (*Dr. Misner*).

5.4.3 Motivation for learning objectives

How effective is the VLS game interface in providing motivation for learning by? Does it stimulate curiosity, meaningful contexts, combine fun with instruction and provide mentally stimulating activities?

The motivational objectives of the VLS game, are to provide a learning environment, which is mentally stimulating, stimulate curiosity, combine fun with instruction, provide meaningful contexts, and involve tasks difficult enough to be interesting but not totally frustrating. The responses from the usability test participants suggest that these objectives were achieved due to the exploratory nature of the game, which keeps the player curious to know what to expect. Moreover, making the virtual world look like the real world put it into meaningful context (Rieber 1996). Hence the usability test participants found the VLS game user interface appealing and fun.

5.5 Usability of the VLS game user interface

The hypothetical phase was used to acquaint the researcher with how the VLS game user interface is used, understand game mechanics and to investigate areas that might present usability problems. Analysis of the observations made during cognitive walkthrough suggests that the following problems were anticipated when playing the game.

- Playing the game required three types of input actions, cursor (mouse) movement, mouse point and click and typing. Hence problems in cursor control, navigation and typing due lack of skills were anticipated.
- The exploration function of the VLS game user interface requires a player to be patient and systematic. This might be problematic to regular computer game players who are used to fast action type games.

- The target player (final year high school/first year university, 17 to 20 years old) might not be familiar with the signs and text used in the VLS game user interface.

Similarly, analysis of the observations made by the heuristic evaluation team suggests that the following problems were anticipated when playing the game.

- Although the player can see clearly the changes that take place as a result of his/her actions, a delay between the "mouse click" and the changes taking place on the screen, may frustrate some players because it makes the game slow.
- The player is not in total control because sometimes the screen keeps on turning without the player's input.
- The buttons ▾ and × have no pop-up labels, therefore players may fail to utilize them properly due to lack of information about their functions.
- The tree carvings hot spot is likely to be missed by the player, because of its close proximity to another hot spot, the *fireplace* (Figure 1.7).
- The heuristic evaluation participants considered typing a disadvantage to players with no typing experience.
- Sound is not fully integrated.
- The lack of contrast between the primary command icons and the dark background may deter proper use of these icons.

Results of the usability test and post-test questionnaire corroborated the findings from the cognitive walk through and heuristic evaluation the following areas:

- The exploration function of the VLS game user interface together with a delay between the "mouse click" and the changes taking place on the screen was indeed problematic to regular computer game players who are used to fast action type games. Their comment revealed that they felt that the game was slow.

- Cursor control was indeed problematic. Players lost control when cursor was moved too quickly. This also resulted in players missing the hot spot, which led to slow navigation.
- All the players missed the tree carvings hot spot as predicted in the heuristic evaluation.
- Sound is not fully integrated. Indeed skilled computer users who felt that the game needs more music and audio to make more interesting.

However analysis of the observations made during the usability test and comments from the usability test participants show that:

- All players appropriately used the signs and text used in the VLS game user interface, including the buttons ▾ and × which had no pop-up labels.
- Although the heuristic evaluation participants considered typing a disadvantage to players with no typing experience, no player failed to type the communication with *Dr. Misner*. The different times in which players accomplished this tasked could not be attributed to lack of typing skills.
- The lack of contrast between the primary command icons and the dark background did not deter proper use of these icons. All the players were able to locate and use the *Exit* and *Help Agent* icons.

The buttons ▾and × not having popup labels was considered to be a major problem that needs to be fixed because players with no computer experience need to know the functions of these buttons are. The lack of contrast between the primary command icons and the dark background was also considered a major problem that was important to fix because of the key nature of their functions.

The more positive aspects in terms of participant feedback included:

- Appearance of the VLS user interface is visually appealing because it is almost life-like with bright and attractive colour.

- The game is an enjoyable experience because it makes you forget about other things and make your mind concentrate on it.
- The game is easy to play because it does not require the use of many buttons.
- The game stimulates curiosity. It makes one want to know what is at the end.

The more negative aspects in terms of participant feedback included:

- Not enough contrast between the primary icons and the dark background.
- The text is small and faint.
- The VLS game user interface response or feedback to player actions is not explicit.
- The *Help Agent* prevents the player from continuing with normal play.
- Experience in computer games is advantageous.

5.6 Limitations of the study

The study was undertaken while the VLS game was still in the process of development in order to develop useful criteria and tools for its usability evaluation. It was noted that there are aspects that were not included. First of all the evaluation was limited to a representative selection of tasks (Appendix VI). These tasks though representative, were disjointed. Therefore they need to be comprehensively tested in wider range of contexts that will be available in the final vision of the game. Secondly, due to the preliminary nature this evaluation, the sample size was small. Extending the evaluation to more and lager groups might give more comprehensive picture of variable viewpoints, which might not have emerged from the current sample. Thirdly, the usability test observations and post-test questionnaire were not supplemented with audio and video data as Rubin (1994) recommends.

5.7 Recommendations

5.7.1 Development of VLS game user interface

The following recommendations are made to address the usability problems that were observed in this study.

Table 5. 1 Recommendations for VLS game user interface improvement

Usability Issue		Problem	Recommendations
Interface Design	Appearance	Visibility Primary interface icons not clearly visible on the interface background. The icon labels and communication with virtual actor window text is small and faint	Use higher contrast between the primary interface icons the interface background to make the icons more clear. Use a larger font size for the icon labels and communication with virtual actor window
	Interaction style	Navigation Lack of control when cursor is moved too quickly	Provide alternative form of navigation, e.g. direction keys
	User Help	Flexibility One form of input	Provide alternative forms of input e.g. index
Player satisfaction	Comprehensible	Learnability Game could be difficult for naïve computer users because it requires some basic computer skills i.e. use mouse and keyboard	Provide a set of instructions
Objectives	Player objectives	Enjoyment level It is a slow-moving game. Lack of sound	Nature of game (cannot be changed) Needs more music and audio
	Motivation for learning objectives	Low level of stimulation of curiosity.	Make game more dramatic, e.g. include an introductory story or a mission."

5.7.2 Testing of the completed game

Testing exposed the game to authentic users from the target group. Therefore the results helped the designers to understand perspectives of the users. Perfetti and Landesman (1984) discovered that in complex user interfaces more users are needed to detect the majority of usability problems. Therefore instead of thinking of usability testing as a discrete activity that takes place once, it is

recommended to make use of ongoing usability testing, by bringing in a user or two every month until the game is finished. Secondly, instruments to evaluate the usability of an educational game were developed. It is recommended that these be revised and developed further as required and used in the final version of the game. Thirdly, it is recommended that for the testing of the final game, the mobile laboratory equipment must include simple audio and video equipment (e.g. web cams) in order to supplement the usability test observations and post-test questionnaire with audio and video data (Rubin 1994).

5.8 Significance of the study

This study assisted in checking that the VLS game user interface meets its design specifications and usability criteria. Secondly, methods and instruments to evaluate the usability of an educational game were developed. It is expected that, these will be refined and used to evaluate the usability of the final version of the game. Thirdly, testing exposed the game to authentic users from the target group. Therefore the results helped the designers to understand perspectives of the users. Lastly this study provided an information base upon which the task performance of the users can be measured (Redmond-Pyle, 1995). Hence this study laid the foundation for the construction of usability specifications for the game. The recommendations from this study have been feedback to the designer/developer team for incorporation into the subsequent versions of the game. Some of the usability problems have already been corrected in a later version. The final version of the game, GammaKhozi, is expected to be released in the first half of 2005.

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APPENDICES

APPENDIX I

Usability Context Analysis

Purpose of this questionnaire is to establish a framework how the game is to be played and to describe the *parameters* of the VLS game.

Focus group

VLS project personnel: scriptwriters. portal developer, programmer, graphical designer, and project head.

Main Objective:

Through this questionnaire I hope to get a detailed description of how the game is to be played.

1. Basic information to the user

1.1 Who are the users?

1.2 Describe the aim of the game.

2. Give a systematic description of player activities:

2.1 Describe **goal**(s) and the expected outcomes for each section of the game.

2.2 In your opinion how long **(approximately) would it take an average player to complete** each actions described in 2.1 above?

3. Describe the environments (technical, physical and organisational) in which a game is designed to operate.

3.1 What are the minimum system requirements for the game?

3.2 Will the product be used on a standalone computer or on a network (state whether inter- or intra-net.)

3.3 Where will the game be played; laboratory, training class or informal setting (home)?

4. Provide any other information that you consider to be important in establishing a context of use description and definition of the *parameters* of the game.

4.1 Have these specifications been documented before? Purpose, Functionality, The game setting, Intended users, Technical environment, Specific environmental characteristics, Tasks, Usability measures and requirements

APPENDIX II

Cognitive Walkthrough
Nielsen's Attributes of Usability (1993)

INSTRUCTIONS

Please rate the system using the heuristics.

1. Try to respond to all the items.
2. For items that are not applicable, use: **NA**
3. Add comments about each item

Evaluation Criteria

	Feature	**Characteristics**	**Comments**
A	Gameplay	Design features, Color,	
		Readability	
		Use of metaphor	
	User interface functionalities,	Dynamics	
		Determinability	
		Transiency	
		Perspective	
		Access	
		Linking	
		Player function	

B	Interaction	Feedback mechanisms	
		Familiarity	
		Error handling and prevention	
		Consistency in behavior and standards	
		Documentation	
		Help	
	Semantic meanings	Signs	
		Texts	
C	Referentiality	Concepts,	
		Structures	
		Signs	

APPENDIX III

Heuristic Evaluation

(Nielsen 1993)

INSTRUCTIONS

Please rate the system using the heuristics.

1. Try to respond to all the items.
2. Add explanations or comments about each item

SECTIONA : INTERFACE DESIGN HEURISTICS

1. Visibility of system status

The system should keep users informed about what is going on:

1.1 The player can see clearly the change that take place as a result of his/her actions.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

1.2 When a player chooses an option it is implemented within reasonable time.

disagree 1 2 3 4 5 agree

Explanation / Comments

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.....

.....

1.3 The player is in control and can see clearly where he /she is all the time.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

1.4 The VLS game user interface actions have clearly identifiable beginning and end.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

2. Match between system and the real world

Game appearance, language and concepts.

2.1 The terminology used in the VLS game is familiar to the player.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

2.2 The dialogue in the VLS game user interface is simple and natural.

disagree 1 2 3 4 5 agree

Explanation / Comments

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.....

.....

2.3 There are no technical terms used in all communications.

disagree 1 2 3 4 5 agree

Explanation / Comments

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.....

.....

2.4 The VLS game user interface follows real-world conventions; information appears in a natural and logical order.

disagree 1 2 3 4 5 agree

Explanation/ Comments

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.....

.....

2.5 The VLS game makes use of metaphors recognizable by the player from their experience of the real world.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

2.6 The VLS game user interface appearance, background and landscape are natural.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

3. User control and Freedom

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue.

3.1 All actions are simple and can simply be redone if a mistake is made.
(the VLS game user interface supports **undo and redo**).

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

3.2 In the VLS game user interface, the player can perform different options free from restrictions.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

4. Consistency and Standards

Users should not have to wonder whether different words, situations, or actions mean the same thing.

4.1 The VLS game user interface follows platform conventions.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

4.2 The VLS game user interface appearance (background, landscape) is relatively consistent from scene to scene.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

4.3 The VLS game user interface functionality/performance is the same through out.

disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

4.4 In the VLS game user interface, the position of messages on the screen is consistent.
disagree 1 2 3 4 5 agree
Explanation / Comments

.....

.....

.....

5. Error Prevention

A good system design should have ***possible user actions pre-validated.***

5.1 The VLS game user interface design prevents error problem from occurring in the first place.

disagree 1 2 3 4 5 agree
Explanation / Comments

.....

.....

.....

5.2 The VLS game user interface allows only valid actions have effect

disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

6. Recognition rather than recall

The system should make objects, actions, and options visible or easily retrievable whenever appropriate.

6.1 The player does not have to remember information from one part of the VLS game to another.
disagree 1 2 3 4 5 agree

Explanation / Comments

.....

.....

.....

6.2 Instructions for use of the VLS game are visible/accessible all the time.
disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

.....

6.3 The relationships between the VLS game actions and their results are clearly visible.
disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

6.4 In VLS game, important information/artefacts are placed in areas likely to attract player's attention.
disagree 1 2 3 4 5 agree
Explanation / Comments

.....

.....

.....

7. Flexibility and efficiency of use

Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users.

7.1 The VLS game user interface is designed to speed up interactions for experience players.
disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

7.2 The VLS game is designed to allow keyboard shortcuts.
disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

8. Aesthetic and minimalist design

All aspects of a system interface should be visually pleasing. Every extra unit of information in a system interface competes with the relevant units of information and diminishes their relative visibility.

8.1 The VLS game choice of graphics colors and object sizes is consistent with good screen design recommendations.
disagree 1 2 3 4 5 agree

Explanation / Comments

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.....

.....

8.2 The VLS game user interface choice of text font sizes and colors consistent with good screen design recommendations.
disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

.....

8.3 The VLS game dialogues do not contain information that is irrelevant.
disagree 1 2 3 4 5 agree
Explanation / Comments

.....

.....

.....

8.4 The VLS game **scenarios** do not contain information that is irrelevant.
disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

9. Error recognition, diagnosis, and recovery

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution

9.1 VLS game error messages are expressed in simple ordinary language (no codes).
disagree 1 2 3 4 5 agree
Explanation / Comments

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9.2 The VLS game error messages precisely indicate the problem.
disagree 1 2 3 4 5 agree
Explanation / Comments

.....

.....

.....

9.3 The VLS game error messages constructively suggest a solution.
disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

10. Help and Documentation

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation.

10.1 The VLS game help and documentation is easy to search.
disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

.....

10.2 The VLS game help is context specific (focused on the user's task).
disagree 1 2 3 4 5 agree
Explanation / Comments

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.....

.....

10.3 VLS game user interface help and documentation list concrete steps to be carried out.
disagree 1 2 3 4 5 agree

Explanation / Comments

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.....

.....

10.4 Help and documentation of the VLS game is not too large

disagree 1 2 3 4 5 agree

Explanation/ Comments

.....

.....

.....

SECTION B: EDUCATIONAL DESIGN HEURISTICS

11. Educational principles

An educational game's general educational objectives should be consistent with educational principles and theories (constructivism).

11.1 The VLS game stimulates curiosity.
disagree 1 2 3 4 5 agree
Explanation/ Comments

.....

.....

.....

11.2 The VLS game combine fun with instruction.
disagree 1 2 3 4 5 agree
Explanation/ Comments

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.....

.....

11.3 The VLS game provides meaningful learning contexts.
disagree 1 2 3 4 5 agree
Explanation/ Comments

.....

.....

.....

11.4 The VLS game require player to identify and solve problems related to learning objectives of the game.
disagree 1 2 3 4 5 agree
Explanation/ Comments

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.....

.....

11.5 The VLS game require player to identify, collect, analyze, organize and critically evaluate information.
disagree 1 2 3 4 5 agree
Explanation/ Comments

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.....

.....

11.6 The VLS game provides player with self-assessment opportunities that are aligned with its educational objectives.

disagree 1 2 3 4 5 agree

Explanation/ Comments

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11.7 The VLS game provides a well-integrated media (reading, listening and pictures or demonstrations).

disagree 1 2 3 4 5 agree

Explanation/ Comments

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.....

12. Clear goals and objectives

The software makes it clear to the learner what is to be accomplished and what will be gained from its use.

disagree 1 2 3 4 5 agree

Explanation/ Comments

.....

.....

.....

13. Context meaningful to domain and learner

The activities in the software are situated in practice and will interest and engage a learner.

disagree 1 2 3 4 5 agree

Explanation/ Comments

.....

.....

.....

14. Content clearly represented and navigable

The message in the software is unambiguous. The software supports learner preferences for different access pathways. The learner is able to find relevant information while engaged in an activity.

disagree 1 2 3 4 5 agree

Explanation/ Comments

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.....

15. Activities scaffolded

The software provides support for learner activities to allow working within existing competence while encountering meaningful chunks of knowledge.

disagree 1 2 3 4 5 agree

Explanation/ Comments

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.....

.....

16. Elicit learner understandings

The software requires learners to articulate their conceptual understandings as the basis for feedback.

disagree 1 2 3 4 5 agree

Explanation/ Comments

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.....

17. Formative evaluation

The software provides learners with constructive feedback on their endeavors.

disagree 1 2 3 4 5 agree

Explanation/ Comments

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.....

18. Performance should be 'criteria-referenced'

The software will produce clear and measurable outcomes that would support competency-based evaluation.

disagree 1 2 3 4 5 agree

Explanation/ Comments

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.....

.....

19. Support for transference and acquiring 'self-learning' skills

The software supports transference of skills beyond the learning environment and will facilitate the learner becoming able to self-improve.

disagree 1 2 3 4 5 agree

Explanation/ Comments

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.....

.....

20. Support for collaborative learning

The software provides opportunities and support for learning through interaction with others through discussion or other collaborative activities.

disagree 1 2 3 4 5 agree
Explanation/ Comments

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ANY OTHER COMMENTS AND OBSERVATIONS

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APPENDIX IV

Background questionnaire

INSTRUCTIONS

1. Try to respond to all the items.
2. For items that are not applicable, use: **NA**

SECTION A: PERSONAL DETAILS

1. Your age.

2. Gender Male Female

3. Regional location of high school(s) attended

Township Town/suburbs

SECTION B: COMPUTER SKILLS

4. Rate your skill at using a computer:

Never used Novice Competent Advanced Expert

Other (please explain)

.....

.....

5. Rate your confidence when you use a computer:

Very confident Confident Some confidence Little confidence No confidence

Other (please explain)

.....

.....

6. How often do you use a computer?

Every day Every 2 to 3 days Once a week Once or twice a month

Less than once a month Never

Other (please explain)

.....

.....

7. Have you ever played computer games? Yes No

If you answered Yes to question 8 continue with the next question; if you answered No to question 7 proceed to question 10.

8. Name the games you have played?

.....

.....

9. What kind of computer games do you prefer to play?

.....

.....

10. Do you consider that you could learn something by playing a computer game?

.....

.....

.....

11. Any further comments you would like to make about computer games?

.....

.....

.....

.....

APPENDIX V

Observation Instrument **Player Number.....**

Task	Instructions	Time	signs	Observations
1.	**The burning ground.** Training task			
2.	Purpose: general navigation .		➨ ✕	
3.	**Misner's Office** Purpose: Idintify possible clues		➨	
4.	**Interaction with puzzle** Purpose: Interaction with puzzle		➨	
5.	**Interaction with virtual player** Purpose: communication .		**Send** ✕	
6.	**Interaction with Help Agent** Purpose: accessibility		?	

Any other comments:

APPENDIX VI

Test Tasks

The VLS Game is an educational adventure game designed to improve the acquisition of knowledge through play. When the game is played, the mouse is used for all navigation and interaction with the game. A player is able to move forward or backwards, or is able to turn right or left. The path that the player follows through the game is represented by a number of active nodes that the player navigates by means of mouse point-and-click actions.

The mission is to explore this place looking clues and information. While investigating the game space the player finds objects, which can be collected, and solves puzzles to gain additional information or to progress to other game areas.

EVAVUALUATE THE GAME BY DOING THE FOLLOWING TASKS

Task	Purpose	Instructions
1.	Training task	**CLICK ON BURNING GROUND** Explore the place and look for objects that may provide clues that may be of help to you in your investigation.
2.	General navigation	Go back into the game play, from the *Fireplace* picture, look around for any other clues and the finally go back to the starting place in the first task. **EXIT**
3.	Idintify possible clues	**CLICK ON PUZLE** Explore and look for objects that may provide clues that may be of help to you in your investigation. **When you finish, go to TASK 4.**
4.	Interaction with puzzle	Do the puzzle using the following answers Vaccine, Irradiation, Age, Herpes, Carcinogen, Chemotherapy, Tumor, Diet, Sarcoma, Malignant, Virus, Cancer, Cell **CLOSE**
5.	Communication with virtual character	**CLICK ON Talk to Dr Misner** Ask the man five simple questions. Write down your questions and his answers. **CLOSE and** **EXIT**
6.	Interaction with Help Agent	**CLICK ON Help Agent** Find the *Help Agent* and ask him two simple questions. Write down your questions and his answers. **CLOSE and** **EXIT**

APPENDIX VII

Post-test Questionnaire

This instrument is based on System Usability Scale (SUS) questionnaire and System Usability Measurement Instrument (SUMI)

The aim of this project is to carry out an evaluation of the game in order to determine faults and problems, which may hinder implementation. The aim of this questionnaire is to evaluate the quality of a user's experience when interacting with the game. You are therefore, requested to respond to the following statements regarding your opinion of the game.

INSTRUCTIONS

Please rate the system using the following statements.

1. Try to respond to all the items.

2. Mark with an ✕ in the box of your choice.

3. Add explanations or comments or give reasons for your choice in each item.

NOTE: -

SA = strongly agree

A = agree

D = disagree

SD = strongly disagree

A. INTERFACE DESIGN

- Appearance

To what extent does the VLS game user interface appearance (colour, graphics and metaphor) facilitate the acquisition of correct information?

1. The general appearance of the game is visually appealing. | SA | A | D | SD |

Explain/Give reasons

.....

.....

2. The colour of the game display is pleasing. | SA | A | D | SD |

Explain/Give reasons

.....

.....

3. The objects and icons are clear and easy to see. | SA | A | D | SD |

Explain/Give reasons

.....

.....

4. The game displays objects, features and concepts that are familiar to the player. | SA | A | D | SD |

Explain/Give reasons

.....

.....

5. Text based communication is easy to read. | SA | A | D | SD |

Explain/Give reasons

.....

.....

6. The display format of the game is consistent across displays. | SA | A | D | SD |

Explain/Give reasons

.....

.....

- Interaction method

To what extent does the VLS game interface design facilitate and enhance interaction between player and game?

7. The response to player input actions were fast enough (quick system response). | SA | A | D | SD |
   Explain/Give reasons

   .....

   .....

8. It is easy to play the game such that the making of mistakes is minimal. | SA | A | D | SD |
   Explain/Give reasons

   .....

   .....

9. When the player makes a mistake it is easy to undo/correct it. (recover from the error). | SA | A | D | SD |
   Explain/Give reasons

   .....

   .....

10. The player is in control of at all times. | SA | A | D | SD |
    Explain/Give reasons

    .....

    .....

11. Player control of the mouse is compatible with cursor movement. | SA | A | D | SD |
    Explain/Give reasons

    .....

    .....

12. The player can establish (see) where he/she has been, is and is going. | SA | A | D | SD |
    Explain/Give reasons

    .....

    .....

13. The game response (feedback) to player actions is clearly noticeable (can be seen). | SA | A | D | SD |

Explain/Give reasons

.....

.....

- User Help

How effective is the VLS game interface help?

14. The player is able to access help at any time when playing the game (readily available/accessible). | SA | A | D | SD |

Explain/Give reasons

.....

.....

15. The game help (help agent) is easy to use. | SA | A | D | SD |

Explain/Give reasons

.....

.....

16. The game help allows each player to use it in a way appropriate to his/her needs (is flexible). | SA | A | D | SD |

Explain/Give reasons

.....

.....

17. The game help does not prevent / hinder the player from continuing with normal play (is unobtrusive). | SA | A | D | SD |

Explain/Give reasons

.....

.....

B. PLAYER SATISFACTION

- Engagement

To what extent can the VLS game interface provide players with intrinsic motivation?

18. The game tasks are interesting. | SA | A | D | SD |
Explain/Give reasons

.....

.....

19. The game tasks are challenging. | SA | A | D | SD |
Explain/Give reasons

.....

.....

20. The game response/feedback to player actions is clear and consistent. | SA | A | D | SD |
Explain/Give reasons

.....

.....

21. Playing the game is an enjoyable experience. | SA | A | D | SD |
Explain/Give reasons

.....

.....

22. I felt very confident playing the game. | SA | A | D | SD |
Explain/Give reasons

.....

.....

- Comprehensible

Is the game easy to learn and play?

23. I think that most people would learn to play this game very quickly
Explain/Give reasons

SA	A	D	SD

.....

.....

24. I think the game was easy to play.
Explain/Give reasons

SA	A	D	SD

.....

.....

- Equitable

To what extent does the VLS game interface accommodate differences in player gender and cultural and educational backgrounds?

25. The game does not have gender sensitive material.
Explain/Give reasons

SA	A	D	SD

.....

.....

26. The game does not discriminate in experience of players in computer-use.
Explain/Give reasons

SA	A	D	SD

.....

.....

27. The game accommodates differences in experience of players in computer games.
Explain/Give reasons

SA	A	D	SD

.....

.....

28. The game accommodates differences of players' academic background. | SA | A | D | SD |
Explain/Give reasons

.....

.....

C. GAME OBJECTIVES

- General game objectives

To what extent does the VLS game interface satisfy general game objectives?

29. The game has different levels of challenge, so that players can continue playing as their skills increase. | SA | A | D | SD |
Explain/Give reasons

.....

.....

30. The game context, characters and a story are appealing (interesting). | SA | A | D | SD |
Explain/Give reasons

.....

.....

31. The game has variety, so that a player can be play repeatedly without becoming bored. | SA | A | D | SD |
Explain/Give reasons

.....

.....

32. The game has clear goals, so that a player can keep track of progress during play. | SA | A | D | SD |
Explain/Give reasons

.....

.....

- General educational objectives

To what extent does the VLS game interface comply with the general education objectives?

33. The game stimulates curiosity. | SA | A | D | SD |
Explain/Give reasons

.....

.....

34. The game provides meaningful contexts / circumstances. | SA | A | D | SD |
Explain/Give reasons

.....

.....

35. The game is fun to play. | SA | A | D | SD |
Explain/Give reasons

.....

.....

36. The game provides mentally stimulating activities. (is mentally stimulating). | SA | A | D | SD |
Explain/Give reasons

.....

APPENDIX VIII Post-test Questionnaire
(First Version)

INSTRUCTIONS

Please rate the system using the following questions.

1. Try to respond to all the items.

2. Add explanations or comments about each item

3. SA = strongly agree A = agree D = disagree SD = strongly disagree

1. Overall, I am satisfied with how easy it is to use this system. **SA A D SD**

Comments

.....

.....

2. It was simple to use this system. **SA A D SD**

Comments

.....

.....

3. I feel comfortable using this system. **SA A D SD**

Comments

.....

.....

4. It was easy to learn to use this system. **SA A D SD**

Comments

.....

.....

5. **The system gives error messages that clearly tell me how to fix problems.**

SA A D SD

Comments

.....

.....

6. Whenever I make a mistake using the system, **I recover easily and quickly**.

SA A D SD

Comments

.....

.....

7. . VLS user interface actions can be reversed easily **SA A D SD**

Comments

.....

.....

8. The information (such as online help, on-screen messages, and other documentation) provided with this system is clear.

SA A D SD

Comments

.....

.....

9. The information provided for the system is easy to understand.

SA A D SD

Comments

.....

.....

10. The information is effective in helping me complete the tasks and scenarios.

SA A D SD

Comments

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11. I found the VLS game mentally stimulating **SA A D SD**

Comments

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12. I found the VLS game thought provoking **SA A D SD**

Comments

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13. I found the VLS game exciting **SA A D SD**

Comments

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14. I found the VLS game self-motivating **SA A D SD**

Comments

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15. I found the VLS game informative **SA A D SD**

Comments

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16. I found the VLS game enjoyable **SA A D SD**

Comments

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17. List the most **negative** aspect(s) of the game.

Comments

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18. List the most **positive** aspect(s) of the game.

Comments

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