A study to determine if experience with mouse-orientated computer games enhances the value that a user draws from an office package in a GUI environment

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List of Abbreviations

ANOVA   Analysis of Variance

BM   Black Male

CD   Compact Disk

CUF   Computer Use Frequency

CUT, FS   Central University of Technology, Free State

DOS   Disk Operating System

FPS   First Person Shooter

GUI   Graphical User Interface

HCI   Human Computer Interaction

HR   Human Resources

IC   Integrated Circuits

ICT   Information and Communication Technology

iCGames   Eye-Coordination Games

IT   Information Technology

LED   Light Emitting Diode

Mouse   A computer peripheral, computer mouse, used as input device

MS Word   Microsoft Word

OAI   Object-action interface model

OS   Operating System

Researcher   The researcher of this study

RPG   Role Playing Game

WM   White Male

Chapter 1
Introduction and Aim of Study

> Computer literacy is the ability to use computer peripherals and software applications [Harris and Hodges, 1995].

1.1 Introduction

It has become very clear that over the past two decades more and more people have started to use computers in their everyday lives. They do not only use computers in their daily work activities but also for communication, information, study and relaxation purposes. Individuals and society are currently undergoing a paradigm shift towards the use of computers. Today individuals and the business world are dependent upon computers for communication, distribution of information (within and between organisations), execution of their daily tasks and survival in the market place.

Simply by observing the number of schools and universities that now have computer laboratories and offer computer training, one can see that the number of computer users in South Africa is increasing at an enormous rate. Computer use is transforming the lives of many South Africans and is fast changing the way organisations communicate and do business. It also means that thousands of people in South Africa, from different cultures, races and age groups, are coming into contact with and using computers, either at home, at school or university, at the office or even at shopping malls.

Many middle-aged people, however, are afraid of computers and have a negative attitude towards them and the new technologies which accompany them [Nel, 2002]. These people feel uncomfortable with and afraid of the

computer because they grew up in an environment that perhaps did not even have electricity: they believe that they will never be able to learn how to use this new technology. Younger people, however, do not experience new technology as a threat, but rather as a challenge. Many of them are growing up with computers in their own homes, and computer literacy has now become a priority rather than a problem.

1.2 Necessity of the study

Simonson, Maurer, Montag-Torardi and Whitaker [1987, p231-247] define computer literacy as "an understanding of computer characteristics, capabilities, and applications, as well as an ability to implement this knowledge in the skilful, productive use of a computer application suitable to individual roles in society."

In order for a user to become computer literate he/she needs to know how to use the computer application effectively. This can only be achieved if he/she knows, *inter alia*, how to use the computer mouse as an input device.

For a computer literate user the computer mouse is not a difficult device to use. As a matter of fact, the use of the computer mouse should be second nature (become transparent) when the user uses an application in a Graphical User Interface (GUI) environment. The computer mouse is seen as the easiest, but not the only, way to navigate through a GUI.

Computers with a GUI make use of a keyboard and mouse. In the Windows environment, however, it is possible to navigate and use the computer just with a keyboard. Some users, however, prefer to use the mouse to make the interaction between themselves and the computer easier and much faster. A computer mouse has limited functions: left click, right click, drag, move, scroll and double click. With these mouse functions a user can navigate and use a computer much more effectively than with a keyboard alone.

1.2.1 Novice/First time computer users

There are many first-year students at universities who have never used a computer before. Many students from previously disadvantaged groups (this includes all people that were discriminated against according to race and include all black and coloured people) have hardly ever had the opportunity to touch a computer, let alone own one. In most cases such students need to undergo a computer literacy course, generally for six months or a year. The idea of this computer literacy course is to teach the student basic computer concepts and computer skills, including the effective use of the computer mouse and keyboard.

During the practical computer classes at the Central University of Technology, Free State (CUT, FS) it has been noticed that many previously disadvantaged students have no idea of how to use a computer mouse. Even after they have been shown how to hold and move the mouse, many of them still struggle for some time to use the mouse effectively. They find it difficult to master the movement of the mouse cursor, which is on a vertical surface, by moving the mouse which is on a horizontal surface. When they have eventually positioned the cursor over a button or icon, they struggle to click one of the mouse buttons. Some of them let go of the mouse and then try to press the button with one finger - while looking at the mouse, and not at the computer screen. In many cases this technique results in the mouse cursor moving off the desired location and then the mouse click has no effect. Others try to perform the click function by holding the hand over the mouse and pressing the button with the index finger; they fail, however, to keep the mouse still, which results in the mouse cursor once again moving off the desired location. They struggle even more to perform a double click.

How can such a user master a computer program when he/she is still struggling to use the computer mouse effectively? A novice/first time computer user (refer to section 3.7) sees the computer keyboard and the mouse as hindrances, rather than as aids. When a user has not been able to master the mouse

effectively he/she concentrates more on the mouse than on the computer program that he/she is supposed to be learning in the computer literacy class. This leads to stress on the part of the user, and he/she may fall behind the rest of the class. Such a user often hinders the progress of the class as the lecturer has to give special attention to the struggling individual.

1.2.2 The ideal environment

If one wishes to have a novice/first time computer user study a computer software package effectively, one must eliminate the stumbling blocks. The primary focus of a computer literacy class is to teach the user to master a specific computer package such as the Microsoft Office suite. The user is not supposed to fall behind because of his/her inefficiency in using the computer mouse. For the user, the use of the mouse must become second nature.

The Windows desktop environment and even a software package like Microsoft Office suite is not the ideal environment in which to teach a user how to use the computer mouse effectively. In the first place, the novice/first time computer user is not familiar with the environment and secondly the environment is not designed for teaching a user how to use a mouse. The environment assumes that the user already knows how to use the mouse effectively.

A more suitable environment for teaching a user how to use a computer mouse is a mouse-orientated computer game which uses the same mouse functions as the GUI (Windows environment) and software applications (Microsoft Office Suite), but with a much simpler approach. In the gaming environment, the user will be less stressed about doing something wrong, like deleting his/her whole day's work: in this environment there is less to lose; at least as far as economical productivity is concerned. Most users also find games enjoyable and relaxing. A user will learn to use a mouse more quickly in this relaxed and

enjoyable environment, simply because he/she is not constantly worrying about doing something wrong and perhaps losing important information.

1.3   Research question and goals

When it became evident to the researcher that novice/first time computer users were struggling with the effective use of the computer mouse as input device, the following research goal was formulated:

The purpose of this study is to determine whether experience with mouse-orientated computer games enhances the value that a user draws from an office package in a GUI environment.

Value, as defined by Dictionary.com [2006d] is to rate according to relative estimate of worth or desirability. In this research, value refers to enhanced productivity of users where users make fewer errors in the office package which in turn results in higher economical gain.

Some additional research questions are: How long does it take a novice/first time computer user to master the basic mouse skills? How long does it take for the user to become discouraged if unsuccessful? What are the minimum mouse skills a user needs to have to use a computer effectively? How long does it take a user to reach a plateau in mouse proficiency, and thereafter, how long does it take him/her to show improvement in mouse proficiency again?

During this study the ability of various users to use the computer mouse will be tested.   The following mouse functions will be tested individually and in combination with one another: left click, drag, move and point. These mouse functions will be tested through the playing of six mouse-orientated computer games that were specifically developed for this study (refer to Appendix A).

These games will be used to capture data related to the various mouse functions. The data will be statistically analysed and the results will be used to find answers to the above stated research questions.

From the preceding paragraphs, the following primary and secondary objectives, as stated in sections 1.3.1 and 1.3.2, can be stipulated.

1.3.1 Primary objective

The primary hypothesis of the study may be formulated as follows:

The playing of mouse-orientated computer games does not enhance the value that a novice/first time computer user draws from an office package in a GUI environment.

The primary objective of this study is to determine whether this hypothesis is true, i.e. whether the playing of mouse-orientated computer games is purely for relaxation and whether it in fact holds no benefits other than this.

This hypothesis will be investigated by:

❖ looking at previous related research on computer mouse hand-eye coordination, computer games in education and training, the history of the computer operating system and the GUI;

❖ analysing the data captured from the users as they play the various mouse-orientated computer games;

❖ analysing the data captured from the completed Microsoft Word tests by a separate group of users who have also played the mouse-orientated computer games.

1.3.2 Secondary objective

The secondary hypothesis of this study may be formulated as follows:

Frequency of computer use has no influence on the maximum skill level that a novice/first time computer user can reach with a mouse-orientated computer game.

1.4 Research design

1.4.1 Research participants

A number of groups of students were included in this study. They played various mouse-orientated computer games and completed tests in Microsoft Word. These students included first, second and third year Information Technology (IT) students as well as a group of first year computer literacy students from various faculties including Management Sciences and Engineering. The necessary permission was obtained from the relevant lecturers and the director of the School of Information and Communication Technology at CUT, FS to make use of these participants.

1.4.2 Measuring instruments

Various tools were developed to gather the data needed for the investigation of the above-mentioned hypotheses. A brief discussion of the instruments used in this study follows in the next few paragraphs. A more detailed description of all the instruments will follow in Chapter 5 and Appendix A.

1.4.3 The computer games

The first group of research participants were allowed to play the mouse-orientated computer games during the first and second terms in 2005, while the third and part of the fourth terms in 2005 were set aside for the second group of research participants. It was not required from the participants to have any specific level of mouse skill proficiency. Various computer laboratories of the School of Information and Communication Technology at CUT, FS were used for this research. The participants were given the opportunity to play all the games as often as they liked, and they were encouraged to see whether they could improve on their scores for each game. A list of the top ten highest scores in each game motivated the students to improve on their own score for each specific game. This also motivated them to try and obtain the highest score in each game and to be the best student in the group. Students also challenged one another.

The playing of the games took place in the participants' practical periods as well as during lunch times when the computer laboratories were available. While the participants were playing the games, data regarding the use of the various mouse functions were captured for each of them.

Each participant also had to complete an electronic form which captured his/her demographic details: name, surname, name of calling (if any), age, gender, nationality, frequency of computer usage, student number and password.

The games were specifically developed to utilise mouse handling skills that are necessary to use a mouse effectively in a normal computer working environment. The games required the use of skills such as move, drag, click, point and a combination of these. The games that were used to gather the data needed to determine the participants' computer mouse hand-eye coordination (mouse skill) were the following:

1. *Infestation*

Infestation is a game in which the player has to squash as many spiders (bugs) as possible within a time limit. Refer to Appendix A, section A.2.4.

2. *Plane Blaster*

In this game the player must shoot down as many planes as possible within a limited time. Refer to Appendix A, section A.2.5.

3. *Pool*

The version of pool that the player confronts in this game is similar to the normal pool that one would play on a pool table, except that the player can sink any ball at any given time. Again the player has a time limit to complete the game. Refer to Appendix A, section A.2.6.

4. *Bunny Wack*

The player must hit as many bunnies as possible, which are appearing randomly from various holes within a fixed time.   Refer to Appendix A, section A.2.7.

5. *Speed*

In this game the player must drag a ball across a floating platform, picking up keys along the way and then escaping at the end without falling off the sides of the platform. The players' total time is measured. Refer to Appendix A, section A.2.8.

6. *Rescue*

The aim of the game is to rescue as many astronauts as possible, within a time limit, while dodging asteroids. Refer to Appendix A, section A.2.9.

Each of these games measures different mouse skills or combinations of mouse skills. Table 1.1 summarises the different mouse skills that were measured in the above mentioned games.

	Move	Point	Click	Drag	Speed
Infestation	✓	✓	✓	-	-
Plane Blaster	✓	✓	-	-	-
Pool	-	✓	✓	-	✓
Bunny Wack	-	✓	✓	-	✓
Speed	-	-	-	✓	✓
Rescue	✓	-	-	-	-

Table 1.1: Summary of mouse functions per game

A more detailed discussion of the games will be given in Appendix A.

1.4.4 Microsoft Word test

The first group of participants played the games only. The second group did not only play the computer games but also completed a Microsoft Word (MS Word) test several times, in different sessions. This group of students was tested during lunch time in one of the above-mentioned computer laboratories.

The time it took a participant to complete a question as well as the total time taken to complete the whole MS Word test was measured with a timer application running on the computer. The correctness of the completed test was also calculated and all the scores that the user obtained in the games were captured and stored in the database.

A more detailed discussion of the timer application as well as the MS Word test will be provided in Chapter 5.

1.5 Methodology

This study consists of two phases.

1.5.1 Phase 1

In phase 1 of the study the first group of participants only played the six mouse-orientated computer games. The data was gathered and stored in a database. This data was then analysed using different statistical tools to determine whether:

- ❖ the race[*] of the student played any significant role in the way the mouse was used; in other words, should this study distinguish between different races or could race be ignored?

- ❖ the difficulty levels of the games played any significant role. Could the scores that the players obtained on the different levels of difficulty of a specific game be grouped together or should they be kept separately?

- ❖ computer use frequency (CUF) played any significant role. Did students who used a computer more frequently obtain higher scores in specific games in comparison with students who used a computer less frequently?

In this phase the effectiveness of the games was tested. Such aspects as whether the games functioned properly, and which of the games measured a specific mouse function the most effectively, were considered. The three most effective games were used in phase 2.

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[*] The use of the word Race does not refer, in any way, to skin colour in a discriminating way. It refers to the person's social economical background and the fact that education at school did not take place in the person's mother tongue.

1.5.2 Phase 2

In phase 2 a new group of participants was used. This group consisted of 16 students. Only the three most effective games were used because some of the same mouse functions were repeatedly measured in different games and testing time was limited.

In this phase, the students did not only play the games, but also completed a number of Microsoft Word (MS Word) tests. In each of the ten sessions the students first completed the MS Word test, then played the three games, after which the same MS Word test was done again. The data captured by the games, the time it took to complete the individual MS Word tests, and the correctness of the MS Word tests were analysed in an attempt to answer the following questions:

- ❖ Is there a difference between the average total completion time for the first MS Word test and the second MS Word test?

- ❖ Is there a difference in the average total completion time between the different sessions?

- ❖ Is there a difference in the average total mark for the first MS Word test and the second MS Word test in any session?

- ❖ Is there a difference in the average total mark between the different sessions?

- ❖ Does a student's score in any of the three games remain constant through different attempts and sessions?

- ❖ Is there a correlation between the score that a user obtains in one of the games and the total completion time for the MS Word test in the different sessions?

In both phases the simple random sampling model was used to gather a sufficient number of research participants for the tests.

1.6   Value of the research

The findings of this study may be used as a recommendation to implement game-playing as an introduction to a computer literacy course. Usually the first week of a computer literacy course consists more of an introduction to the subject than anything else. This first week could be used more effectively to improve the computer mouse hand-eye coordination of the students by means of the mouse-orientated computer games. This could assist in minimising the difficulty experienced by students regarding the mouse, so that using the mouse can become second nature for the student. This will not only assist the student in improving his mouse skills but it will also enable him to focus on the course work, i.e. the Windows environment and the office applications, rather than on the mouse. The lecturer and those students who are already comfortable with the computer mouse will also benefit because less time will be spent helping the struggling students with the mouse.

Secondly, the findings of this study may be used to develop new and/or better games that might help students to develop their computer mouse hand-eye coordination faster. New games might also be more enjoyable and more visually attractive. Thirdly, such games might be used not only in tertiary institutions, but may also be made available to employees to play during their lunch breaks at work. This could improve their computer mouse skills and they may become more productive in a relaxed environment without even realising it.

1.7   Chapter outline

The layout of the study as presented in this dissertation is described below.

1.7.1 Chapter 1 - Introduction and Aim of Study

In this chapter an introduction and overview of the dissertation is given. The problem is stated briefly and the objectives of the study are discussed. This chapter establishes who the research participants will be, and outlines the measuring instruments to be used in the study. Furthermore, the value and the benefits of the research are discussed.

1.7.2 Chapter 2 - Exposure to Computers through Computer Games

The focus of this chapter is on the various benefits of computer games. The benefits range from the improvement of fine motor abilities to the educational aspects of computer games.

1.7.3 Chapter 3 - Graphical User Interfaces and the Computer Mouse

The computer mouse as input device is discussed in this chapter. The history of the operating system is discussed in an attempt to establish the origins of the GUI. Finally, this chapter ends with Shneiderman's [1983] definition of the different types of computer users.

1.7.4 Chapter 4 - Methodology Outline

This chapter gives a broad outline on the methodology that is followed in this study. It focuses on the different phases of data collection and analysis, and certain questions are posed that will be investigated in Chapter 5.

1.7.5 Chapter 5 - Analysis and Results

The results of the statistical analysis of the captured data are discussed in this chapter, with various graphs and tables provided to highlight the results. The conclusions reached as a result of the data analysis are employed in the attainment of the primary and secondary objectives of this dissertation.

1.7.6 Chapter 6 - Conclusion

In this final chapter a summary is given on all the results that were discussed in detail in Chapter 5. The objectives and final conclusions reached are discussed, and recommendations are made for the way forward in this field.

1.7.7 Appendix A - Instruments Used – Games

An explanation of the games is given, and the mouse functions and scoring are discussed in detail in this appendix.

1.7.8 Appendix B - Printed Microsoft Word test

This appendix shows the Microsoft Word tests that were printed and handed out to the second group of respondents. These were the questions that they had to complete before playing the games.

1.7.9 Appendix C - Partially completed Microsoft Word Document

This appendix shows the partially completed Microsoft Word document that was given on stiffy to the second group of respondents. They completed this electronic file using the printed Microsoft Word test questions.

1.7.10 Appendix D - Correct Microsoft Word Document

This appendix shows what the correct Microsoft Word document looked like after the completion of the test questions.

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Chapter 2
Exposure to computers through computer games

According to Eisenberg and Johnson [2002] computer literacy is not the knowing of how to operate computers, but to use technology as a tool for research, problem solving, organization and communication.

Spatial integration is "the perceptual ability to create meaning by manipulating visual and auditory forms of information." [Natale, 2002, p27].

2.1 Introduction

For a novice/first time computer user to use an office application effectively he/she must be able to use the computer mouse. It was observed by the researcher that many novice/first time users were struggling to use the computer mouse effectively. The only way to acquire this skill is through practice. In order to work competently in the Graphical User Interface (GUI) or office application, using the mouse must become second nature to the user. The user must be able to use it effortlessly and without actually even being aware that he/she is using it.

The computer mouse, as input device, does not only play a significant role in the operating system's GUI but also serves as the main or primary input device in many computer games. Computer games are played by many people around the world for relaxation, entertainment and even tournament purposes. Players range from school children to adults, and encompass both male and female players.

Obviously, if the computer mouse is the main input device in computer games, then gamers must have excellent computer mouse hand-eye coordination and they must be able to use the mouse effectively in a GUI environment. It has been observed that computer programmers, who spend many hours programming, have weaker computer mouse hand-eye coordination than that of computer gamers. The purpose of this study is *to determine whether mouse-orientated computer games enhance the value that users draw from an office package in a GUI environment.* In other words, can the novice/first time computer user acquire the mouse skills, which are needed to use the office application effectively in the GUI environment, through the playing of mouse-orientated computer games?

The rest of this chapter will focus mainly on the benefits of playing computer games.

2.2 Benefits of playing computer games

Sociological data reveals how popular video games have become. The data reflects a totally established reality, and one that is still growing. A powerful cultural video game industry has been established that is constantly evolving, and this evolution includes hardware and software advances. It is a virtual universe frequently visited by millions of citizens, especially younger people (which includes everyone under 35, since, although the first generation of players has matured, they have not given up their hobby) [De Aguilera & Mèndiz, 2003].

It has been generally observed that more and more people, mostly males, play games, which they see as a hobby or sometimes as a way of escaping the real world. They are able to run around in and become part of a fantasy world which allows them to switch off after a busy day at work. Males are the primary players of computer games, and one of the reasons for this is because they are

specifically targeted by the marketing departments of software firms [Natale, 2002].

The games they play are a far cry from the traditional games people used to play outside in the fresh air and sunlight: they play a variety of electronic games on various devices, which include computers, Playstations, PSP, Xbox, Gameboy and even cellular telephones. Each of these electronic gaming devices makes use of a different input device(s) and are designed to be as easy to use as possible with no complex operating and file system to confuse the novice/first time user. The computer, however, is the only machine that makes use of a computer mouse and a keyboard.

The variety of different types of computer games is large, and action, adventure, educational, role-playing (RPG), strategy, racing, flying, simulation, first person shooter (FPS) and third person shooter games are included in the list. In the computer game environment, the most used input device, is the mouse. In many of these games, the keyboard is also used to support the mouse.

However, games are not for relaxation purposes only; they also play an important role in the development of the hand-eye coordination skills of their users. Good hand-eye coordination plays an important role in the successful and productive use of a computer in a work related or educational environment, and can assist the user to get more value from the application he/she is using.

A user needs two distinct skills when playing computer games (refer to section 5.2). Firstly he/she needs to master the mouse and/or keyboard as input device(s) and secondly he/she needs to know how to play the game. Knowledge of how to play the game can quickly reach its maximum, so that the user knows exactly what he/she needs to do, yet the mouse/keyboard skills may still need practice as these take time to develop.

Playing mouse-orientated computer games not only assists in improving computer mouse skills and enhancing the value that that user draws from an office package: it has a number of other advantages as well. These advantages are listed below and will then be discussed in more detail.

- ❖ It provides the ideal environment for acquiring the computer mouse skills necessary to use a computer effectively and efficiently.

- ❖ It improves the hand-eye coordination of surgeons who carry out laparoscopic surgery.

- ❖ It decreases reaction times.

- ❖ It reverses the declining effect of response speed and reflexes of older people.

- ❖ It stimulates spatial learning.

- ❖ It increases computer literacy skills.

- ❖ It assists in enhancing children's learning.

- ❖ It increases the learning and recollection capabilities of the user.

- ❖ It serves as a rehabilitative and therapeutic tool.

- ❖ It increases interest in learning about new and more challenging software including computer programming.

- ❖ It stimulates feelings of success and achievement.

- ❖ It aids and enriches the lives of the elderly.

- ❖ It improves skills that are used in ordinary daily tasks.

- ❖ It may change a person's attitude towards computers because playing games is fun.

- ❖ It assists in lessening computer anxiety on the part of the user because computer systems, like computer games, are relatively simple and easy to use. It is also a relaxing environment.

- ❖ It creates greater confidence when using a computer for other tasks.

- ❖ A contribution is made towards the development of other specific skills.

2.3 Ideal environment to improve hand-eye coordination

Hand-eye coordination plays an essential role in the effective use of a computer mouse in a GUI; it also enhances the value that the user will draw from an office package. The games used in this study were specifically developed to measure and improve a user's hand-eye coordination and computer mouse skills in a GUI environment. Depending on the resolution of the computer screen the user must be able to point the mouse cursor to a small object (icon or file) on the computer screen. If the user lacks good hand-eye coordination this task could be difficult and time consuming.

With advancing age, changes occur in the human perceptual-motor system, and declines in the visual, proprioceptive, motor and central nervous systems have been documented in earlier studies [Bondareff 1985; Fozard 1990; Kenshalo 1977; Spirduso & MacRae 1990].

Human hand-eye coordination is characterised by the ability to adapt to sensory modifications [Held & Freedman, 1963; Welch, 1978]. When exposed to an optical distortion, individuals quickly readjust their hand-eye coordinative patterns and function normally under such a new visual environment [Harris, 1963; Hay & Pick, 1966; Held & Hein, 1958; Helmholtz, 1925; Redding & Wallace, 1993].

Computer mouse hand-eye coordination is not something individuals are born with: it is something that must be acquired through practice. Computer games provide the ideal environment for practising and acquiring this skill. The computer games used in this study create a relaxed environment where the user can learn to play the games easily, without having to worry about losing important information. It is an environment in which the user is afforded the opportunity to improve his/her mouse skills while enjoying the experience.

2.3.1 Training environment for surgeons

Good computer mouse hand-eye coordination does not only assist users in using the computer applications in the GUI environment more effectively, but can also improve a user's fine motor skills, which could be a great advantage to surgeons, for instance.

Video games have often been judged to be merely meaningless form of entertainment [De Aguilera & Mèndiz, 2003]. However, research has shown that young surgeons, who spent many hours playing video games during their childhood, make fewer mistakes at the operating table [Rosser, 2004].

Rosser [2004] has also developed a course called Top Gun, in which surgical trainees warm up their coordination, agility and accuracy by means of a video game before entering the operating room.

Thus, computer games will benefit the surgeon not only in his/her use of the Office package, but will also give him/her the edge in the operating room: operations will be performed faster and with greater success.

2.3.2 Hand-eye coordination: Differences between males and females

Kosinski [2002] states that in almost every age group males have faster reaction times than females. This, according to Gorriz and Medina [2000], is because girls are more interested in creating than destroying and prefer to use puzzle solving skills rather than hand-eye reflexes.

Jessica [2002-03] found that boys could drive a radio controlled car faster through a course and with less mistakes than their female counterparts could.

Research still needs to be done to discover which computer games are preferred by females. Such games could then perhaps be used to help females to improve their reaction times so that they, too, can derive benefit from both the games and the office package, as well as from other non-related computer activities where faster reaction times are needed.

2.3.3 Why females lack interest in computer games

Natale [2002] states that the reason why females do not play computer games is biological in nature. Males have an infinite affinity with technology - they like to figure out how things work, and they enjoy delving deeper into complex, technical matters.

Gorriz and Medina [2000] stated that most girls' first experience with computers is through computer games. Software developers indirectly send a message to females that the gaming industry is male territory only and not relevant to their lives: the gaming industries do this by designing games targeted specifically at males. It is partly because of this male-orientated marketing technique that females are put off when it comes to any advanced interest in using computers. A lack of interest in games places females at a disadvantage when it comes to learning how to navigate computer technology. This could explain the dearth of females pursuing computer science degrees and ultimately a career in the computer field [Natale 2002, Gorriz and Medina 2000].

2.3.4 Female-orientated games

Littleton et al. [1998] conducted a study with two gender spesific computer games. The one game was called "King and Crown" which involved masculine characters and symbols. The other game was entitled "Honeybears" and was free of male stereotyped associations.

The results showed that boys were little affected by the type of game they played. The girls, on the other hand, were substantially affected. Their mean score on "Honeybears" was higher than that of the boys yet it was significantly lower in "King and Crown".

Littleton et al. [1998] concluded that as long as the content of the game was something that the females could relate to, their performance would increase.

It is becoming increasingly important for every person, male and female, to become computer literate. If more computer games were developed specifically for females, with marketing concentrating on this area, female computer use and literacy would increase [Natale, 2002].

The games in this study were not designed to be gender specific. They were designed according to the mouse functions needed for testing of specific skills. No feedback was received from females indicating that the games were inappropriate. The researcher wanted to test the same number of males and females but this was not possible because fewer females study computer science.

2.3.5 Males spend more time playing computer games than females

Natale [2002] found that males spend approximately double the time playing computer games than females do. Buchman and Funk [1996] find similar results in their study, having surveyed the game-playing habits of 900 fourth to eighth grade boys and girls. Davies, Klawe, NG, Nyhus and Sullivan (2000) also reveal that, compared to boys, girls spend less time per day playing computer games at home, own fewer games, and are less interested in or knowledgeable about the gaming industry.

The Women's Educational Equity Act (WEEA) Equity Resource Centre [1992] found that the gender gap in computer use becomes more evident in advanced classes, as girls tend to have less confidence in their use of computers.

Koch [1995] found that there is a strong correlation between students who do not like and rarely play computer games and those who judge their computer skills as weak and avoid spending time on the computer.

Since males are dominant in the playing of computer games, it is easy to understand why they have greater confidence when using the computer for other, more complex tasks. Males, therefore, also have a greater tendency to enter computer-related career fields [Natale, 2002].

It is once more emphasised that the six games in this study were not specifically developed to be gender-orientated. Mouse skills, with the focus on the value that a user will draw from an office package, were the main focus.

2.4   The correct computer games can enrich the lives of the elderly

The enhanced value that a user will draw from an office package is the focus of this study. The improvement of computer mouse skills through game playing is part of the focus, but this is not the only positive consequence of game playing. The playing of computer games may also benefit older people in various ways.

Whitcomb [1999] points out that today's elderly have lived through many technological changes, and that most older people have been exposed to numerous innovations like the automobile, airplane, television, telephone and the computer.

Ryan and Heaven [1986] have identified a number of different areas for computer applications that could involve the elderly. These areas include communication and social interaction for the speech-impaired or hearing-impaired, health education programs, monitoring vital life functions and emergency alarm systems and rehabilitation or cognitive therapy.

There is an age-related decline in speed of tasks performed [Clark, Lanphear, & Riddick, 1987]. Hand-eye coordination forms part of the perceptual-motor functions and is not spared from the effects of aging. Examples of age-related modifications of this function include delays in reaction time and movement time, decreased manual dexterity, reduced speed in writing digits and words, decreased accuracy in reaching-aiming movement and the decreased steadiness in the non-preferred hand [Birren & Botwinick, 1951; Chaput & Proteau, 1996; Miles, 1931; Welford, 1977].

Clark et al. [1987] stated that, in elderly people, the decline in speed of response can be reversed, although not totally eradicated, with an appropriate intervention such as video games.

Whitcomb [1999] stated that there are only a limited number of games that older people enjoy. He also pointed out that many games are unsuitable for older people for a number of reasons, for example the small size of objects on the screen, rapid movements or reactions required or the sound being inappropriate.

The above studies proved that older people can derive benefit from computer games. Not only are their reflexes improved but they are able to use some of the skills that they have acquired in their daily tasks. The computer games have thus improved their fine motor skills and hand-eye coordination. This present study will also investigate whether computer games assist in improving the fine motor skills and computer mouse hand-eye coordination of users. The

games that were developed for this study provide the perfect "practice" environment to improve a user's computer mouse skills so that more value could be drawn from an office package.

2.5   Computer games enhance spatial learning

Spatial processing skills are an important component in cognitive development. Cognition is a complex process that is predicted on the interaction of an individuals sensory-motor and neurological systems. Spatial cognition plays an important role in the process where a child perceives, edits, communicates, stores, creates and recalls spatial images and develops higher level thinking. An individual creates meaning by manipulating visual images through the process of spatial cognition. It is likely that a child will have difficulty in daily life as well as in the academic environment when he/she has difficulty in spatial cognition. If the spatial skills can be enhanced, the general learning skills will also be enhanced [Natale, 2002].

Natale [2002] also observes that the vast majority of computer games require a character to move from one place to another, and along the way a user must manipulate symbols to extract meaning. An individual's visual senses are stimulated by computer games because the primary output device of a computer is the monitor. Spatial reasoning is the main challenge in these types of games. Kahana, Sekuler, Caplan, Kirschen and Madsen [1999] proved in their study that computer games engage spatial learning.

According to Natale [2002] there is a conspicuous gender gap between male and female employees in the computer industry. He traces this back to the playing of computer games. He states that computer games provide a medium through which individuals can become computer literate through the engagement of spatial learning and cognitive processing abilities. Thus, males are more computer literate because of the playing of computer games. This

also provides males with an easy lead-in to more advanced utilisation of computers such as programming. Females are discouraged as a result of the male stereotyping and male-orientated marketing, and these factors create the gender gap. This problem could be eradicated if game marketing were to focus more on females.

Natale [2002] concludes that a person would become more computer literate if he/she were to play more computer games. He explains that computer literacy is a function of spatial learning, and that the use of other computer programs becomes easier as an individual learns computer functions through the utilisation of games.

Mayer, Schustack and Blanton [1999] found that students who have excellent computer game playing skills also have the ability to learn new programs more easily than students who lack similar experience.

The games used in this study will also stimulate the user's spatial learning. The use of the computer mouse will not only become second nature for the user, but he/she will also learn how to use the office package and GUI environment faster.

2.6   Increased learning and recollection capabilities

Brainwaves are part of the everyday functioning and processing taking place in the human brain. Brainwaves are linked to various brain functions and occur at different frequencies. The alpha wave is associated with relaxation and the theta wave is associated with navigational and spatial learning. The theta wave is activated when a user plays computer games, because in most games a user must find his way from one place to another. In more complex games, the more frequently theta oscillations occur. Playing computer games therefore actually increases learning and recollection capabilities in the user. This translates into

greater academic, social and computer literacy skills. Children who do not play computer games at young ages may actually end up disadvantaged in later years [Natale, 2002].

When it comes to education the effective use of the computer is beneficial to the learner (child). De Aguilera and Mèndiz [2003] state that video games play an important role in the process of learning new things, especially at different academic levels. De Aguilera and Mèndiz [2003], Mandinacht [1987], White [1984] and Okagaki and Frensch [1994] explaines that video games are considered very useful in acquiring practical skills, as well as in increasing perception and stimulation and developing skills in problem-solving, strategy assessment, media and tools organisation and obtaining intelligent answers. De Aguilera and Mèndiz [2003] found that of all the games available, simulators stand out for their enormous educational potential. Simulators can include flight simulators for pilot training, tank driving simulators, and so forth.

Robertson and Good [2004] list various benefits, especially for children, that may be derived from playing computer games. The benefits include: increased motivation, development of discussion skills and the improvement in aspects of story writing.

Robertson and Good [2004] also mention that appropriately designed computer games can be used to enhance children's learning, and enabling children to create their own computer games offers a further range of learning opportunities.

Playing computer games is an extremely popular leisure activity for children. Young children are willing to devote considerable amounts of their time to playing games [Robertson and Good, 2004]. A UK survey reported that boys are approximately twice as likely to be playing games as girls. Almost 25% of

pupils reported that they play more than two hours at a time [McFarlane, Sparrowhawk & Heald, 2002].

The teachers reported that the children rarely gained knowledge from the game content but they did find the games useful in stimulating the children's creative activities, such as in story-writing about game characters or scenarios.

Robertson and Good [2004] conclude that the strong motivational influence of computer games on children can be used positively in education, and the educational benefit of computer games can be enhanced if the games are designed to teach a user specific everyday computer skills, such as navigating a menu structure. This is one of the tasks that a novice/first time computer user must be able to do in an office application in a GUI environment, before he/she is considered to be computer literate.

Griffith et al. [1983] prove that the visual and motor coordination of players of video games is better than that of non-players in the same peer group. Greenfield proves in her famous book, The *Child and the Media* [1985], that the sensor-motor activity of children who play video games regularly is much greater than average. Dorval and Pépin (1986), Lowery and Knirk (1982-83), and Driskell and Qwyer (1984) converge in pointing out that adolescents with medium- or long-term experience in playing video games show greater visual capacity, motor activity, and spatial ability-reflexes and responses.

The computer games in this study will primarily be used to determine whether a user's computer mouse hand-eye coordination improves with the playing of the games. If this is the case then a novice/first time computer user will draw more value from an office package in a GUI environment. It will thus be faster to train the user in computer literacy. The games in this study do not teach the player specific office commands but the mouse functions that are tested in the games are the same as the mouse functions that a user will use in the office package.

2.7 Positive attitudes towards computers

The Oxford Dictionary of current English defines *attitude* as "a setteled opinion or way of thinking" [Thompson, 1995].

The attitude of many individuals towards computers is negative. They see computers as a disabling technology, something that will replace them in the workplace. A person's attitude towards the computer plays an important role in that person's ability to learn. A negative attitude towards computers will hamper one's ability to learn and understand computer science.

Quite a number of first-year students who enrol for computer literacy courses have never worked on a computer before and do not know what to expect. Some of them are afraid and have a negative attitude towards computers from the beginning. This negative attitude can be reduced, if not totally eradicated, by introducing these students to computer games.

In a study by Bailey et al. [1989] the attitudes of 28 elderly people were examined in a before-and-after comparison. The participants were exposed to two games. Only 25% of them stated that they would like to use a computer before they were exposed to the games, whereas 64% indicated that they would like to use a computer after playing the games.

Emmet [1988] identified the following key motivators that may help computer users to enjoy working with computers:

- ❖ Computers are problem-solving devices. Users should be taught how to get the most out of them.
- ❖ Employees should be encouraged to develop a "personal" sense of belonging regarding the computer.

❖ Computers can make people and communication more efficient by providing a convenient means of storing information that can be easily and quickly retrieved.

❖ Computers save time and money by allowing users to accomplish complicated tasks in an easy manner.

❖ Computers are fun.

❖ Computer skills are marketable.

One further strategy to encourage people to make more use of the computer is training. Speier, Morris and Briggs [2002] argue that training should include a component focusing on attitude change, and the ease with which work can be accomplished by using a computer function should be emphasised.

People who have to perform their daily tasks on computers will be more productive if they have a positive attitude towards their machines. The computer games used in this study are conducive to relaxation, and participants will experience feelings of success and achievement after playing the games. This will contribute to the building up of a positive attitude towards computers.

2.8 Computer games reduce computer anxiety

The Reader's Digest Great Encyclopaedic Dictionary describe *anxiety* as uneasiness or concern [Coulson, Carr and Hutchinson, 1964]. The Concise Oxford Dictionary defines anxiety as "a concern about an imminent dander, difficulty, etc." [Thompson, 1995].

Computers play an increasingly important role in most businesses and companies and are already at the centre of most workplaces. Students with computer skills will have an advantage over students suffering from computer

anxiety when the time comes for them to seek employment or to deal with computers in the workplace [Fajou, 2002].

Fajou [2002] comments that there are certain negative feelings associated with computers which may lead to panic. These negative feelings include anxiety, frustration and irritation. Some people may harbour a fear being embarrassed; they may also fear failure or even disappointment.

Parents who have had little or no dealings with computers may pass their negative feelings on to their children [Fajou, 2002]. According to Delvecchio [1995], however, "young people are slightly less likely to be anxious than older users". Fajou [2002] argues that the previous statement has less to do with age and than with knowledge and experience in using computers because young people have much more opportunity to interact with computers than past generations have had.

Shashaani [1997] reports that female students in secondary school evidenced higher anxiety levels along with lower confidence and less interest in computers than the male students.

Computer games can be used to gradually introduce anxious users to computers. Their experience with computers will increase through playing the games and this in turn will result in lower levels of anxiety. It was observed that one of the students who participated in this study was more relaxed and less anxious after playing the games.

Computer attitude and computer anxiety play important roles when it comes to the learning process of individuals. However, since the aim of this study is to determine whether the skills that a user can acquire through the playing of mouse-orientated computer games will benefit him/her in the use of an office application in a GUI environment, computer attitude and computer anxiety were

not measured during this study. These aspects should be kept in mind for further research. The games used in this study did however create a relaxed atmosphere and reduced the computer anxiety that users might have experienced in a normal computer working environment.

2.9 Negative versus positive influences of computer games

In a study conducted by Radi [2002] it was found that some parents, who voted against the use of computers in education, argued that the high use of computers would not allow their children to develop their literacy skills as expected for their ages. Radi [2002] concluded that computers might have a negative impact on young people who are still in the process of learning and developing their basic language and literacy skills. Ball [1978], on the other hand, argues that video games are beneficial, because they teach the user a number of intellectual skills, which include reading comprehension and assimilation of numerical concepts.

Provenzo [1991] contends that violent video games condone, promote, and justify the use of violence while concealing realistic consequences. Funk [2002] reports that computer games can also become hypnotic when played too much.

It is true that some computer games could have a negative influence on certain individuals; the correct computer games, however, can be a learning tool for children and an asset to their education (refer to section 2.6). Computer games, like films, have age restrictions. It is the duty of the parents to apply parental control regarding the games their children play.

The focus of this study is however on skills development, and specifically on the development of computer mouse skills, together with the enhanced value that users will draw from an office package. The games used in this study promote computer mouse skills rather than violent behaviours.

2.10 Chapter summary

Hand-eye coordination with fine motor abilities plays a significant role in the effective use of the computer mouse, which in turn plays a significant role in the effective and productive use of an office package in a GUI environment. A novice or first time computer user can increase his/her computer mouse abilities by practice. Mouse-orientated computer games provide the perfect practice environment.

Computer games have both positive and negative effects on people, especially on children. The main problem arises with extremely violent games, particularly when parents have no insight or knowledge regarding what their children are playing. Computer games have great learning potential nevertheless, and can assist in early child development as well as in adult training.

Many benefits of computer games have been discussed in this chapter. This does not imply that an individual should only play computer games and do nothing else. It implies that a user should play computer games to enhance his/her reflexes and to improve his/her computer mouse skills. Employers should allow their employees to play computer games during their lunch breaks because of the embedded benefits for the employees and ultimately for the company.

Many previous studies have proven that computers can assist in educational and training areas, and can even enhance the skills of a surgeon. However, it must be remembered that, as previously stated, the focus of this research is on the value that a user can draw from an office package in a GUI environment by playing computer games.

The games that will be used in this study are specifically designed to measure a user's skill with a computer mouse and also to improve this skill through the playing of the games. The games are easy to understand and simple to master.

Competition amongst players will also encourage the players to improve upon their previous scores. Only by practising will they improve their computer mouse skills. A detailed discussion of the games is attached in Appendix A.

This chapter focused primarily on the various benefits of computer games. Chapter 3 will focus on the computer mouse as an input device for computers. A discussion on operating systems, GUIs and direct manipulation will also be included.

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Chapter 3

Graphical User Interfaces and the Computer Mouse

Mayer, Schustack and Blanton [1999, p27-31] define computer literacy and include a cognitive aspect by stating that "computer literacy represents a form of near transfer". They add that "students learn from interacting with computers" and "students may learn specific facts and procedures that are relevant to operating computers - that is, what can be called computer literacy."

3.1 Introduction

The world of technology, and especially the field of computers, is expanding at a great rate. Computers have tremendous potential, from running processes in industries to performing life-saving tasks, from office automation to applications in education. Unfortunately this potential is not equally distributed amongst all sections of the population. What one individual finds facilitating may have little impact or even a negative effect on another. One section of the population may see it as an enabling technology and others as a disabling technology. It is thus naive to think that the application of technology in education will benefit everyone equally [Norman, 1998]. For some, computer technology has become a way of living, while for others it is a field unknown and ready to be explored.

Already, in most job advertisements, one of the criteria is that the applicant must be computer literate. The workplace is already so advanced that on almost every desk a computer will be found. Communication in the workplace occurs mostly via e-mail. Electronic media make it so much easier to communicate and storage and retrieval of documents can be done at the click of a button. Business documents such as leave applications and Human

Resources (HR) documentation can be stored on the network server for easy access by all employees.

With modern day technology and the personal computer, correcting typing errors is as easy as using the "backspace" key on the keyboard. Paper wastage is limited as printing only needs to be done once the layout on the screen is correct. The spelling checker makes life easier as the computer continuously suggests the correct spelling and grammar. Filing in the office environment has become effortless, as most of the documentation is filed electronically, on the hard drive, stiffy, memory stick, server, streamer, compact disc (CD) or digital versatile disk (DVD).

In a job interview, the person with computer skills has a distinct advantage over the person with none. Although training is a given in each company, the person with computer skills requires less training and is far more productive in a shorter time period than the person with no computer skills at all.

Computer skills include the effective usage of software applications such as an office package in a Graphical User Interface (GUI). A user can only use the GUI and a software package efficiently if he/she can use the computer peripherals like the mouse and the keyboard.

How can one, in the minimum amount of time, improve a user's computer mouse hand-eye coordination so that he/she can draw more value from an office package in a GUI environment? *Can mouse-orientated computer games enhance the value that a user draws from an office application in a GUI environment?*

The previous chapter focused on various advantages associated with the playing of computer games, which range from improved education to faster and more efficient surgery. It was seen that computer games do not only enhance a

user's computer mouse hand-eye coordination, but that his/her fine motor skills are also improved. Many of the hand-eye coordination and fine motor skills that elderly people use in their daily activities can also practised in computer games. This chapter will focus, however, only on the computer mouse, operating systems, direct manipulation and the GUI environment.

3.2 The graphical user interface (GUI) and direct manipulation

The computer mouse as input device is the easiest device to use and to control the computer hardware and software through the GUI. To understand the origins of the GUI, one has to look at the evolution of the computer operating system (OS).

The OS contains the necessary links to control the computer's hardware and contains the set of functions needed by most applications [Tucker, Cupper, Bradley, Epstein, Kelemen, 1995]. Without the OS each program would need its own drivers to control all the computer peripherals such as the video card, sound card, hard drive, etc. [Wikipedia, 2005]. Tucker, Cupper, Bradley, Epstein and Kelemen [1995] define an OS as a group of programs that are designed to serve two basic purposes: firstly, to control the allocation and use of the computing system's resources among the various tasks and users, and secondly, to provide an interface between the computer programmer and computer hardware to simplify the creation, coding, debugging and maintenance of programs.

3.2.1 History of the operating system

The history and evolution of computer OSs and computer hardware run parallel to each other and are usually divided into five generations [Tucker et al., 1995]. It is necessary to understand the evolution of the computer OSs because this is

the reason for increased computer mouse usage and give support to why this research was done.

Tucker et al. [1995] define the *Zeroth Generation* as the period of development of computing which predated the commercial production and sale of computer equipment.

The first computers lacked any form of operating system, and only one user at a time had control over the computer. The computer only worked as long as the program was loaded into the machine. The program data was written in machine language and often stored on punched paper tape [Tucker et al., 1995].

The beginning of commercial computing and the introduction of the UNIVAC I in early 1951 marked the beginning of the *First Generation (1951-1956).* Operation still continued without the benefit of an OS. Operators were hired to boot the computer and run the programs, and they controlled the computer [Tucker et al., 1995].

In the *Second Generation (1956-1964),* vacuum tubes were replaced by transistors. This change in the hardware led to research enhancements in the OSs [Tucker et al., 1995].

In April 1964 IBM announced their System/360 family of computers. They used integrated circuits (ICs) with increased speed and economy as advantages. The *Third Generation* officially began here. During this generation the OS became a reality [Tucker et al., 1995]. The first OS lacked the GUI as we know it today. "Today an OS that is without a GUI or various file viewers is often considered not to be a true or complete OS" [Wikipedia, 2005, http://en.wikipedia.org/wiki/history_of_operating_systems].

The *Fourth Generation (1979-present)* is characterised by the appearance of personal computers and the OSs as we know them today.

The early OS, in the mainframe era, were very diverse. Various vendors produced different OSs, each for their own specific hardware. Later, many of the OSs were collections of utilities that allowed users to run software on the machine [Wikipedia, 2005].

The majority of the earlier machines were manufactured without any OS because many of them were bought for entertainment and educational purposes. They were seldom used for scientific or business or science-orientated applications. Video games and the rare word processors and office applications were mostly self-contained programs which took over the machine completely [Wikipedia, 2005].

The first original GUI was developed in the early '70s at the Xerox Palo Alto Research Centre. Many other vendors imitated and improved on this original GUI concept [Wikipedia, 2005].

3.2.2 Operating systems today

Today almost no computer is sold without an OS. OSs are very graphical and easy to use with input devices such as the computer mouse and keyboard. Direct manipulation, a term first coined by Ben Shneiderman [1983], is one of the interaction methods allowed by a GUI. Direct manipulation is used when a user directly manipulates graphical representations of office entities instead of dealing with these entities abstractly through a command language or menu system [Hudson & King, 1986]. Jacob [1986] showed that a direct manipulation user interface presents a set of visual representations on a display and various manipulations can be performed on any of them. These representations might include spreadsheet cells, scroll bars, flowchart boxes or buttons. For example,

instead of using the command prompt or menu structure to delete a file, the user can drag an icon, which is in the form of a file, to another icon, which is in the form of a trashcan. This imitates the real world where a user would take a file from his table and drop it in the trashcan.

Direct manipulation in the GUI environment evolved from the first OS. Direct manipulation makes the computer more user friendly, because everything is done with a few functions of the computer mouse.

3.3 "Computer mouses" or "computer mice"?

Hale [1996] repeats the question which many people have asked before: "What is the plural of that small, rolling pointing device invented by Douglas Engelbart in 1964?" He prefers *mouses* because *mice* refers to furry little rodents. Fouts [1994] also states that one should rather speak about *mouses* than *mice*. Clark [1995] states that one should avoid using the plural word *mice* and that one should rather talk about *mouse devices*.

According to an Internet poll (http://www.dvo.com/newsletter/monthly/2005/march/pollresults.html) 58% of the people responding voted that one should talk about *computer mouses* rather than *computer mice*. The term *mouse device* is unpopular, however, and not often used. It was therefore decided that the plural form, i.e. *computer mouses,* will be used in this study, rather than *computer mice* or *computer mouse devices*.

3.4 Computer mouses

Wang and MacKenzie [1999] state that the patterns found in pointing with the hand to physical targets may or may not follow the patterns found in pointing on a computing screen with an input device. There are many reasons for this

different behaviour, due to various differences between the cursor motion and hand motion.

Direct hand pointing to a physical object is carried out with proprioceptive feedback of the hand position in the human arm. The cursor is used to point at graphical objects on the screen, which does not have a direct, absolute mapping with hand motion. Instead, the feedback is given through the eyes [Smith, Ho, Ark & Zhai, 2000].

Smith et al. [2000] indicate that the mapping of the input device and the cursor motion is often a complex transfer function, which may further increase the complexity of the mouse cursor and hand-eye relationship in target acquisition tasks. They also state that most of the computer mouses are power mouses with non-linear acceleration schemes. The control gain in a power mouse is not constant and therefore the speed of the mouse motion determines the control gain in a power mouse. The faster the mouse is moved the higher is the control gain.

It was observed that a number of first year students studying at the Central University of Technology, Free State (CUT, FS) find it difficult to use or even to hold the computer mouse effectively. This lack of dexterity in using the computer mouse delays their learning progress in the office package which they have to learn in their first year of study. The question is, can this difficulty in using the mouse be overcome by practice, for example by playing mouse-orientated computer games?

3.4.1 *History of the computer mouse*

The word 'mouse' was originally coined because of the cord, which initially extended from the back of the device [Israel, 2006] and also because the motion on the screen is rather mouse-like [Wikipedia, 2006]. Some people

claim that the word MOUSE is an acronym for "Manually Operated User Selection Equipment" but not everybody agrees on this [Wikipedia, 2006].

Initially, personal computers were operated with only a keyboard as input device. There was no need for a computer mouse because the operating system did not have a GUI that supported a computer mouse. A disk operating system (DOS) was used as the communication interface between the user and the computer, and this was a text interface only. The keyboard was used to type in commands that the computer could understand and execute. A keyboard is fairly easy to use once you know the layout of all the keys: the problem, however, is remembering all the commands.

3.4.1.1 The first computer mouse

Douglas Engelbart developed the first computer mouse at the Stanford Research Institute after extensive usability testing [Wikipedia, 2006]. This first computer mouse can be seen in Figure 3.1.

Figure 3.1: The first computer mouse, held by Douglas Engelbart [Wikipedia, 2006]

The computer mouse was a totally different kind of input device; it was also challenging for the users to master. The mouse was bulky and used two gear wheels placed perpendicularly to each other. The motion of the wheels was translated to the movement of the cursor on the screen. This first mouse had only one button [Wikipedia, 2006].

3.4.1.2   Mechanical, optical and laser mouses

Just as the development of the computer went through different generations, so too were there different generations of mouses. In the early 1970s Bill English invented a newer version of the mouse where the external wheels, as can be seen in Figure 3.1, were moved to the inside of the mouse. A ball was placed inside the mouse: it could rotate in any direction, rotating in turn one of the two wheels [Wikipedia, 2006].

The mechanical ball mouse evolved into an optical mouse which was invented by Steve Kirsch of Mouse Systems Corporation. An optical mouse uses a Light Emitting Diode (LED) and photodiodes to detect movement. Computer gamers prefer optical mouses to mechanical ball mouses, because of their increased precision. Gamers demand still further advances in optical mouse technology to give them even more precision, especially for First Person Shooter (FPS) games [Wikipedia, 2006].

Laser mouses are also available. This new technology increases the detail of the image taken by the mouse because instead of an LED, a small laser is used [Wikipedia, 2006].

3.4.1.3   Mouse buttons

Mouse buttons have changed very little over time, varying only in size, shape, placement and number. Although in the late 1990s mouses supported up to five buttons, commercial mouses today have from one to three buttons. Mouses with more buttons are still available, with the extra buttons usually being used by computer gamers as quick commands instead of the keyboard. These extra buttons can also be configured to perform special actions in the GUI.   Scroll wheels were also added to the mouses for easy and fast navigation, especially for moving up and down in a multi-page document [Wikipedia, 2006].

3.4.1.4   Mouse variations

There are many variations of the mouse. The variation closest to the mouse that we know today is the trackball. The trackball can basically be seen as a mechanical mouse lying on its back. In the beginning trackballs were found on almost all notebook computers as they were small and did not take up too much space. Touch pads have replaced the trackballs on notebooks because they are even more compact and do not become dirty as trackballs do; they are also very easy to use. On some notebooks there is also a pointing stick situated between the keys. This pointing stick works like a joystick and can be used instead of the touchpad.

Currently the mouse is still the most common input device used by most users around the world. The mouse is used not only as a navigational tool in a GUI but also, more often, as the main input device in computer games.

3.4.2 Applications of the computer mouse

The computer mouse is one of the main input devices used in a GUI. It is used to control the cursor in two dimensions. The mouse can be used for pointing and clicking and also for gestures.

Gestural interfaces are rarer and harder to use because they require finer motor control from the user. A gesture in a drawing program, for example, can be a rapid 'x' movement over an item that you wish to delete - instead of pressing 'delete' on the keyboard. A few of the gestural conventions have become widespread in the OSs that we use today, like the *drag-and-drop* gesture [Wikipedia, 2006].

The computer mouse is also used in special application domains like interactive three-dimensional graphics where the mouse motion is directly translated into

the changes in the virtual camera orientation. A good example is the popular Quake computer game where the mouse is used to control the player's 'head'. Moving the mouse around controls what the player can see [Wikipedia, 2006]. This is also everything that the user sees.

3.5 Graphical user interfaces and eye tracking

Human computer interface research has traditionally focused on performance. Input devices and techniques are usually tested against a set of standard tasks in which user's performance on task completion time and error rate is measured and analysed [Card, English, & Burr, 1978]. These results of performance analysis served as the basis for refinement and redesign of the devices and techniques.

To improve a user's computer mouse hand-eye coordination one needs to understand how users use the computer mouse. This can be accomplished by looking at the user's eye gaze and doing eye tracking. In the field of Human Computer Interaction (HCI), eye tracking has helped to improve the understanding of how users search and select menu items [Card, 1982].

Smith et al. [2004] have undertaken research on eye tracking. Their participants were required to do two different tasks with three input devices: mouse, touchpad and pointing stick. Task one was a reciprocal pointing task and task two a random pointing task. Smith et al. [2004] found that the hand-eye relationship among their participants was not very consistent. They found three different pointing behaviours: eye gaze following the cursor to the target, eye gaze leading the cursor to the target and eye gaze switching between the cursor and the target. The first two were the most prevalent in the participants. Overall, they found that participants used a variety of combinations of hand-eye coordination patterns.

In this study the researcher prefers to test the participants against a set of standard tasks in which their performances on task completion time and error rate are measured and analysed. However, eye tracking still plays an important role and needs to be investigated in the future.

3.6 Manual aiming

In a GUI environment it is important for a user to be able to aim and point the computer mouse with fine precision. The user must be able to click on icons, files and menu items. Depending on the screen resolution, the size of these items can differ dramatically.

When the person is required to make a discrete manual aiming movement towards a stationary target a person's eyes normally fixate on the target before any movement preparation begins [Carlton, 1981]. This provides the control system with visual information about the position of the target and later the hand as it moves towards the target [Elliot, 1992]. Extra-retinal information about the position of the eyes and the head during fixation also has the potential to contribute to the preparation of the limb movement by specifying the position of the target in body-referenced coordinates [Abrahams, Meyer & Kornblum, 1990].

Eye and hand movements toward a target must be coordinated in order to maximise accuracy for situations in which the target is not known in advance or in the case of sequential aiming. In these situations the eyes usually begin moving towards the target in advance of the limb movement [Carnahan & Marteniuk, 1991]. Helsen, Elliot, Starkes and Ricker [2000] explain that this provides the system with visual information about the target position and the limb as it approaches the target.

The above skills are very important for first time or novice computer users to acquire, especially in the GUIs of modern day computing. Is it possible that mouse-orientated computer games could help the user to acquire these skills faster?

3.7 Types of computer users and usability

Manual aiming, with a computer mouse, is an important skill to acquire in order for a user to draw maximum value from an office package in a GUI environment. Not all users will take the same amount of time to acquire this mouse skill.

According to Shneiderman [1998] one can distinguish between four types of computer users namely:

❖ *Novice computer users* are users who know little about the task or the interface concepts. This, for example, may be a user who does not know how to do accounting nor does he/she know how to use the accounting software.

❖ *First-time computer users*, by contrast, are professionals who know the task concepts, but have shallow knowledge of the interface concepts. This type of user, for example, knows how to do accounting but does not know how to use the new accounting software.

❖ *Knowledgeable intermittent computer users* have a broad knowledge of interface concepts and stable task concepts, but they have difficulty in retaining the location of features and menu structure. Such a user, for example, knows how to do accounting and knows how the software works, but can't remember exactly where all the commands in the interface are.

❖ *Expert frequent computer users*, also known as *Power users*, are thoroughly familiar with the task and interface concepts and try to complete their work as quickly as possible. This type of user, for

example, knows how to do accounting and where all the commands are in an accounting software package. They also try to finish their work as quickly as possible.

All of these types of computer users have the same usability goals as defined by the ISO standard 9241 [cited in Dix, Finlay, Abowd & Beale. 1998]:

❖ *Usability* is the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in a particular environment.

❖ *Effectiveness* is the accuracy and completeness with which specified users can achieve specified goals in particular environments.

❖ *Efficiency* is the resources expended in relation to the accuracy and completeness of goals achieved.

❖ *Satisfaction* is the comfort and acceptability of the work system to its users and other people affected by its use.

The participants in this study can be classified as either *novice* or *first time computer users*. Some of the users know how to play the real pool game on a table and are therefore classified as *first time computer users* because they know the task concepts but, have shallow knowledge of the interface concepts. In the other games the users are classified as *novice* users because they know little about the task or interface concepts.

3.8 Chapter summary

The first time the computer mouse was really used by the public was when Microsoft Windows 3.1 became the GUI for the Disk Operating System (DOS) that accompanied most of the new computer sales. If it had not been for the evolution of the computer and OS the computer mouse would not have evolved from the one-button mouse developed by Douglas Engelbart, to the sophisticated mouses that we have today.

The mouse as input device is not only used in the GUI and office environment but also in computer games as the pointing or movement device. For certain computer games, the mouse is used as the primary input device, supporting the keyboard.

The computer games that were developed for use in this study (refer to Appendix A) are strictly mouse-orientated. The focus from this point onward will be entirely on computer mouse skills and the improvement of hand-eye coordination. The computer games as developed will be used to improve the user's computer mouse hand-eye coordination so that the user will draw more value from an office package in a GUI environment.

Chapter 4 will explain the methodology used in this study. The different phases, users and hypotheses that were statistically analysed, will be discussed.

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Computer literacy, a term coined by Andrew Molnar, "is the ability to operate a computer and to understand the language used in working with a specific system or systems" [Dictionary.com, 2006c].

4.1 Introduction

Up to this point, an overview and problem statement of this dissertation have been provided, the different advantages of playing computer games has been discussed, and the concepts of computer mouse, operating system (OS), graphical user interface (GUI) and direct manipulation have been introduced.

Computer games have various advantages for different people. For children, for instance, some games hold important educational advantages, and the educational benefits of playing games were explored in Chapter 2. Improved hand-eye coordination as a result of playing mouse-orientated computer games is explored to determine whether a person can draw more value from an office package in a GUI environment. The improvement of mouse skills will be investigated in more detail in Chapter 5.

A broad outline of the methodology that was followed to gather the data and to investigate the various hypotheses will be given in the next few sections. A more detailed discussion of the methodology used will be given at the different sections in Chapter 5.

4.2 Methodology background

According to Trochim [2002] an empirical study is based on observations and measurements of reality and external validity is the degree to which the conclusions in your study would hold for other persons in other places and at other times.

According to Trochim [2002] the quasi-experimental research design is similar to the experimental design but lacks random assignment. With a quasi-experimental research design you would have either a control group or multiple measures.

This research was based on an empirical study and the quasi-experimental research design was applied. Simple random sampling was used and the results were used to generalise back to the population. The reason why the quasi-experimental research design was applied was because random sampling was not used but there were multiple groups of students that did perform certain tasks multiple times.

4.3 Phase 1

Phase one of the study involved a large group of students taking various courses at the Central University of Technology, Free State (CUT, FS). An open invitation to participate was addressed to all the students. No specific criteria were used to filter students.

In this phase of the study all the students formed one group. This group of participants only had to play the six mouse-orientated computer games developed for the study: Infestation, Plane Blaster, Pool, Bunny Wack, Speed and Rescue (refer to Appendix A for the full discussion on the games). There was no limitation on the number of times that the students could play the

games. They were however asked to play all the games at least five times on each difficulty level. This ensured that sufficient data was gathered in order to do statistical analysis and to obtain meaningful results.

Three questions were investigated in this first phase of the study to determine which factors could be left out and which ones played a significant role in the performance that a player can achieve in a computer game. The questions were:

1. Does race play a significant role?

2. Do difficulty levels play a significant role?

3. Does computer use frequency (CUF) play a significant role?

4.3.1 Question 1: Does race play a significant role?

The first hypothesis: "There is no difference between the average scores of white males and black males on any of the difficulty levels" led to an investigation as to whether race, black or white, played a significant role in this study (refer to section 5.4). Should this study distinguish between different races or can race be ignored?

4.3.2 Question 2: Do difficulty levels play a significant role?

The second hypothesis: "The level of difficulty has no effect on the score that a user obtains in a game" led to an investigation of whether the difficulty levels of Infestation, Plane Blaster, Pool and Rescue played a significant role (refer to section 5.4). The question that needed to be answered was: Can the scores that the users obtained on the different difficulty levels of a specific game be grouped together or should they be kept separate?

4.3.3 Question 3: Does computer use frequency (CUF) play a significant role?

The last hypothesis of phase 1: "There is no difference between the average score, in a specific game, of users that use a computer more frequently and the average score of users who use a computer less frequently" led to an investigation into computer use frequency (CUF) (refer to section 5.5). It was necessary to determine whether students using a computer more frequently obtained higher scores in a specific game than students using a computer less frequently.

4.3.4 Effectiveness of games

The effectiveness of the games was also investigated to see which games could be left out in phase 2. The following aspects were considered:

- ❖ Do the games function properly?
- ❖ Which games measure specific mouse functions most effectively?
- ❖ Which games did students enjoy the most?

Only the three most effective games were used in phase 2.

4.4 Phase 2

Phase 2 involved a new group of participants consisting of only 16 students. These students were carefully selected according to specific criteria (refer to section 5.6.1) using random sampling. Only the three most effective games (Infestation, Bunny Wack and Speed) were used because some of the same mouse functions are repeatedly measured in different games and testing time was limited. All the mouse functions in these three games - move, point, click, drag and speed - were measured (refer to Appendix A, Table A.7).

During this phase the students did not only play the games but also completed a number of Microsoft Word (MS Word) tests (refer to Appendix B, Appendix C and Appendix D). In each of the ten sessions the students first completed the MS Word test, then played the three games, and then did the same MS word test again.

The students had to play the games five times each on difficulty level Easy only. A timer application (refer to section 5.6.4) was developed to measure the time it took each student to complete the individual questions as well as the total time. The data captured from the playing of the games, the time it took to complete the individual MS Word tests as well as the correctness of the MS Word tests were analysed to answer the following questions:

4.4.1 Question 1: Is there a difference between the average total completion times for the two MS Word tests within a session?

The hypothesis (refer to section 5.6.5): "There is no difference between the average total completion times for the first MS Word test and the second MS Word test within any specific session" was formulated to investigate whether a user's computer mouse skill improved, with the playing of the games, from the first MS Word test to the second.

4.4.2 Question 2: Is there a difference in the average total completion times between the different sessions?

The hypothesis (refer to section 5.6.5): "There is no difference in the average total completion times between the different sessions?" led to an investigation into how many sessions it took for the students' mouse skills to improve significantly.

4.4.3 Question 3: Is there a difference between the average total marks for the MS Word tests in any session?

The first two hypotheses investigated only the MS Word completion times for the different sessions. The hypothesis (refer to section 5.6.6): "There is no difference between the average total mark for the first MS Word test and the second MS Word test within any specific session" was formulated to investigate the user's accuracy in completing the MS Word tests. A user's computer mouse skills had obviously improved if he/she completed the MS Word test faster and more accurately after playing the computer games.

4.4.4 Question 4: Is there a difference in the average total marks between the different sessions?

Hypothesis 4 (refer to section 5.6.6): "There is no difference in the average total mark between the different sessions" led to an investigation of the students' average total marks in the first MS Word test and second MS Word test respectively to see if their marks (accuracy) increased over the sessions.

4.4.5 Question 5: Does a student's score in any of the three games remain constant through different attempts and sessions?

The previous hypotheses investigated the times and marks of the MS Word tests. The hypothesis (refer to section 5.7): "A student's score in any of the three games remains constant through different attempts and sessions" was formulated to investigate the scores that the students obtained in the three games to find out whether their computer mouse skills in the games had improved. This could be seen by a student's improved score in a specific game.

4.4.6 Question 6: Is there a correlation between the score that a user obtains in one of the games and the total completion time for the MS Word test in the different sessions?

To answer this question the hypothesis (refer to section 5.8): "There is no correlation between the score that a user obtains in one of the three games and the total completion time for the MS Word test in the different sessions" was formulated to compare the MS Word marks and the games scores to see whether there is any correlation. Does a student who scores highly in one of the games also complete the MS Word tests in a good time?

4.5 Chapter Summary

This chapter focused on the methodology that was followed throughout this dissertation and serves as an introduction to Chapter 5. Both phase 1 and phase 2 helped with the investigation of the central hypothesis of this study: *Do mouse-orientated computer games enhance the value that a user draws from an office package in a GUI environment?*

A detailed discussion on all the hypotheses and conclusions follows in Chapter 5.

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> Natale [2002, p27] defines computer literacy as "... the developmental ability to employ, as a result of spatial integration, the comprehension of computer characteristics, capabilities, and applications sequentially to a task and allow for a productive outcome."

5.1 Introduction

The main focus of this study was to determine how long it takes a person to learn how to use a computer mouse effectively, and also, specifically in terms of mouse skills, whether *mouse-orientated computer games enhance the value that a user draws from an office package in a GUI environment.*

Various students, studying for a number of different qualifications ranging from Agriculture to Information Technology, participated in this study.   All the students were enrolled at the Central University of Technology, Free State (CUT, FS).   The group of students that participated ranged from first year to fourth year (B.Tech.) students.

Some of the students played the games in their compulsory practical classes and other students came in during their lunch breaks. The computer laboratory could only accommodate a maximum of thirty students at a time.   Multiple groups of students were tested over a period of approximately three months.

This study was done in two phases. In phase one of the study the students only played the six computer games (refer to Appendix A). Three questions were investigated in this phase:

- ❖ Does race play a significant role? (Section 5.4)

- ❖ Do difficulty levels play a significant role? (Section 5.4)

- ❖ Does computer use frequency (CUF) play a significant role? (Section 5.5)

Phase two of the study focuses on only three of the computer games as well as on Microsoft Word (refer to Appendix B, Appendix C and Appendix D). Six questions were investigated in this phase:

- ❖ Is there a difference between the average total completion times for the two MS Word tests within a session? (Section 5.6.5)

- ❖ Is there a difference in the average total completion times between the different sessions? (Section 5.6.5)

- ❖ Is there a difference between the average total marks for the MS Word tests in any session? (Section 5.6.6)

- ❖ Is there a difference in the average total mark between the different sessions? (Section 5.6.6)

- ❖ Does a student's score in any of the three games remain constant through different attempts and sessions? (Section 5.7)

- ❖ Is there a correlation between the score that a user obtains in one of the games and the total completion time for the MS Word test in the different sessions? (Section 5.8)

Various statistical tests were done on the captured data. These tests included Analysis of Variance (ANOVA), Tukey's test for the honestly significant differences and Spearman's correlation.

5.2 Knowledge and skill

Shneiderman [1998] is responsible for having developed the object-action interface (OAI) model, according to which, he state, users learn the task objects and actions independently. He contends that users must first become proficient in the task domain before they can learn to use the computer to accomplish real world tasks. He states that there are three methods that a user can follow to learn interface objects and actions: users can watch a demonstration, they can listen to an explanation or they can make use of trial and error sessions. Shneiderman [1998, 69] further states that novices "are most likely to make correct choices when they only have a few options and are protected from making mistakes". He also explains that users with a strong knowledge of the tasks and interface concepts can make rapid progress.

Two factors play a significant role in this study, namely knowledge and skill. Knowledge [Dictionary.com, 2006a] is the state or fact of knowing or the familiarity, awareness, or understanding gained through experience or study. It refers to the knowledge the user has in regard to the game he/she will play or the Microsoft Word (MS Word) test that he/she will do. It also refers to knowledge of how the game works with regard to goals and scoring. Knowledge, with the MS Word test, refers to the user's knowledge of how to perform certain tasks, where certain items are located and how they operate.

Skill [Dictionary.com, 2006b], on the other hand, refers to proficiency, facility, or dexterity that is acquired or developed through training or experience. It refers to the skill that the user has in handling the mouse and keyboard. Can he/she use a computer mouse effectively or does he/she find it difficult to move the mouse cursor from one location on the screen to another? This also refers to how fast the user can perform certain tasks with the mouse. This skill includes the click, double click, drag and move actions.

Throughout the playing of the games and completion of the MS Word tests the user's knowledge and skills will be improved. A user's knowledge usually

increases faster than his/her skills do; thus it is quicker to learn how to play the mouse-orientated computer game than it is to use the computer mouse effectively. Skills are developed through time and practice. This study will focus more on the user's skill than on his/her knowledge.

5.3 Learning time

It was necessary to explain and demonstrate iCGames to the different groups of students before they started to play on their own. This demonstration showed the users how to register themselves on the system and explained how each game is played. This was done to minimise the users' system learning time, thus increasing their knowledge (referred to section 5.2). This process took between 10 and 15 minutes.

After the demonstration the users were left on their own to do the registration and to start playing the games. The individual registrations took between 3 and 5 minutes. The researcher was present for the duration of the period and assisted with registration problems or questions regarding the games. A total time of one hour was available.

5.4 Phase 1 - The effect of race and difficulty levels

The first two questions that had to be answered in phase one were: "Does race play a significant role?" and "Do difficulty levels play a significant role?" All the students in this first group only played the games. All the relevant game data was saved in a database.

5.4.1 Methodology

The data that was gathered from the games included player scores on all three difficulty levels. The first step was to determine whether there is a significant difference between the scores of the two races, black males (BM) and white males (WM). Not enough females participated in this study, and this is why only the scores of males, black and white, were considered.

It was also necessary to determine whether the scores that players obtained on the different difficulty levels could be considered to be on the same scale. Can the scores on difficulty level one be compared with the scores that were obtained on level two and also on level three? In other words, can the difficulty level be ignored in this study?

A user's skill should remain the same throughout the different difficulty levels. The user's ability to use the mouse (mouse skill) does not change from one level of difficulty to the next, although his/her score may differ because of different scoring that is applied on different difficulty levels. The researcher's objective was to determine whether this was truly the case.

The following hypotheses were formulated to address these questions:

$H_{0,1}$: *There is no difference between the average scores of white males and black males on any one of the difficulty levels.*

$H_{0,2}$: *The level of difficulty has no effect on the score that a user obtains in a game.*

5.4.2 Results

Table 5.1 shows the means of Plane Blaster scores for the different user groups. The interaction plot between the two factors *level* and *race* are shown in Figure 5.1.

Difficulty Level	WM			BM		
	1 (Easy)	2 (Medium)	3 (Hard)	1 (Easy)	2 (Medium)	3 (Hard)
N	13	13	13	41	41	41
Mean	547.36	841.28	1188.72	468.95	706.96	828.98
SD	146.59	208.46	455.08	117.07	260.01	478.69

WM: White male; BM: Black male

Table 5.1: Means of Plane Blaster scores for different user groups
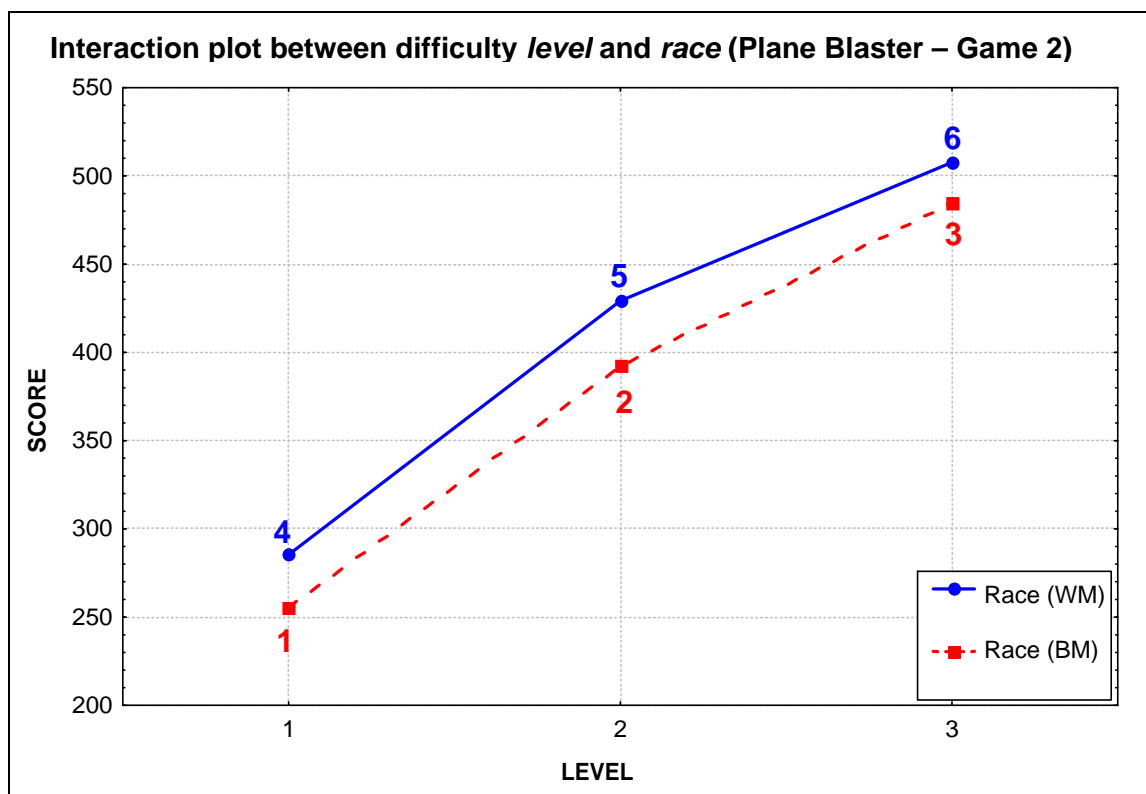
Figure 5.1: Interaction plot between difficulty *level* and *race* for Plane Blaster (Game 2)

An analysis of variance (ANOVA) was done for the Plane Blaster game and it was found that the interaction effect of *race* and difficulty *level* was not

significant (α=0.05; F(2,156)=0.05; p<.9490). This means that the two main effects are independent of each other and can be interpreted independently.

Of the two individual main effects (*race* and *level*), *level* was significant (α=0.05, F(2,156)=0.05). Thus, $H_{0,1,}$ which indicates that race has no significant effect in this study (α=0.05, F(1,156)=0.05) and can be ignored for the rest of the statistical analysis to follow, cannot be rejected.

Since there were three levels of difficulty, Tukey's test for the honestly significant difference was used to determine which of the differences between group means for the respective difficulty levels were statistically significant (α=0.05). The results are tabulated in Table 5.2. The significant values are highlighted and printed in red.

	WM–L1	WM–L2	WM–L3	BM-L1	BM-L2
WM–L1					
WM–L2	0.0009				
WM–L3	0.0000	0.2476			
BM-L1	0.9089	0.0000	0.0000		
BM-L2	0.0033	0.8095	0.0012	0.0000	
BM-L3	0.0000	0.4098	0.9680	0.0000	0.0001

Table 5.2: p-values showing the significance of differences in mean scores between *race* and *difficulty level* for Plane Blaster

The differences between the following points (Figure 5.1) are significant: 1-2, 1-3, 2-3, 4-5 and 4-6 with a single exception of 5-6. This means that $H_{0,2}$ can be rejected and that the level of difficulty has a significant influence on the scores that players obtain with Plane Blaster (Game 2).

Similar analyses were done for the other games. The results are summarised in Table 5.3.

	Interaction effect	Effect of race ($H_{0,1}$)	Effect of level of difficulty ($H_{0,2}$)
Infestation (Game 1)	S	S	S
Plane Blaster (Game 2)	N/S	N/S	S
Pool (Game 3)	N/S	S	S
Rescue (Game 6)	N/S	N/S	S
Bunny Wack (Game 4)	S	S	-
Speed (Game5)	N/S	N/S	-

Table 5.3:   Significance of effects of different games
(S: Significant; N/S: Not significant)

An interesting observation was made in considering Table 5.3. The interaction effect of Pool (Game 3) is not significant; although the effects of *race* and *difficulty level* are significant. The interaction plot between *level* and *race* for Pool (Game 3) is shown in Figure 5.2.
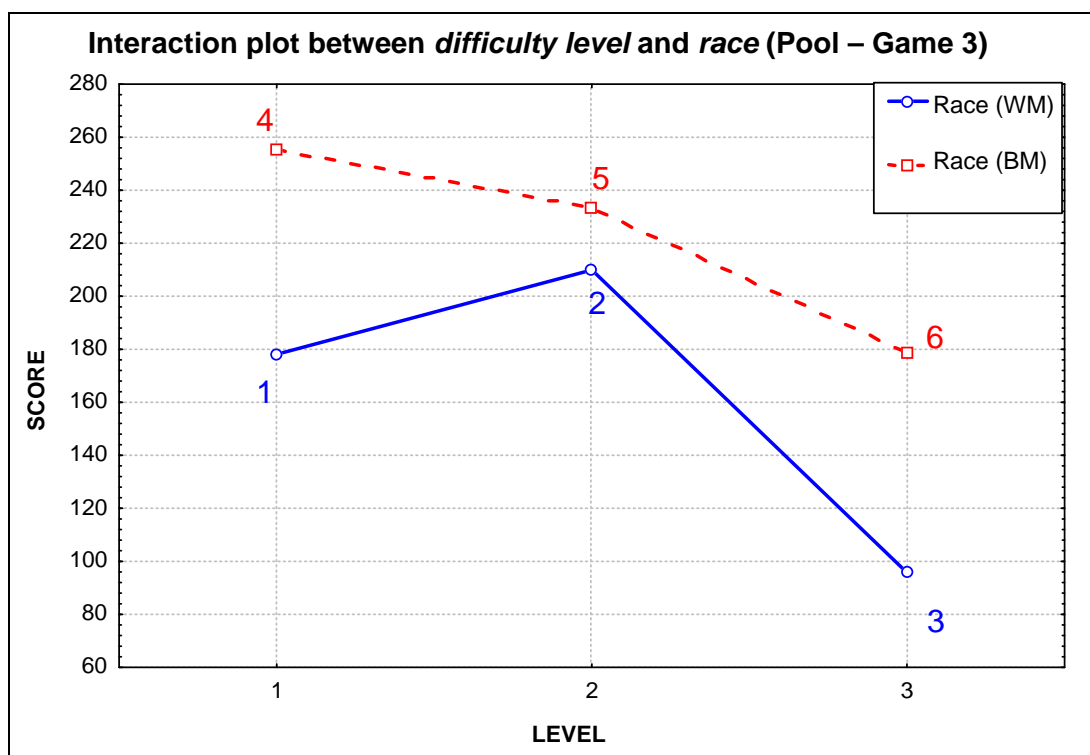
Figure 5.2: Interaction plot between *difficulty level* and *race* for Pool (Game 3)

Tukey's test for the honestly significant difference was used to determine which of the differences between group means for the respective difficulty levels were statistically significant (α=0.05).

It was found that the difference between the following points (Figure 5.2) were statistically significant: 1-4 and 3-6. This indicates that the average score of black males are significantly higher that those of white males on difficulty levels one (Easy) and three (Hard). It is clearly visible from Figure 5.2 that the average score of black males are, on all three difficulty levels, higher than those of white males. The reason for this could be that black males have more experience in the actual game than do their white counterparts or that they have practised/played this game more, resulting in better/higher scores.

It was also found that the difference between the following points (Figure 5.2) were statistically significant: 1-3, 2-3, 4-6 and 5-6. This confirms the fact that difficulty level does play a significant role.

5.4.3 Discussion

It is clear that the overall effect of race is not significant (although some of the differences between specific points were significant) in Plane Blaster, Rescue and Speed and this factor will therefore be left out in the rest of the statistical analysis to follow. The level of difficulty, however, plays a significant role in all the games that have difficulty levels. Thus from this point onward, all analyses will be done on the data captured for difficulty level one (Easy) only.

5.5 Phase 1 - Computer use frequency (CUF)

All the players (including all races and genders) were grouped together to form a single group. This was done because race does not play a significant role in

this study (refer to section 5.4) and not enough females participated in this study to distinguish between genders. Thus all the analyses from this point onward, in phase one, will be done with this single group on difficulty level one only.

The final question to be answered in phase one was whether computer use frequency (CUF) plays a significant role.

5.5.1 Methodology

Upon registration the players had to indicate how often they use a computer, excluding their compulsory computer practical classes. There were five options: 'Never', 'once a month', 'once a week', 'once a day' and 'a few times a day'. In order to maximise the number of respondents in each group and to balance the groups as far possible, the players were divided into three groups according to their frequency of computer use. The different groups are shown in Table 5.4.

	Computer usage
Group 1 (CUF 1)	Never Once a month Once a week
Group 2 (CUF 2)	Once a day
Group 3 (CUF 3)	A few times a day.

Table 5.4: Computer usage groups

It was necessary to determine whether a person's frequency of computer use and number of attempts had an influence on the score that could be obtained per game. It was also necessary to determine how many times a user had to

play a game before he reached a plateau (a score that is difficult to improve) and could only improve his score with much effort.

The following hypotheses were formulated, for games 1 to 6, to address the above stated question:

$H_{0,1}$: *There is no difference between the average score, in a specific game, of users that use a computer more frequently and the average score of users who use a computer less frequently.*

$H_{0,2}$: *The average score of users that use a computer more frequently will reach a plateau at the same time as the average score of users that use a computer less frequently.*

5.5.2   Results

Figure 5.3 shows the scores, per attempt, obtained by users in Infestation (Game 1) for the three CUFs.
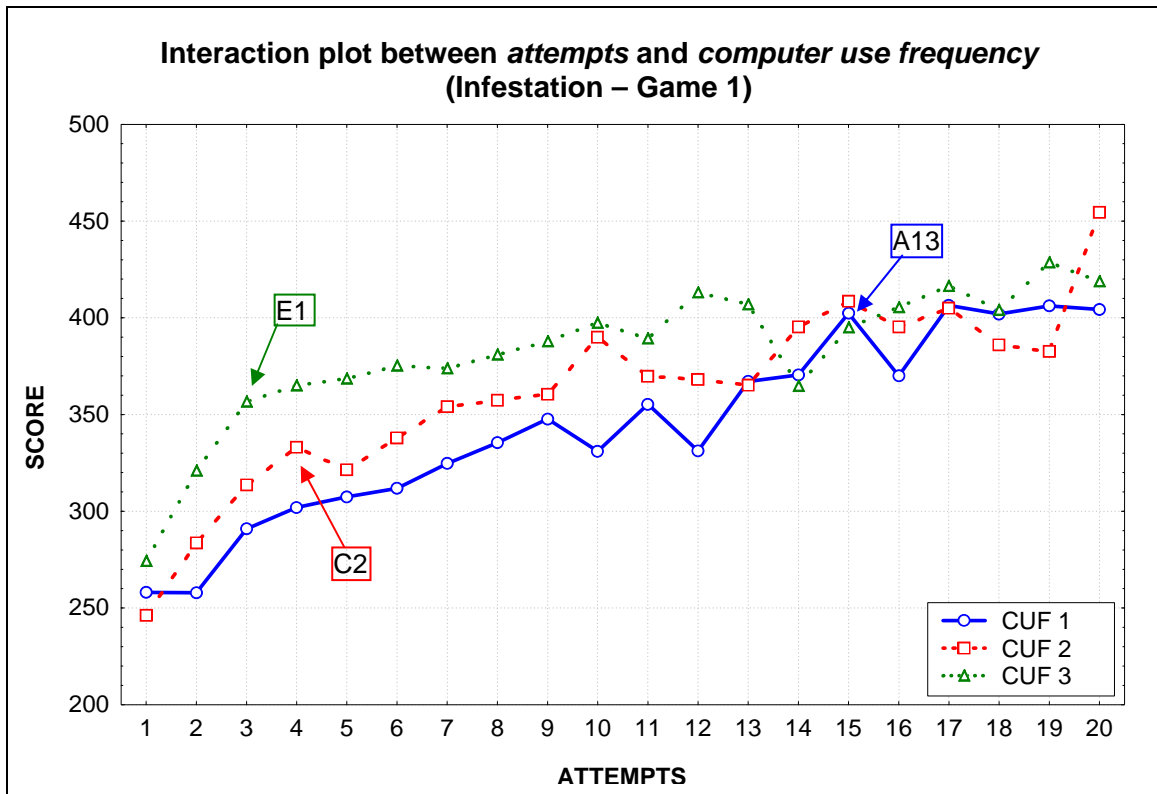
Figure 5.3: Interaction plot between *attempts* and *computer use frequency* for Infestation – Game 1

An analysis of variance (ANOVA) was done for Infestation (Game 1) and it was found that the interaction effect of *computer use frequency (CUF)* and *attempts* was not significant (α=0.05; $F_{(38,3075)}$ =.59; p<.9802). This indicates that the two main effects are independent of each other and can be interpreted independently.

Tukey's test for the honestly significant difference was used to determine which of the differences between group means, as indicated in Figure 5.3, were statistically significant (α=0.05). The results regarding the experience are tabulated in Table 5.5. In order to enhance readability, only the most informative *p-values* are shown.

		A	B	C	D	E	F
		CUF 1		CUF 2		CUF 3	
	ATTEMPTS	1	2	1	2	1	2
1	3					0.000	
2	4			0.039		0.000	
3	5					0.000	
4	6			0.027		0.000	
5	7			0.001		0.000	
6	8			0.002		0.000	
7	9			0.001		0.000	
8	10			0.000	0.011	0.000	
9	11			0.001		0.000	
10	12			0.003		0.000	0.006
11	13			0.018		0.000	0.036
12	14			0.000		0.033	
13	15	0.023	0.026	0.000	0.035	0.000	
14	16			0.004		0.000	
15	17	0.037	0.041	0.007		0.000	
16	18	0.043	0.047			0.000	
17	19	0.038	0.042			0.000	
18	20	0.034	0.037			0.003	

Table 5.5: p-*values* showing the significance of differences between mean scores for different attempts and computer use frequencies (CUF) for Infestation.

From Table 5.5 it is clear that there are no significant differences between the scores of the three groups of CUFs (α=0.05). This means that the user who uses a computer more frequently does not perform better than the user who uses a computer less frequently. Table 5.5, however, indicates that there are significant differences between the scores within a CUF group from the first attempt to the last attempt.

The first significant improvement in score after the first attempt, within CUF 1, occurs after 15 attempts (α=0.05) as indicated in Figure 5.3, point A13, and in Table 5.5, cell A13. The line slopes upward, indicating that the users improve the more they replay the game.

The first significant improvement in the score after the first attempt, within CUF 2, occurs after the 4th attempt (α=0.05) as seen in Figure 5.3, point C2 and in Table 5.5, cell C2. In Figure 5.3 the line climbs steeply and then reaches a plateau between attempts 7 to 13, with an exception in attempt 10, after which it climbs again.

With CUF 3 the first significant improvement in score occurs after only 3 attempts, as seen in Figure 5.3, point E1 and in Table 5.5, cell E1. In Figure 5.3 it is seen that the line climbs steeply for three attempts and then a plateau is reached until attempt seven. From eight attempts onward it climbs again.

Similar analyses were done for the other games. The results are summarised in Table 5.6.

	Interaction effect	Effect of attempts	Effect of CUF
Infestation (Game 1)	N/S	S	S
Plane Blaster (Game 2)	S	S	S
Pool (Game 3)	N/S	S	S
Bunny Wack (Game 4)	N/S	S	S
Speed (Game 5)	N/S	S	S
Rescue (Game 6)	N/S	S	N/S

Table 5.6: Significance of effects of different games
(S: Significant; N/S: Not significant)

5.5.3 Discussion

It was noted that the number of *attempts* and *computer use frequency (CUF)* played a significant role. It is clearly visible, in Figure 5.3, that all three lines (CUF1-CUF3) run more or less parallel until they reach attempt 15 where they

intersect. From attempt 15 onward there is no significant difference between the different CUFs. Thus attempts 15 to 20 can be ignored.

It is clearly visible from Figure 5.3 that the slope of the lines at the start differs. The slope of CUF1 is less than that of CUF2 and the slope of CUF2 is less than CUF3. For CUF1 the plateau is reached after 15 attempts. For CUF2 the plateau is reached after 7 attempts and for CUF3 the plateau is reached after only 4 attempts.

Here the influence of the two factors (knowledge and skill) that were mentioned in section 5.2 is clearly visible. The users in CUF1 had to learn how to play the specific game and how to use the computer mouse effectively. The users in CUF3 only had to learn how to play the game as they could already use the computer mouse effectively.

5.6 Phase 2 - The Office package

In sections 5.4 and 5.5 computer mouse hand-eye coordination was all that was tested and analysed. It must be kept in mind that the main research question of this study is: *to determine whether experience with mouse-orientated computer games enhances the value that a user draws from an office package in a GUI environment.* To investigate the second part of the research question the researcher had to investigate the Office package.

5.6.1 Methodology

To investigate this main research question it was decided to use a new group of first year students, studying at the CUT, FS, as respondents, and using Microsoft Word (MS Word) as the Office package. These students had not previously participated in the games or come into contact with them. Sixteen

randomly selected first-year students were selected to assist with this part of the research. The criteria that were used for selecting the students included the following:

❖ The student had to be a non-IT student.

❖ The student still needed to be busy with the computer literacy course.

❖ The student had to be a novice computer user (as described in Chapter 3, section 3.7).

The students were tested every second day, over a period of five weeks, during lunch time in one of the computer laboratories in the School of Information and Communication Technology at the CUT, FS. During the September holiday there was an interruption of one week.

For each session, lasting one hour, the students had to complete two MS Word tests and play three of the games. The results of both the tests as well as those of the games were captured. Ten sessions were held during which only ten of the original sixteen students completed all the sessions.

5.6.2 Microsoft Word test (Appendix B, Appendix C and Appendix D)

It is important to understand that the students' knowledge on MS Word was not tested, but rather that MS Word was used to test the student's mouse skills. Because of this, a copy of the MS Word test was handed out to all the students a few days before the research sessions started. The same MS Word test was given each time in every session to minimise the influence of the knowledge factor for each student. This also ensured that the speed in completing the tasks was measured more accurately.

The MS Word test that was handed out to the students can be seen in Appendix B. Appendix C shows the partially completed MS Word file that the students

received on disk for each session and Appendix D shows the correct MS Word document that the students had to create by answering all the questions in the MS Word test.

The MS Word test was photocopied and handed out to the students at each session. At each session the students also received the partially completed MS Word file (Appendix C) on disk.

When the researcher met with these students for the first session they went through the MS Word test together. It was necessary to determine whether the students improved at the MS Word test as a result of more computer mouse hand-eye coordination exercises during the playing of the games. In order for them to practise and to improve their computer mouse hand-eye coordination, they were given the games to play.

5.6.3 Setup and marking of the MS Word tests

During each session the students had to complete the MS Word test, play three games (Infestation (Game 1), Bunny Wack (Game 4) and Speed (Game 5)) five times on difficulty level Easy and then complete the same MS Word test again.

The MS Word test was set up in such a way that all ten questions could be done (and had to be done) by using the computer mouse only. Each student had to print his/her MS Word document after completion. Thus, two MS Word documents were submitted by every student for each session.

The questions were ranked from easy to difficult. The difficulty of the questions was determined by considering the criteria below. These criteria were also used to determine a weight allocation for each question.

❖ Depth

The depth refers to the menu structure. How deep in the menu does the user have to go to <u>find the command/item he/she requires</u> to complete the question? This does not refer to completing the question. (Example: To print a document using the File menu the user must click on File and then on Print. The depth is two. Keep in mind that the document is not yet printed.)

❖ Total actions

Total actions refers all the actions (mouse clicks) that a user needs to do in order <u>to complete</u> a question. These are all the mouse actions from the beginning of the question till the question is completed. (Example: To print a document using the File menu the user must click on File and then on Print. When the print dialogue box opens the user must click on OK, assuming no settings are changed. The total actions are three. The document is now printed.)

❖ Types of mouse actions

Three mouse actions were identified. They include Click, Double Click and Drag. Each mouse action had a different weight (refer to Table 5.7).

Mouse action	Marks
Click	1
Double click	2
Drag	3

Table 5.7: Mouse actions and respective weights

(Example: To print a document using the File menu the user must click on File and then on Print. When the print dialogue box opens the user must click on OK, assuming no settings are changed. The mouse action during all the tasks consists of only one click thus the weight would be

one. When the user has to select a word using double click or the drag selection method the respective weight is two or three.)

❖ Knowledge

This factor can only count zero or two. This weight was decided on by considering the contents of the prescribed text book for the basic computer literacy subject which these students were enrolled for. If the students had covered the specific content tested in the question the knowledge factor for that question was zero. The allocated weight for a question was two if the contents of the question were something that the students had not done in the subject.

The detail and total weight of the different questions, as seen in Appendix B, are displayed in Table 5.8.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
Depth	0	0	0	2	2	2	3	2	2	4	
Total actions	2	2	5	4	5	5	6	6	7	8	
Mouse action	1	3	1	1	1	2	1	1	1	1	
Knowledge	0	0	0	0	0	0	0	2	2	0	
Total	**3**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**84**

Table 5.8: Weight allocation for the different questions

5.6.4 Time measurement (minutes)

The time it took a student to complete the test was also measured as well as the time it took to complete each individual question. The time was measured in minutes.

A Timer Application was developed to measure the time that a student took to complete a question. Figure 5.4 shows the initial screen that the students saw each time before they started with the MS Word test.
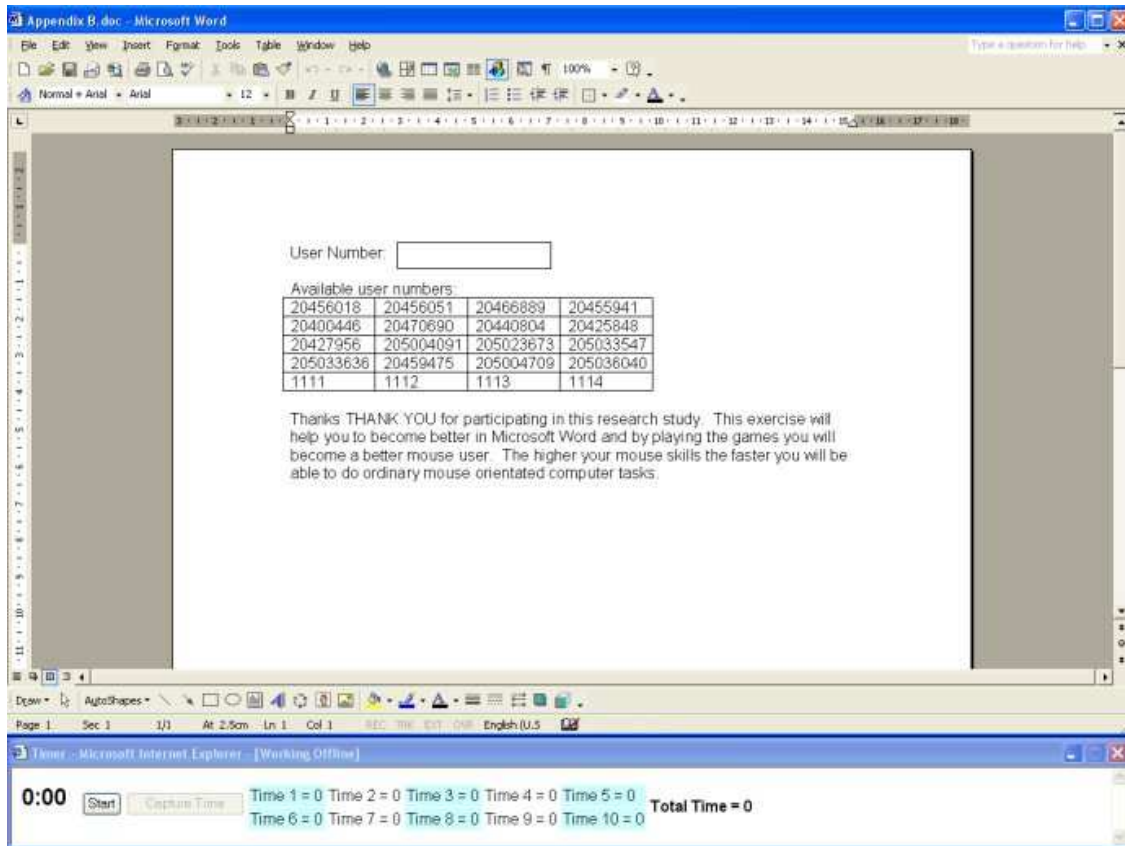
Figure 5.4: MS Word test and Timer Application

The Microsoft Word test filled the top 87% of the screen and the Timer the bottom 13%, as seen in Figure 5.4. This ensured that the student did not have to jump between two open applications, lying behind one another, and also that the expired time was visible for the duration of the test.

The first instruction on the MS Word test (Appendix B) was to click on the 'Start' button in the Timer at the bottom of the screen (Figure 5.4). After completing each question the student had to click on the 'Capture Time' button. The current time was then written to the respective placeholders.

The Timer ensured that the correct times were captured each time. As soon as the user clicks on the 'Start' button the timer starts, the 'Start' button disappears and the 'Capture Time' button becames enabled. The Timer Application also ensures that only one time is captured even if the user double-clicks the 'Capture Time' button accidentally.

5.6.5 MS Word test total completion time

The first two questions that were investigated in phase two were: "Is there a difference between the average total completion time for the two MS Word tests within a session?" and "Is there a difference in the average total completion time between the different sessions?"

Ten students, from the original sixteen, completed ten sessions each where each student completed two MS Word tests. The results of the MS Word tests prior to the games and those after the games were kept separate. This was done to see if the playing of the games helped to improve the computer mouse hand-eye coordination in the Office (GUI) working environment.

5.6.5.1 Methodology

One of the important things to determine was whether or not the playing of computer games (Infestation, Bunny Wack and Speed) improved the users' computer mouse hand-eye coordination. If this was the case, it was necessary then to determine whether a user draws more value from the Office package. Thus, to investigate the above the total completion time for the MS Word test would have to be investigated first. The following hypotheses were formulated to investigate these aspects:

$H_{0,1}$: There is no difference between the average total completion time for the first MS Word test and the second MS Word test within any specific session.

$H_{0,2}$: There is no difference in average total completion time between the different sessions.

5.6.5.2   Results

In order to do parametric tests the inverse of time (1/t) was used to normalise the data. The inverse of time will be used during the duration of this phase of the study and is expressed in min^{-1}.

The interaction plot between *session* and *test* for the MS Word tests are shown in Figure 5.5.
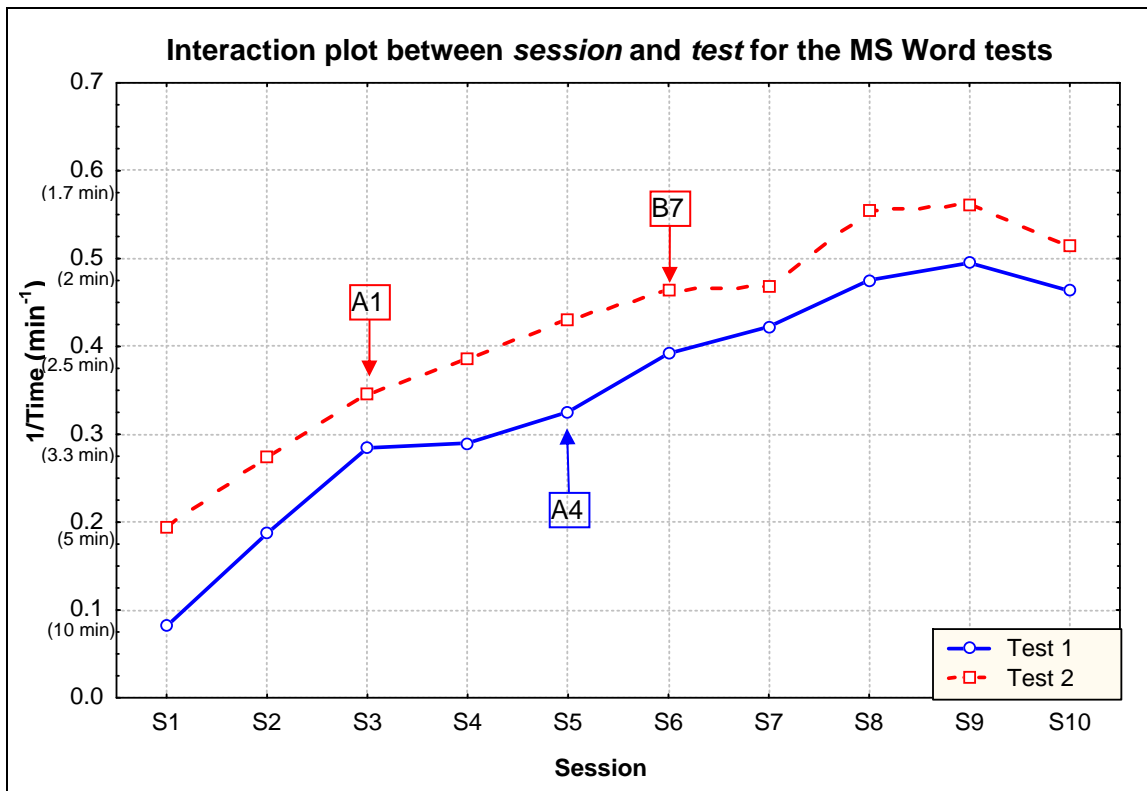
Figure 5.5: Interaction plot between *session* and *test* for the MS Word tests

An analysis of variance (ANOVA) was done for the MS Word tests and it was found that the interaction effect between *session* and *test* was not significant (α=0.05; $F(9,180)$=.11; $p<.9995$). Therefore, the main effects (*session* and *test*) could be analysed independently.

It was found that both of the two individual main effects (*session* and *test*) were significant (Session: α=0.05, $F(9,180)$=13.76 ; Test: α=0.05, $F(1,180)$=12.87). Thus both $H_{0,1}$ and $H_{0,2}$ are rejected.

Tukey's test for the honestly significant difference was used to determine which of the differences between group means for the respective MS Word *tests* and *sessions* were statistically significant (α=0.05). The results are tabulated in Table 5.9. In order to enhance readability, only the most informative *p-values* are shown.

		A	B	C	D	E	F	G
		S1-T1	**S1-T2**	**S2-T1**	**S2-T2**	**S3-T1**	**S3-T2**	**S4-T1**
1	**S3-T2**	0.016						
2	**S4-T1**							
3	**S4-T2**	0.002						
4	**S5-T1**	0.047						
5	**S5-T2**	0.000		0.050				
6	**S6-T1**	0.001						
7	**S6-T2**	0.000	0.012	0.008				
8	**S7-T1**	0.000						
9	**S7-T2**	0.000	0.010	0.007				
10	**S8-T1**	0.000	0.006	0.004				
11	**S8-T2**	0.000	0.000	0.000	0.007	0.122		0.016
12	**S9-T1**	0.000	0.001	0.001				
13	**S9-T2**	0.000	0.000	0.000	0.005	0.008		0.011
14	**S10-T1**	0.000	0.013	0.009				
15	**S10-T2**	0.000	0.001	0.000				

Table 5.9: *p-values* showing the significance of differences between 1/t for different sessions and tests.

The first significant increase in time for the first MS Word test occurred after five sessions (Figure 5.5, point A4, and Table 5.9, cell A4). It must be kept in mind that this is only for the MS Word test 1. For each session the students completed the first MS Word test and then they played the three games before they completed the second MS Word test. The first significant increase in time for the second MS Word test occurred after six sessions (Figure 5.5, point B7, and Table 5.9, cell B7).

It will be more accurate to use the results of both the MS Word tests to see where the first significant increase in time is. The first significant increase occurred after the first three full sessions as seen in Figure 5.5, point A1, and in Table 5.9, cell A1.

In both cases, MS Word test 1 and MS Word test 2, the results indicate that the more sessions the students attend the faster they can do the MS Word tests. Thus the value they draw from the Office package increases. This value increases after only three sessions.

The graph, as seen in Figure 5.5, also shows that the two lines, MS Word test 1 and MS Word test 2, run parallel to each other from session one to session ten in a positive, upward direction indicating that the students' total time taken to complete the tests is decreasing. It can also be noted that MS Word test 2 is above MS Word test 1 which indicates that the students' total time in completing the MS Word test improved from the first MS Word test to the second one within the same session. The students' ability to use the mouse more efficiently/effectively increased from the first to the second test. This could be due to the fact that the students played the three mouse-orientated computer games between doing the two tests, thus improving their computer mouse skill. Short term memory retention could also play a role: The problems experienced in test 1 were not repeated in test 2.

It must also be noted that the students' ability to retain knowledge, especially with the MS Word test, is not totally lost between sessions. Note that the total time to complete the first MS Word test in session two is almost equal to the total completion time of the second MS Word test in session one. The same result can be seen from session two to session three. This indicates that the students' skill retention increased and that the learning time is minimised and plays a smaller role. The knowledge factor is thus decreased and the skill factor is the only factor measured.

5.6.5.3 Discussion

It can clearly be seen from Figure 5.5 that the students' ability to use the mouse increased from the first session, resulting in a decrease in the total completion time for the MS Word test; the value that he/she drew from the Office application increased.

5.6.6 MS Word test total mark

It is clear from the previous section that the total time for completing the first and second MS Word tests decreased from the first session onwards. This indicates that the users' computer mouse hand-eye coordination increased after each session. Between the sessions the users lost a little of the mouse skill which they had acquired during the previous session; not all of it was lost, however.

A more accurate estimate of value drawn from the Office application would be obtained by measuring the accuracy of the completed MS Word test handed in by the students. Thus, questions three: "Is there a difference between the average total marks for the MS Word tests in any sessions?" and four: "Is there a difference in the average total mark between the different sessions?" were investigated.

5.6.6.1 Methodology

After completing each MS Word test the student handed in a printed copy of his/her test. This printout was marked using the weights in Table 5.8. To determine whether a user truly gained more value from the Office application it was important to see whether the total average mark of the group increased, decreased or stayed the same between the sessions. To investigate the above the following hypotheses were formulated:

$H_{0,1}$: *There is no difference between the average total mark for the first MS Word test and the second MS Word test within any specific session.*

$H_{0,2}$: *There is no difference in average total mark between the different sessions.*

5.6.6.2 Results

The interaction plot between *session* and *test* for the MS Word tests is shown in Figure 5.6.
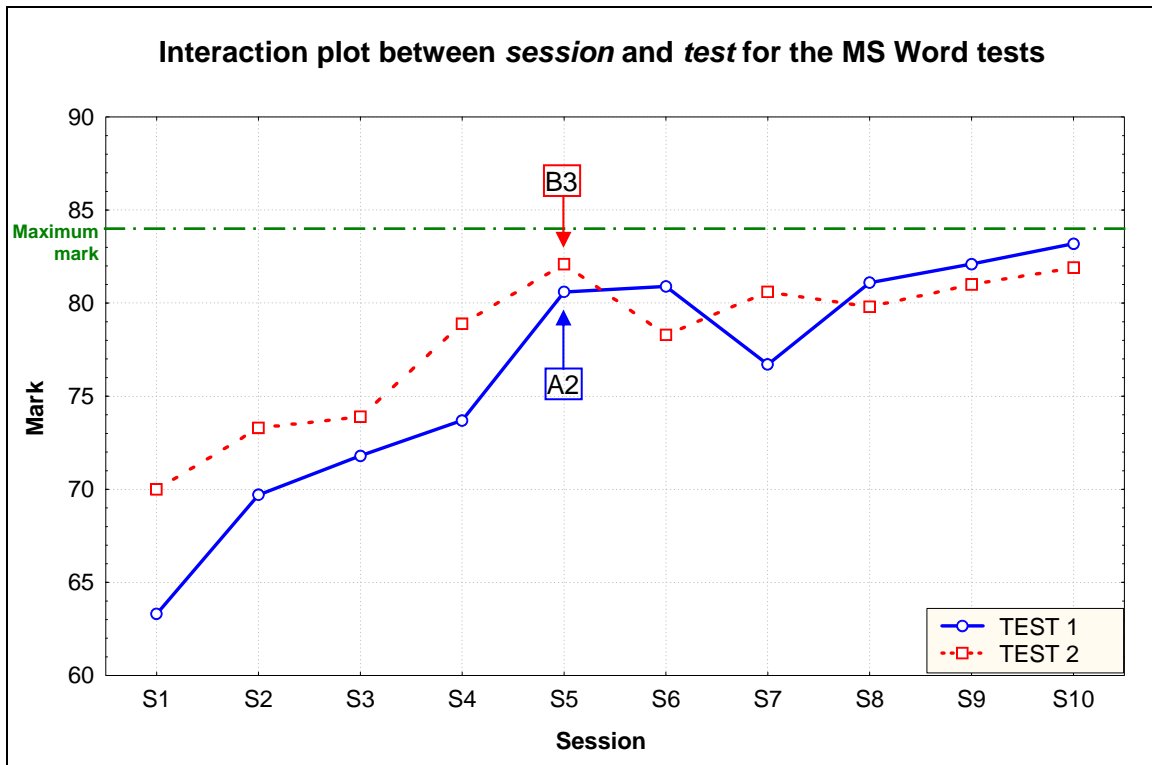
Figure 5.6: Interaction plot between *session* and *test* for the MS Word tests

An analysis of variance (ANOVA) was done for the MS Word tests and it was found that the interaction effect between *session* and *test* was not significant (α=0.05; $F_{(9,180)}$=.94; p<.4878). Therefore the main effects (*session* and *test*) can be investigated individually.

Of the two individual main effects (*session* and *test*), *session* was significant (α=0.05, $F_{(9,180)}$=10.33; p<.0000). Therefore *$H_{0,2}$ can be rejected.*

Since there were ten sessions, Tukey's test for the honestly significant difference was used to determine which of the differences between group means for the respective sessions were statistically significant (α=0.05). The results are tabulated in Table 5.10. In order to enhance readability, only the most informative *p-values* are shown.

		A S1-T1	B S1-T2	C S2-T1
1	S4-T2	0.000		
2	S5-T1	0.000		
3	S5-T2	0.000	0.028	0.020
4	S6-T1	0.000		
5	S6-T2	0.000		
6	S7-T1	0.006		
7	S7-T2	0.000		
8	S8-T1	0.000		
9	S8-T2	0.000		
10	S9-T1	0.000	0.028	0.020
11	S9-T2	0.000		
12	S10-T1	0.000	0.008	0.005
13	S10-T2	0.000	0.035	0.025

Table 5.10: *p-values* showing the significance of differences between mean marks for different *sessions* and *tests*.

The first significant increase in mark, for MS Word test 1, occurs after five sessions (refer to Figure 5.6, point A2, and Table 5.12, cell A2). From Figure 5.6 one can see that the line, MS Word test 1, slopes upward in a positive direction from session one onward. A plateau is reached between sessions five and ten with an exception at session 7.

It is interesting to note that a dip occurs in session seven for MS Word test 1. This is due to the September holiday. This indicates that the students did not retain all the information during the September holiday, although they remembered everything quickly, after only one test, as seen in session seven MS Word test 2. The average mark in session seven (MS Word test 2) is almost equal to the mark in session six (MS Word test 1).

The first significant improvement in mark after the first test occurred after the fifth session (Figure 5.6, point B3, and Table 5.12, cell B3). By looking at Figure 5.6 one can see that the line, MS Word test 2, slopes upward in a positive

direction from sessions one to five although the incline is less than that for MS Word test 1.

It seems that the students performed worse in the second MS Word test in sessions six to ten, with an exception in MS Word test 1, session seven. These results were not significant, however. During sessions eight to ten it was observed that the students did not have the same enthusiasm in completing the tests as they did in the beginning. Many of them wanted to finish as fast as possible and leave. This could be due to the fact that the students wanted to study for their year-end tests in other subjects.

The gap between the lines for MS Word test 1 and MS Word test 2 narrows from session one to session five. Thereafter there is no significant difference between the two tests. At session five the two lines intersected, indicating that the students' knowledge factor had reached a maximum and from there onward only computer mouse skill contributed to an improved mark. It should be noted that it is highly improbable that all students will obtain full marks for a specific test. It is therefore unlikely that the average will ever reach full marks (dotted line in Figure 5.6).

5.6.6.3 Discussion

It is clearly visible, from Figure 5.6, that the group's average mark for both tests improved from session one onward. At session five the students' knowledge factor reached a maximum. From there onward only computer mouse skill continued to improve. The figure also indicates that the student draws more value from the Office application after gaining better computer mouse hand-eye coordination from the mouse-orientated computer games.

5.7 Phase 2 - The Games

In section 5.6.5 it was found that the students' time taken to complete the MS Word test decreased significantly from the first session onwards. In section 5.6.6 it was found that the students' mark in the MS Word test also increased significantly from session 1 to session 5. Furthermore, it was seen that the students' knowledge stabilised at session 5, indicating that their knowledge did not increase further. At this point only mouse skills developed further.

The mouse skills of the students were mostly developed through the playing of the games. To address the research question: *"Do mouse-orientated computer games enhance the value that a user draws from an office package in a GUI environment?"* it was necessary to look at the computer games as well.

In section 5.4 it was found that the effects of race and gender did not play a significant role in the playing of the games. Thus race and gender were ignored in this study. It was, however, found that difficulty level did play a role. Thus only the data that were gathered from the games played on difficulty level Easy were used. It was clearly visible from section 5.5 that Computer Use Frequency (CUF) played a significant role. The more a user played the games the better he/she became at it.

"Does a student's score in any of the three games remain constant through different attempts and sessions?" was the fifth question to be investigated in phase 2.

5.7.1 Methodology

The same group of students that participated in the MS Word tests (section 5.6) also played the games.

The following hypothesis was investigated:

H_0: A student's score in any of the three games remains constant through all the attempts and different sessions.

5.7.2 Results

The average *score* per *session* for Infestation (Game 1) is shown in Figure 5.7.
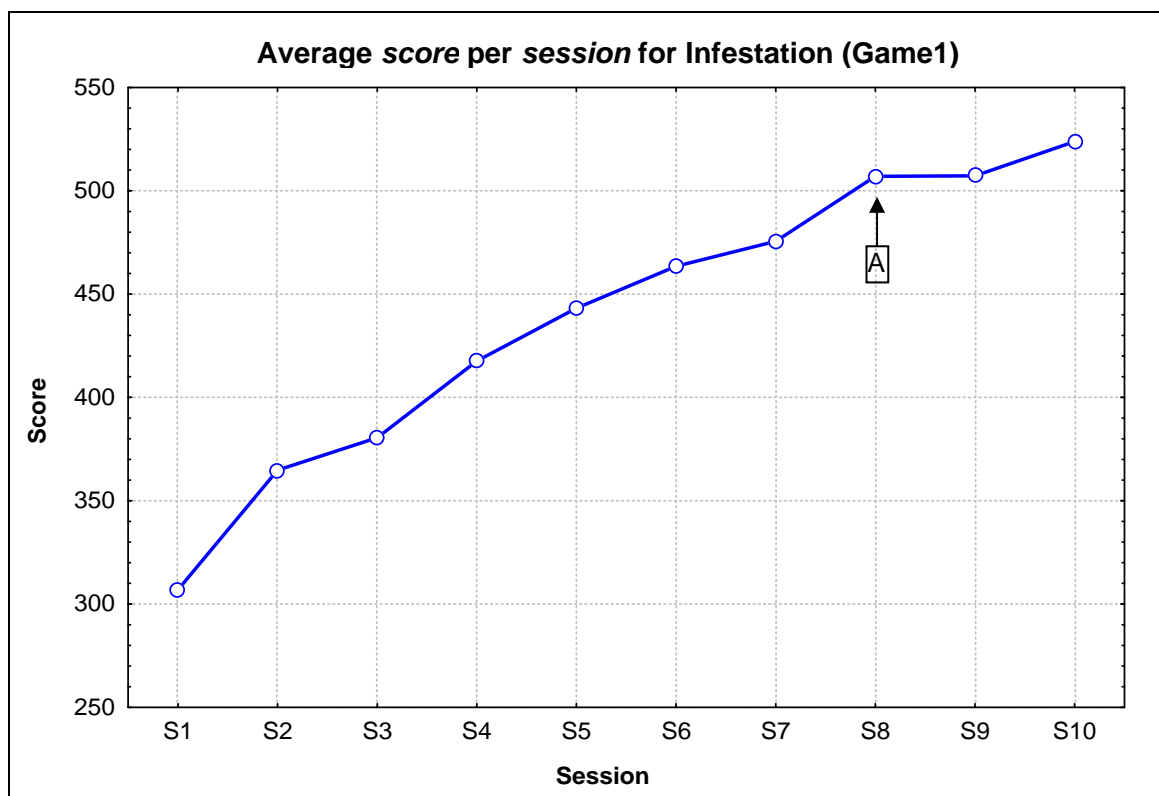

Figure 5.7: Average *score* per *session* for Infestation (Game1)

An analysis of variance (ANOVA) was done for Infestation (Game 1) and it was found that the main effect was significant (α=0.05; $F_{(9,89)}$=2.68; p<.0084). Therefore H_0 can be rejected.

Since there were ten sessions, Tukey's test for the honestly significant difference was used to determine which of the differences between group means for the respective sessions were statistically significant (α=0.05). The results are tabulated in Table 5.11. In order to enhance readability, only the most informative p-values are shown.

	S1
S8	0.045
S9	0.044
S10	0.020

Table 5.11: *p-values* showing the significance of differences between mean scores for different *sessions* and *scores* for Infestation (Game 1)

The first significant improvement from session 1 for Infestation occurred after eight sessions as seen in Figure 5.7, point A, and in Table 5.11. Figure 5.7 depicts clearly that the line slopes upward in a positive direction from session one onward. This incline in the line indicates that the students' computer mouse hand-eye coordination increased after each session, proving that the students' mouse skill was continuing to increase.

The knowledge factor also plays a role and cannot be left out. This role is very small, however, because there is not much a user needs to know in order to play the games. For each session the user plays each game five times, thus the knowledge factor is minimised fully within the first session.

Similar analysis was done on the two remaining games (Bunny Wack and Speed). The results are summarised in Table 5.12.

	Main Effect
Bunny Wack	N/S
Speed	N/S

Table 5.12: Significance of main effect of different games
(S: Significant; N/S: Not significant)

From Table 5.12 it is clear that the main effect between *session* and *score*, for Bunny Wack and Speed, is not statistically significant. This, however, does not mean that the users' computer mouse hand-eye coordination does not increase when they play these games.

5.7.3 Discussion

In this section it can be seen (Figure 5.7) that a users' computer mouse hand-eye coordination increases dramatically through playing mouse-orientated computer games (Infestation). The mouse-orientated computer games must therefore enhance the value that a user draws from an office package.

5.8 Phase 2 - Games and MS Word

Up to this point it was found that the users improved their computer mouse skill by playing the games (section 5.7). They also improved on their scores (section 5.6.6) and total completion time (section 5.6.5) in the MS Word tests.

The final question: "Is there a correlation between the score that a user obtains in one of the games and the total completion time for the MS Word test in the different sessions?" in phase two will be investigated. Does a user who performs well in the games also complete the MS Word test in a short time?

5.8.1 Methodology

The question also arose as to whether there is a correlation between the scores that a user obtains in one of the three games and the time he/she takes to complete the MS Word test. The results that were captured from the students who played the games and completed the MS Word tests were used to address this question.

In order to answer the above question the following hypothesis was formulated:

H_0: *There is no correlation between the score that a user obtains in one of the three games (Infestation, Bunny Wack and Speed) and the total completion time of the MS Word test for the different sessions.*

5.8.2 Results

Table 5.13 shows the game scores of Infestation (Game 1) and the time taken to complete the second MS Word test for session 3. The significant values are highlighted and printed in red.

	Session 3			
	Infestation		MS Word test	
	Score	Rank	1/t	Rank
Student 1	134	10	0.12	10
2	280	6	0.30	7
3	530	3	0.41	6
4	198	9	0.45	2
5	459	5	0.42	3
6	503	4	0.49	1
7	260	8	0.18	9
8	272	7	0.24	8
9	546	2	0.42	3
10	623	1	0.42	3
R	0.709			
P	0.022			

Table 5.13: Infestation scores and MS Word test total completion time for session 3

Spearman's correlation test was done on the data and it was found that there is a significant correlation ($r = 0.709$; $df = 8$; $\alpha=0.05$) between the score that a user obtains in Infestation and the time it takes to complete the MS Word test in

Session 3. Thus, H_0 can be rejected (α=0.05). This means that if a user has a high score in the game he/she would also have a good completion time in the MS Word test. The opposite is also true.

The same analysis was done for all the games, MS Word tests and all the sessions. The results are summarised in Table 5.14. The significant values are highlighted in red.

Game	Session	r	p
Infestation	1	0.741	0.014
	2	0.383	0.309
	3	0.709	0.022
	4	0.803	0.005
	5	0.767	0.010
	6	0.676	0.032
	7	0.759	0.011
	8	0.638	0.047
	9	0.805	0.005
	10	0.629	0.051
Bunny Wack	1	0.729	0.100
	2	0.728	0.063
	3	0.470	0.240
	4	0.686	0.029
	5	0.811	0.004
	6	0.893	0.001
	7	0.697	0.025
	8	0.827	0.003
	9	0.803	0.005
	10	0.644	0.061
Speed	1	-0.643	0.176
	2	-0.949	0.051
	3	-0.348	0.399
	4	0.066	0.857
	5	-0.365	0.335
	6	-0.738	0.015
	7	-0.487	0.184
	8	-0.730	0.017
	9	-0.905	0.001
	10	-0.48	0.229

Table 5.14: Summary of meaningful correlations for all the game scores, MS Word test total completion times and sessions.

The correlation values (r-values) for Speed in Table 5.14 are negative. The reason for this is that the user had to try and get his final score as low as possible to be the best player. This is done by completing the game as quickly as possible.

It is also obvious from Table 5.14 that there is no significant correlation (α=0.05) between the score that the users obtained and the time in which the MS Word test was completed in a number of sessions. The most correlations can be seen with Infestation. However, there is no significant correlation (α=0.05) for session ten in any of the games. It was mentioned earlier that the students started to lose interest in the tests as they neared session ten. This lack of interest on the part of the students could be the explanation for this. Another explanation for this could be that a student's time in completing the MS Word tests can only improve up till a certain point, after which further improvement is difficult or even impossible. Session ten can therefore be ignored.

With Speed there are only three significant correlations (α=0.05). The mouse function that was measured in Speed was Drag. In MS Word this mouse function is not performed often which could be the reason why there are only three significant correlations (α=0.05). Infestation and Bunny Wack measured mouse functions that are more often used in MS Word. This is the reason why there are more significant correlations (α=0.05).

5.8.3 Discussion

There are sufficient correlations to support the statement that mouse-orientated computer games do improve the user's ability to use the mouse more effectively and efficiently in MS Word. Thus, the user will gain more value from an Office package if he/she has good computer mouse hand-eye coordination.

5.9 Chapter summary

In this study it was necessary to determine how long it takes a person to learn how to use a computer mouse effectively and also whether *mouse-orientated*

computer games enhance the value that a user draws from an office package in a GUI environment.

Two factors play a significant role in this study, namely knowledge and skill (refer to section 5.2). Knowledge refers to the knowledge that the user has with regard to the game he/she is playing or the Microsoft Word test that he/she is completing. Skill refers to the computer mouse skill that the user has. Can he/she use a computer mouse effectively or does he/she find it difficult to move the mouse cursor from one location on the screen to another?

This study was done in two phases. In phase one, data was gathered by having a group of students only play the games. The students were of different races and genders. It was found (section 5.4) that race and gender did not play a role in this study and that these factors could be ignored in the statistical analysis to follow. Difficulty level, however, played a significant role. It was decided to use only the data that was captured on difficulty level Easy.

In section 5.5 three groups of computer use frequencies (CUFs) were defined. It was proved that Attempts and CUFs played a significant role. However, no significant difference between mean scores from different CUFs was encountered, although there were differences within the groups. This means that the more a user plays a specific game the better he/she gets at it. Not only did the students' knowledge of the games improve but there was a definite increase in computer mouse skill as well.

In phase two of the study, a new group of first year non-IT students were used to test computer mouse skills not only in the games but also in an Office package (section 5.6). The students completed an MS Word test first, played three games (Infestation, Bunny Wack and Speed) and then completed the same MS Word test again. This was done to minimise the influence of the knowledge factor. In section 5.6.5 it was found that the students' ability to use

the mouse increased from the first session onwards, resulting in a decrease in their total completion time in the MS Word test.

In section 5.6.6 it was found that the students' marks for both of their tests increased from session one onward. This also indicates that computer mouse hand-eye coordination increased and that users gained more value from the Office package.

The results of the games for the same group of non-IT students were used to see whether there was an improvement in their scores for the different games (section 5.7). The graph (Figure 5.7) indicates that the scores improved from the first session onwards; however, statistically the first significant improvement from the first session, for Infestation, occurs after eight sessions.

The most significant results were the meaningful correlations between the computer games and the MS Word tests (section 5.8). These results show the positive relationship between the mouse-orientated computer games and MS Word. Thus, the user will gain more value from an office package if he/she has good computer mouse hand-eye coordination. Playing mouse-orientated computer games can help improve a user's computer mouse skills.

The final conclusions, goals achieved and recommendations will be discussed in Chapter 6.

> Major and Prueher [1984] define computer literacy as sufficient knowledge and skills to co-exist with the technology of a computer society and sufficient skills in the use of computers and the knowledge to use those skills in one's environment.

6.1 Introduction

Today, computers play an increasingly dominant role in many people's lives. Computers can be seen in many different forms and in many different devices: they can take the form not only of personal computers in the home, the workstation at the office or the notebook on the road, but also the servers in big companies and on the Internet, the new advanced cell phones, automatic teller machines, point of sale systems in the shops, information terminals and even the lotto machines. All of these different kinds of computers have different housings and interfaces to make them more user friendly and easier for the user to interact with.

Everywhere we go and in almost everything we do we find ourselves in touch with computers. It is becoming increasingly important for everyone to become computer literate. Many schools, universities and IT companies offer computer training. Most of them focus, in the beginning, on the basic computer functions and computer usage to help the user to become computer literate. Computer literacy is not only the use of the software but also the ability of the user to use the computer input and output devices.

It is almost impossible to teach a user to use computer software if that user is unfamiliar with the input and output devices. A user cannot start using the

operating system (OS) or office applications in the graphical user interface (GUI) if he/she cannot or does not know how to use the computer keyboard and mouse.   Both of these devices are difficult to use for a novice/first time computer user.

Two factors played an important role in this study, namely knowledge and skill (refer to section 5.2).

6.2 The problem identified

It was observed that many of the first year students at the Central University of Technology, Free State (CUT, FS) were struggling with the computer literacy classes. They found it difficult because they could not use the computer mouse effectively and efficiently.   Therefore the following research goal was formulated:

The purpose of this study was to determine whether experience with mouse-orientated computer games enhances the value that a user draws from an office package in a GUI environment.

In this study, value refers to enhanced productivity of users where users make fewer errors in the office package which in turn results in higher economical gain (refer to section 1.3).

The secondary hypothesis stated that: *Frequency of computer use has no influence on the maximum skill level that a novice/first time computer user can reach with a mouse-orientated computer game.*

The above stated hypotheses were investigated in this study and interesting results were uncovered during phase one and phase two. The two phases will be discussed in the next few sections.

6.3 Phase one

During phase one of the study, the six mouse-orientated computer games (discussed in Appendix A) were used to capture user input data. The captured data was statistically analysed to investigate three questions:

1. Does race play a significant role in this study?

2. Do difficulty levels play a significant role in this study?

3. Does computer use frequency (CUF) play a significant role in this study?

6.3.1 First question

The following hypothesis was derived from the first question: "Does race play a significant role in this study?" (section 5.4):

Hypothesis 1: *There are no differences between the average scores of white males and black males on any one of the difficulty levels.*

This hypothesis could not be rejected, which indicates that race did not play a significant role in this study and that all the users, black and white, could be combined into one group.

6.3.2 Second question

The following hypothesis was derived from the second question: "Do difficulty levels play a significant role in this study?" (section 5.4):

Hypothesis 2: *The level of difficulty has no effect on the score that a user obtains in a game.*

This hypothesis could be rejected. The difficulty level in the games played a significant role and had to be kept in mind during the statistical analysis. It was decided to make use only of the scores which were captured on difficulty level Easy. Bunny Wack and Speed were the only two games that did not have difficulty levels.

6.3.3 Third question

"Does computer use frequency (CUF) play a significant role in this study?" was the last question to be answered in phase one (section 5.5). The following hypotheses were derived from this question:

Hypothesis 3: *There is no difference between the average score, in a specific game, of users that use a computer more frequently and the average score of users who use a computer less frequently.*

Hypothesis 4: *The average score of users that use a computer more frequently will reach a plateau at the same time as the average score of users that use a computer less frequently.*

The third hypothesis could not be rejected. This indicates that there is no score difference, in the games, between novice and expert computer users. However,

the fourth hypothesis could be rejected. Students who used a computer more frequently reached a plateau faster, in the games, than students who used a computer less frequently.

6.3.4 Phase one conclusion

Phase one also proved that the more times that a user plays one of the specific mouse-orientated games the better he/she becomes at it and the more his/her hand-eye coordination improves. This was evident from the scores obtained in the respective games. Thus, mouse-orientated computer games have a positive effect on the fine motor skills and hand-eye coordination of computer users.

6.4 Phase two

Phase one of the study focused only on the mouse-orientated computer games. In phase two a new group of users were used to gather data in MS Word (Office package) and in three of the computer games (Infestation, Bunny Wack and Speed). The data was captured and statistically analysed to answer six questions:

1. Is there a difference between the average total completion times for the two MS Word tests within a session?

2. Is there a difference in the average total completion time between the different sessions?

3. Is there a difference between the average total marks for the MS Word tests in any session?

4. Is there a difference in the average total mark between the different sessions?

5. Does a student's score in any of the three games remain constant through different attempts and sessions?

6. Is there a correlation between the score that a user obtains in one of the games and the total completion time for the MS Word test in the different sessions?

6.4.1 First and second questions

The first part of phase two considered the total completion time for the MS Word tests. Is there a difference between the average total completion times for the two MS Word tests? From this first question the following hypothesis was formulated (section 5.6.5):

Hypothesis 1: *There is no difference between the average total completion times for the first MS Word test and the second MS Word test within any specific session.*

Question two asked whether there was a difference in the average total completion times between the different sessions. To answer this question the following statement was hypothesised:

Hypothesis 2: *There is no difference in average total completion times between the different sessions.*

Both of these hypotheses could be rejected. It was clearly seen that the students' ability to use the mouse increased from session one onward. This was evident from the reduction in total completion time for each MS Word test. Thus, it can be inferred that the student draws more value from the Office package as his/her mouse skills improve.

6.4.2 Third and fourth questions

The reduction in total completion time for each MS Word test gives a good indication that the users' computer mouse skill improved: it is however also necessary to take into account the correctness of each completed MS Word test.

The question: "Is there a difference between the average total marks for the MS Word tests in any session?" led to the following hypothesis (section 5.6.6):

Hypothesis 3: *There is no difference between the average total mark for the first MS Word test and the second MS Word test within any specific session.*

In order to find an answer to the question: "Is there a difference in the average total mark between the different sessions?" the following hypothesis was investigated:

Hypothesis 4: *There is no difference in average total mark between the different sessions.*

Hypothesis 3 was not rejected, and hypothesis 4 was rejected. The students' average marks, in both MS Word test one and MS Word test two, improved from session one onward. This indicates that the more a user plays mouse-orientated computer games the better his computer mouse hand-eye coordination becomes and the more value that user draws from an office application.

6.4.3 Fifth question

At this point it has been proven that a user's time to complete the MS Word test decreased from session one onward and that the user's total mark for the MS Word test increased. Both indicate that the user's computer mouse hand-eye

coordination improved. This had to be proved by looking at the scores of the three games.

The following hypothesis (section 5.7) was derived from question 5: "Does a student's score in any of the three games remain constant through different attempts and sessions?":

Hypothesis 5: *A student's score in any of the three games remains constant through all the attempts and different sessions.*

This hypothesis was rejected. The users' scores in the games increased dramatically from session one onward. The knowledge factor was eliminated very early and only mouse skills were developed.

6.4.4 Sixth question

The final question: "Is there a correlation between the score that a user obtains in one of the games and the total completion time for the MS Word test in the different sessions?" investigated in phase 2 led to the following hypothesis (section 5.8):

Hypothesis 6: *There is no correlation between the score that a user obtains in one of the three games (Infestation, Bunny Wack and Speed) and the total completion time of the MS Word test for the different sessions.*

This hypothesis was rejected which indicates that if a student obtains a high score in the games he/she will also get a high mark in the MS Word test. Thus, the user will gain more value from an office package if he/she has good computer mouse hand-eye coordination.

6.5 Conclusion

A final conclusion can be drawn from the above investigated questions and the primary hypothesis, as stated in Chapter 1, can thus be rejected.

The playing of mouse-orientated computer games enhances the value that a novice/first time computer user draws from an office package in a GUI environment.

The secondary hypothesis is also rejected as it was proven that _frequency of computer use has an influence on the maximum skill level that a novice/first time computer user can reach with a mouse-orientated computer game._

6.6 Recommendations

The findings of this research indicate that the playing of the mouse-orientated computer games enhances the value that a novice/first time computer user will draw from an office package.

During the phases of research it was noted that some of the games performed better than others indicating that some of the games could be omitted when improving computer mouse hand-eye coordination. Infestation performed the best amongst these games but cannot be used solely because the mouse function drag is not included in this game. Therefore it is recommended that Infestation and Speed be used when helping users to improve their computer mouse hand-eye coordination.

All six games, which were presented in this study, or only Infestation and Speed or even similar mouse orientated games can be used as a practice environment for:

❖ any person (scholars, first-year students, etc.) studying computer literacy;

❖ employees at work during their lunch break. They will not only relax but will also improve on their computer mouse skill, thereby becoming more productive;

❖ children, to encourage them to practise their mouse skills from an early age;

❖ elderly people, to improve their fine motor abilities and reaction times; and

❖ surgeons, to warm up before they go into surgery.

6.7 Research contribution

In previous studies by Natale [2002], it is stated that a person would become more computer literate if he/she were to play more computer games. He explains that computer literacy is a function of spatial learning, and that the use of other computer programs becomes easier as an individual learns computer functions through the utilisation of games.

Mayer, Schustack and Blanton [1999] also found that students who have excellent computer game playing skills also have the ability to learn new programs more easily than students who lack similar experience.

This study, however, did not only quantitatively confirm the findings of the above researchers but also investigated the amount of time it takes a user to reach a more acceptable level of computer literacy (refer to Chapter 5). This was done by increasing the users' computer mouse skill by letting them play mouse-orientated computer games.

Koch [1995], on the other hand, found that there is a strong correlation between students who do not like and who rarely play computer games, and those who judge their computer skills as weak and avoid spending time on the computer. Koch's statement was also quantitatively measured and confirmed in this study. This study also proved that the student's knowledge of the games was not the only thing that improved but that there was also a definite increase in computer mouse skill as well, which resulted in improved MS Word skills.

There are further benefits to playing computer games than only the above stated (refer to Chapter 2): reduced computer anxiety, positive attitude towards computers, higher productivity, increased learning and recollection capabilities and more satisfaction, amongst others, may be mentioned in this regard.

The games provide a relaxed and enjoyable environment for users to improve their computer mouse skills in a short time. Users can gain more value from an office package more quickly.

6.8 Future research

Various instruments can be developed to measure mouse proficiency to determine the fastest way for a user to become mouse proficient. This can be done by analysing data gathered through using mouse orientated computer games, mouse tutors and applications that use the computer mouse as input device. A benchmark must be set indicating what the minimum mouse proficiency is that a user needs to have, to reach a certain level of productivity in an office package. This newly developed instrument can then be used to measure the time it takes the user to reach the benchmark.

Further research can include measurements of computer attitude and computer anxiety to determine which of the instruments mentioned above create a more

relaxed environment. This can be done by measuring computer attitude and computer anxiety in all the measuring instruments.

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Appendix A

Instruments Used - Games

A.1 Introduction

For a person to use a computer effectively he/she must be able to use the various input devices, like the computer mouse and keyboard. Using a computer mouse is a terrifying experience for a first-time computer user. It feels very strange to be moving the mouse on the flat horizontal surface of the table while looking at the computer screen. Novices/first-time users tend to move the mouse on the table and then release the mouse before trying to click the button. Some use a hard jam of the forefinger, resulting in the mouse pointer moving off the desired location.

Six games were developed and used in this study to measure and determine how long a user needs to practise with a computer mouse before he/she can use it effectively. The games were developed by two honours' students as part of their projects. The games are included on the Compact Disk (CD) (The CD will AutoPlay the "index.htm" file. When the information bar appears at the top of Internet Explorer, click on it and select "Allow Blocked content").

It was decided to use mouse-orientated computer games as measuring instruments for two reasons. Firstly, the environment would not be stressful to the users, and would, in fact, be enjoyable. Users would also not have to worry about losing important data if they were to do something wrong in the game. Secondly, the Office package and the GUI (Windows) environment were not developed to give a user computer mouse training. Suitable computer games provide this perfect "training" environment where users can enjoy the game as well as improve their computer mouse skills without realising it.

A.2 Measuring instruments

The six games that were used are: Infestation (Game 1), Plane Blaster (Game 2), Pool (Game 3), Bunny Wack (Game 4), Speed (Game 5) and Rescue (Game 6). All six games were inserted into one Web application (Website) with

a central menu screen. All the data captured by means of the games was stored in a database.

A.2.1 Web application

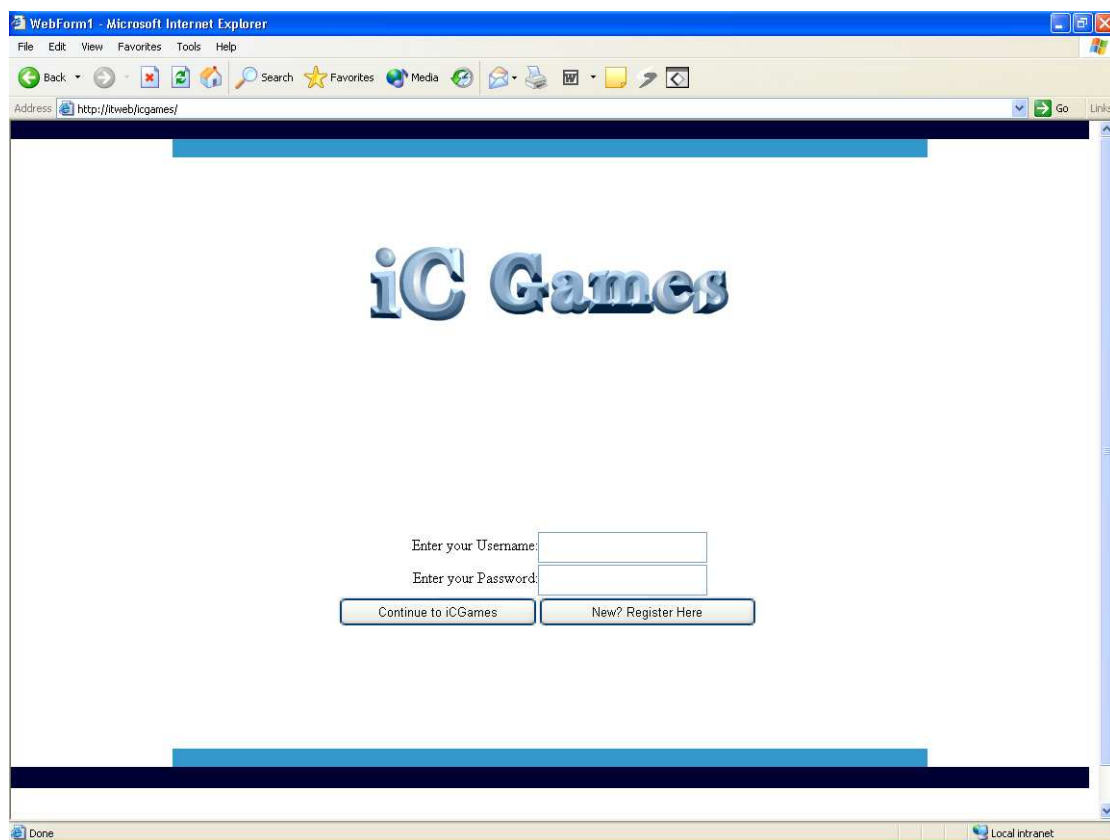The Website was called iCGames (Eye-Coordination Games) and the opening screen can be seen in Figure A.1.

Figure A.1: iCGames opening screen

For this study Internet Explorer was used. The entire website was hosted on an internal Web server in one of the computer laboratories in the School of Information and Communication Technology, Central University of Technology, Free State (CUT, FS).

This main screen served a dual purpose. Registered users filled in their user name, which was their student number, and password, to gain access to the games. This helped to distinguish between the users. New users had to click on the "New? Register Here" button to go to the registration screen (Figure A.2).

A.2.2 Registration screen

All the fields on the registration screen (Figure A.2) were compulsory and had to be completed before the user could play the games.

Figure A.2: iCGames registration screen

In the Race combo box the user had the following options: -, White, Black, Indian, Asian, Other. The user had the option to choose the hyphen (-) if he/she were sensitive about his/her race. In the second combo box the user had to enter information on computer usage, which excluded compulsory practical

computer classes. (All the students who were tested had to attend compulsory practical computer classes. These classes ranged from training in the Office suite to advanced computer programming.) The user had the following options to choose from: Never, Once a month, Once a week, Once a day and A few times a day. In the last combo box the user could choose his/her current year of study: 1, 2, 3 or B Tech (fourth year).

A.2.3 Welcome screen

As soon as the user logs on (Figure A.1) or clicks on the "Register" button (Figure A.2) he/she is redirected to the Welcome screen (Figure A.3).
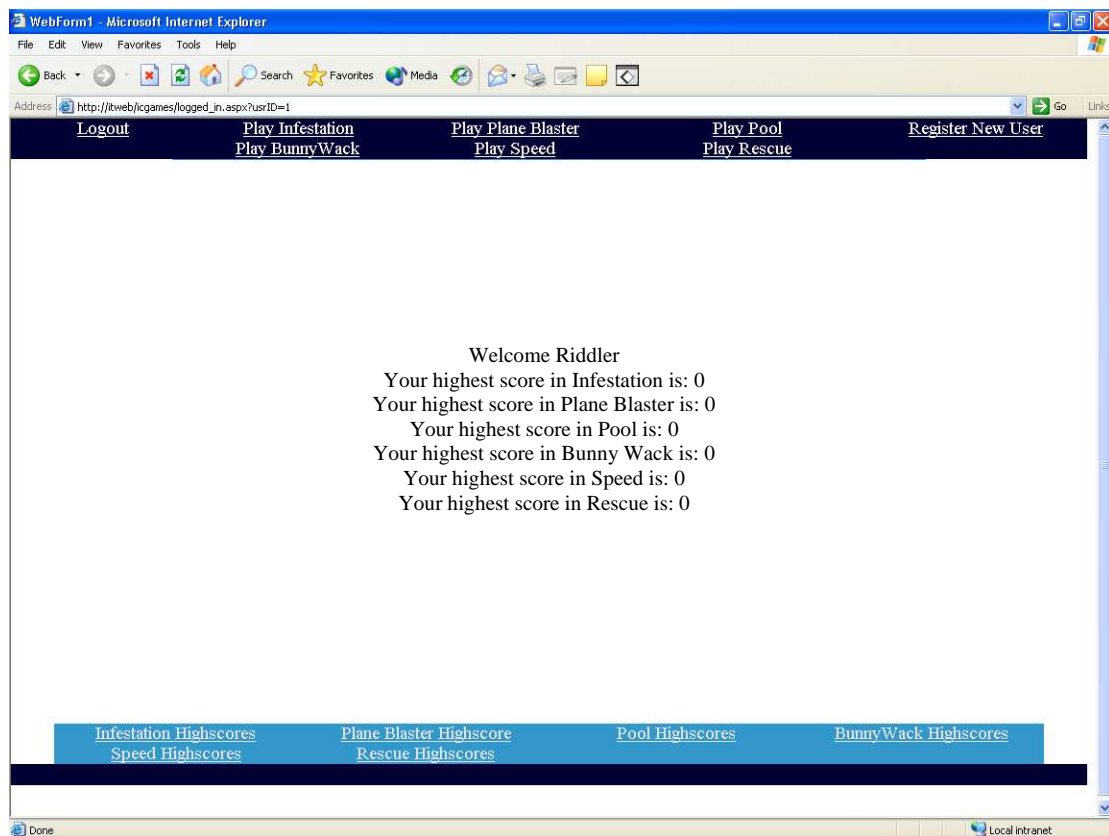
Figure A.3: iCGames Welcome screen

On this screen the user sees a welcome note and his/her highest scores in Infestation, Plane Blaster, Pool, Bunny Wack, Speed and Rescue. The links to

all six games are at the top of the screen, together with a Logout and 'Register New User' link. At the bottom of the screen the user can view the highest scores of the individual games. The top 10 highest scores of the best players are shown. The links to the games are deactivated as soon as the user has selected a game to play. This ensures that a user does not quit a game half way through.

A.2.4 Infestation (Game 1)

Infestation is the most effective game for measuring mouse control. Three sizes of spiders run across the screen at different speeds and the user must try to click on (squash) as many as possible before they disappear at the other side of the screen. A user with more mouse experience will be able to move more quickly to the next spider and to click accurately. *Mouse functions move, point and click are measured in this game as well as mouse speed.*

The opening screen is shown in Figure A.4. In this game the mouse cursor is changed to a hammer as seen in Figure A.5. The rules and scores per difficulty level are shown one after the other in the block at the bottom left hand corner of the game screen. To start the game, the user clicks on the start button and then selects the difficulty level as shown in Figure A.5.
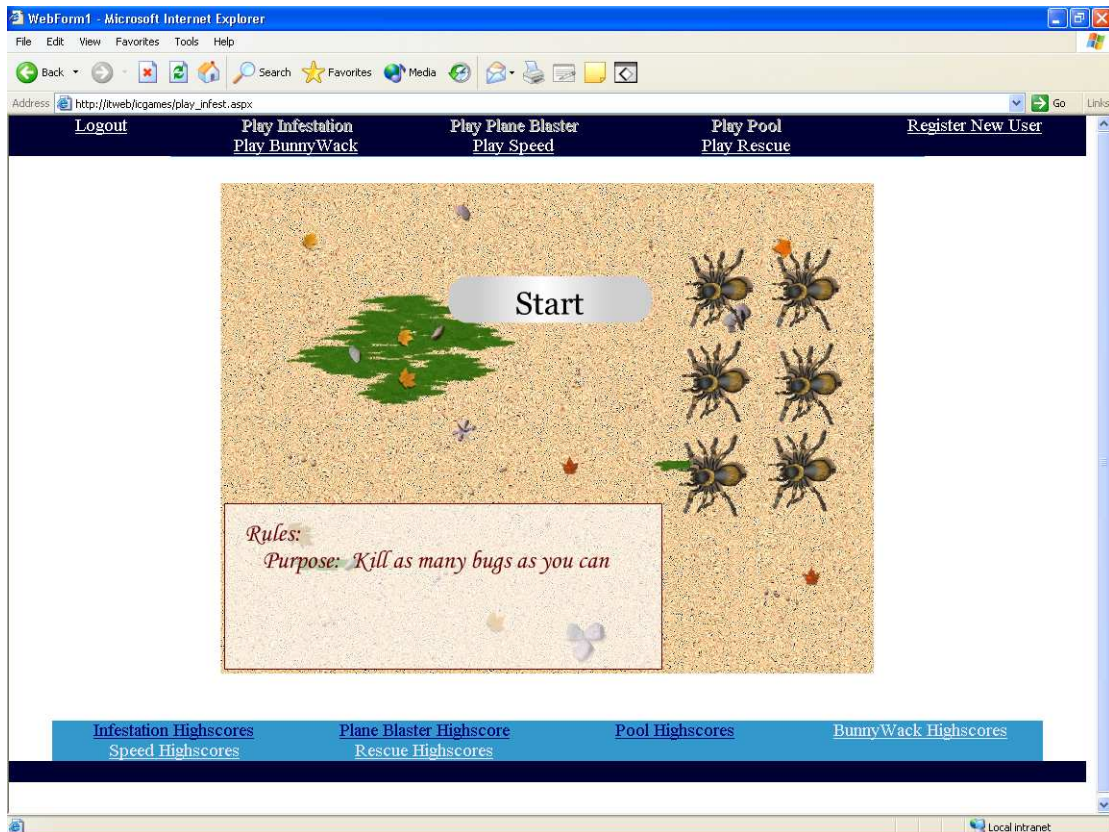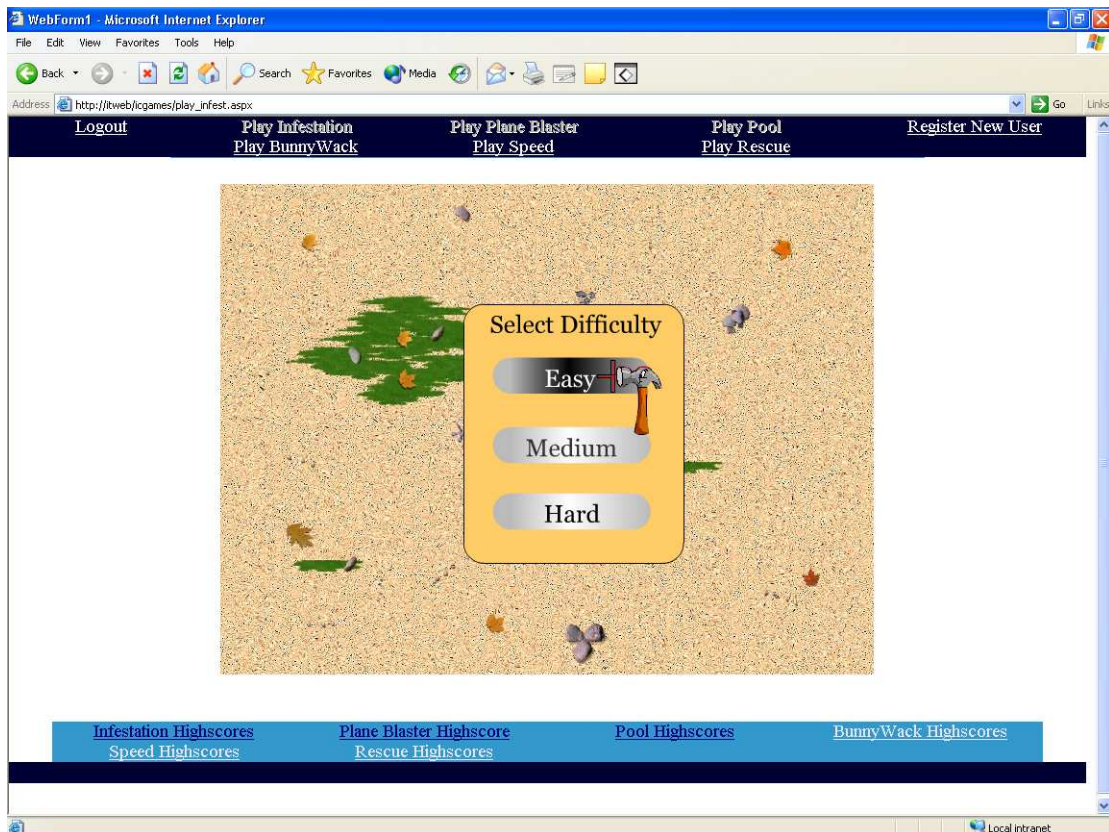
Figure A.4: Game 1 – Infestation screen 1

Figure A.5: Game 1 – Infestation screen 2

There are three difficulty levels, namely Easy, Medium and Hard. On the easiest level the spiders move across the screen at a slow speed. For expert users it is easy to squash all the spiders on this difficulty level. On the medium level the game becomes a little more challenging with the spiders moving faster across the screen. On the hardest level the spiders move so fast across the screen that even expert users find it difficult to squash all of them.

Figure A.6 shows the playing screen. The user has 45 seconds to play the game. This time allocation is the same for all three difficulty levels.
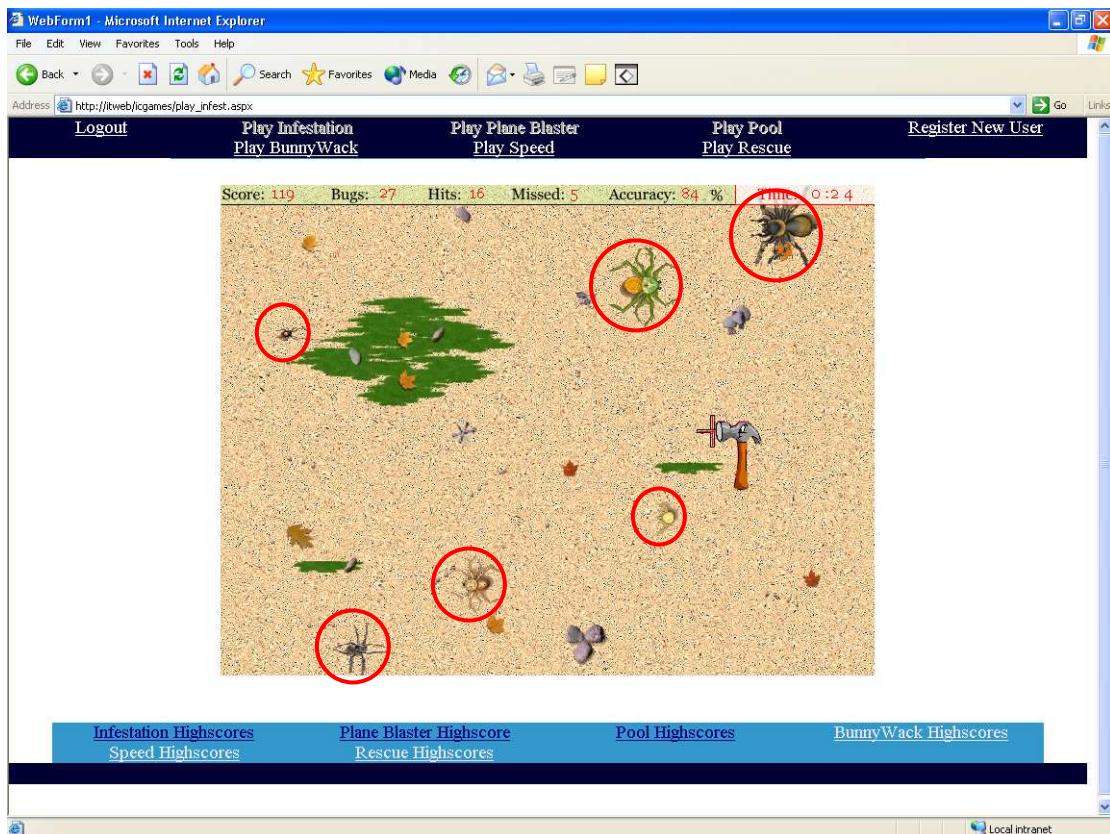
Figure A.6: Game 1 – Infestation screen 3

At any moment in time there is always a maximum of six spiders on the screen (encircled in red). There are always two of each size of the spiders (small, medium or large) on the screen as seen in Figure A.6. As soon as a spider is squashed or moves off the screen, a new one will enter. Spiders can enter the screen from either the left hand side or the right hand side. The small spiders

move the slowest, and the large spiders move the fastest. The speed differences between the different spider sizes stay the same irrespective of the difficulty level.

The time remaining is displayed in the top right hand corner (Figure A.6). Statistics such as: score, bugs, hits, misses and accuracy are displayed at the top of the gaming screen.

Different points are awarded for different spiders squashed. The smaller the spider, the more points you get for squashing it. The user must decide on his strategy in terms of which spiders to squash, because points are deducted if he/she misses.

After the time has expired the user sees his score (Figure A.7) and will then, if he has not already clicked on the "Save my scores" button, automatically be redirected, after five seconds, to the high scores page (Figure A.8) where he can see his ranking.
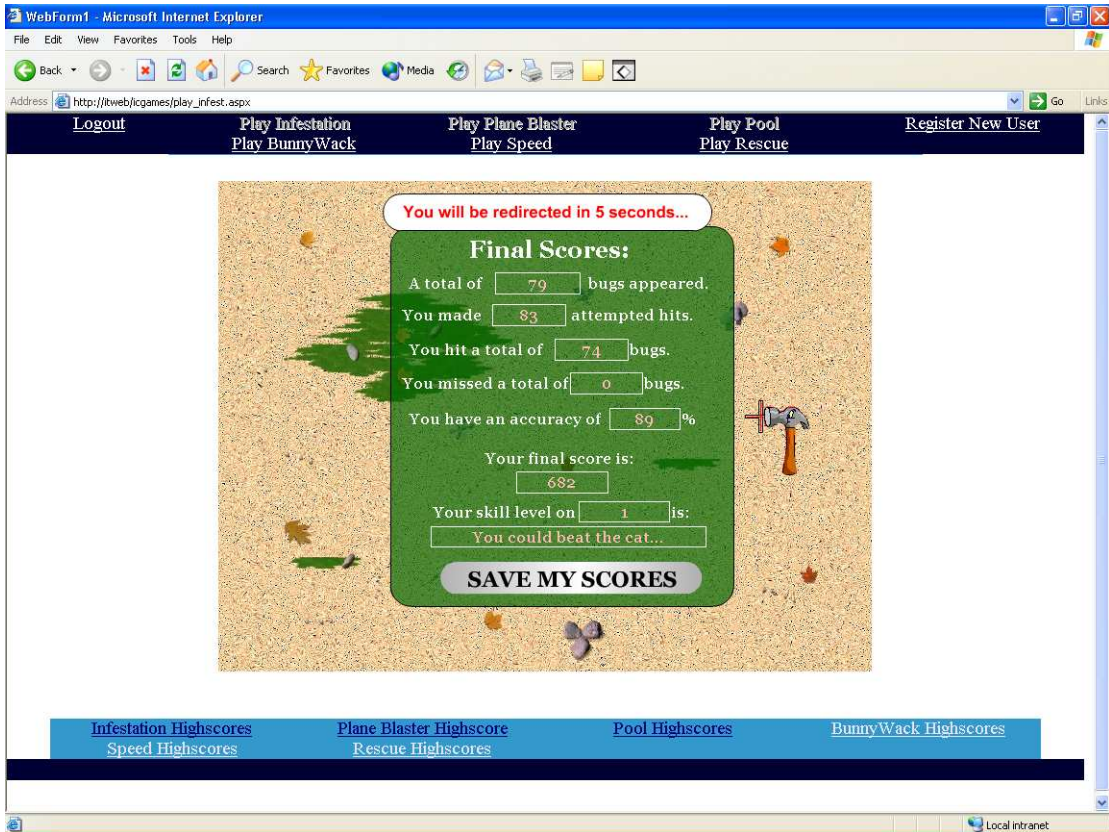
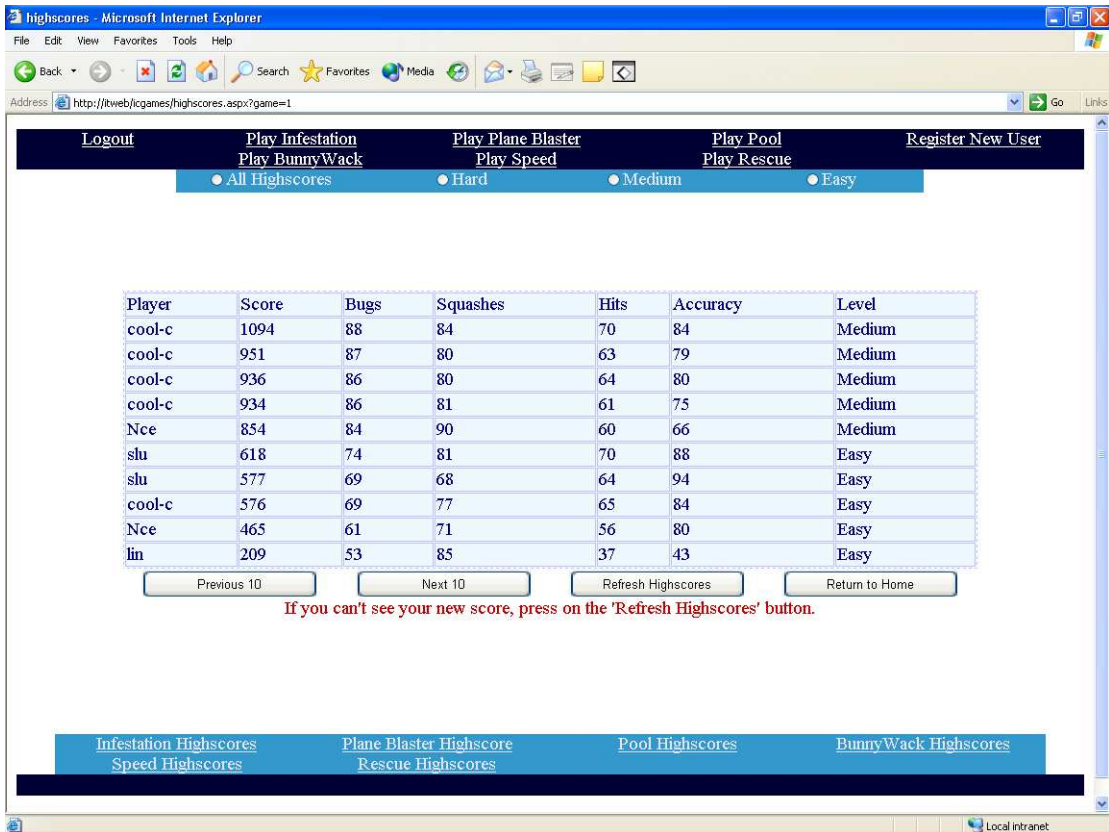Figure A.7: Game 1 – Infestation screen 4

Figure A.8: Game 1 – Infestation screen 5

Only the top 10 highest scores for Infestation are shown at a time (Figure A.8). The user can use the buttons to view the next or previous 10 high scores. From this screen the user can select any game to play by selecting it from the top menu.

The highest score for expert users can range up to a maximum of 2500 while the score for beginners remains between 0-500. The scoring for Infestation is summarised in Table A.1.

	Small spider	Medium spider	Large spider	A miss	Playing time (Seconds)
Easy	15	10	5	-2	45s
Medium	22	16	12	-3	45s
Hard	42	30	25	-5	45s

Table A.1: Infestation scores per difficulty level

A.2.5 Plane Blaster (Game 2)

Plane Blaster is easier to start with but is more difficult to master. The user must be able to fire a bullet at a moving target, while compensating for the fact that the bullet takes some time to reach the target. The user is given a specific time limit during which he needs to shoot down as many planes as possible. The bullets are fired from the turret which is positioned at the bottom centre of the screen. It is therefore more difficult to hit consecutive planes with accuracy. *Mouse functions move and point are measured in this game.*

The opening game screen can be seen in Figure A.9. The user's mouse cursor is changed to a crosshair at the beginning of the game. On this screen the user can see the start button as well as the rules of the game. After clicking on Start the user must select the difficulty level as seen in Figure A.10.
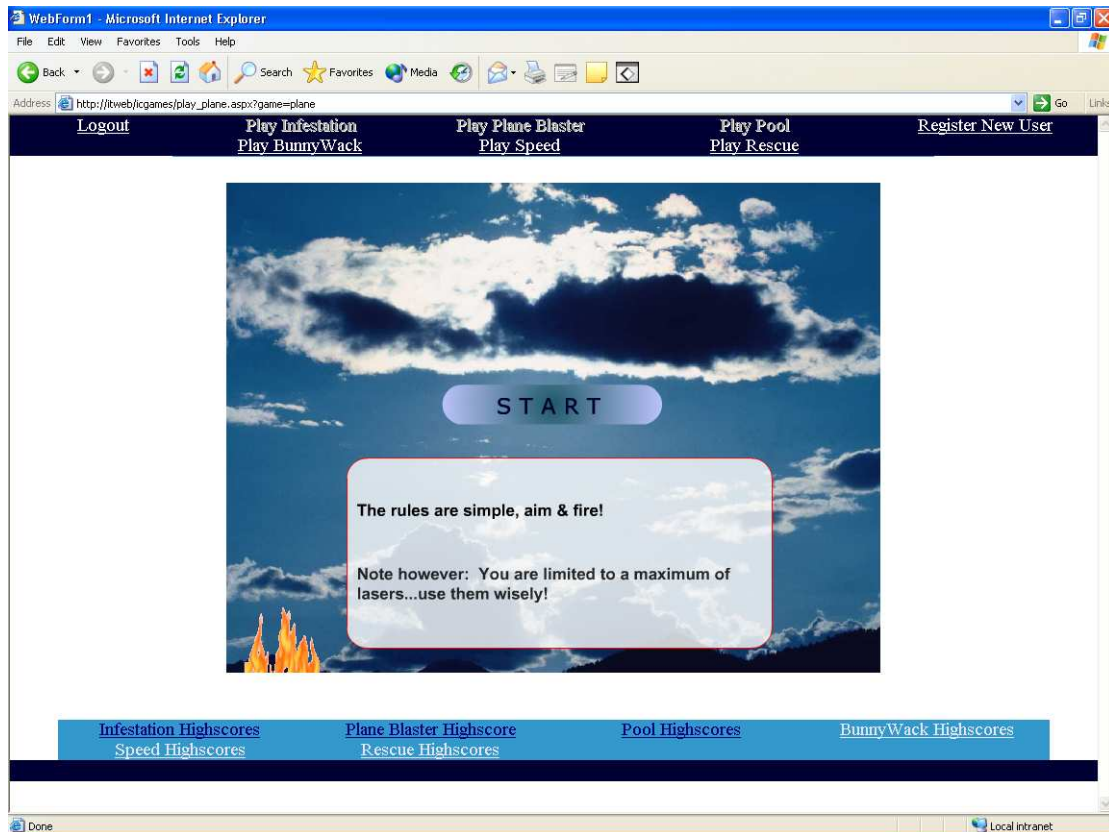
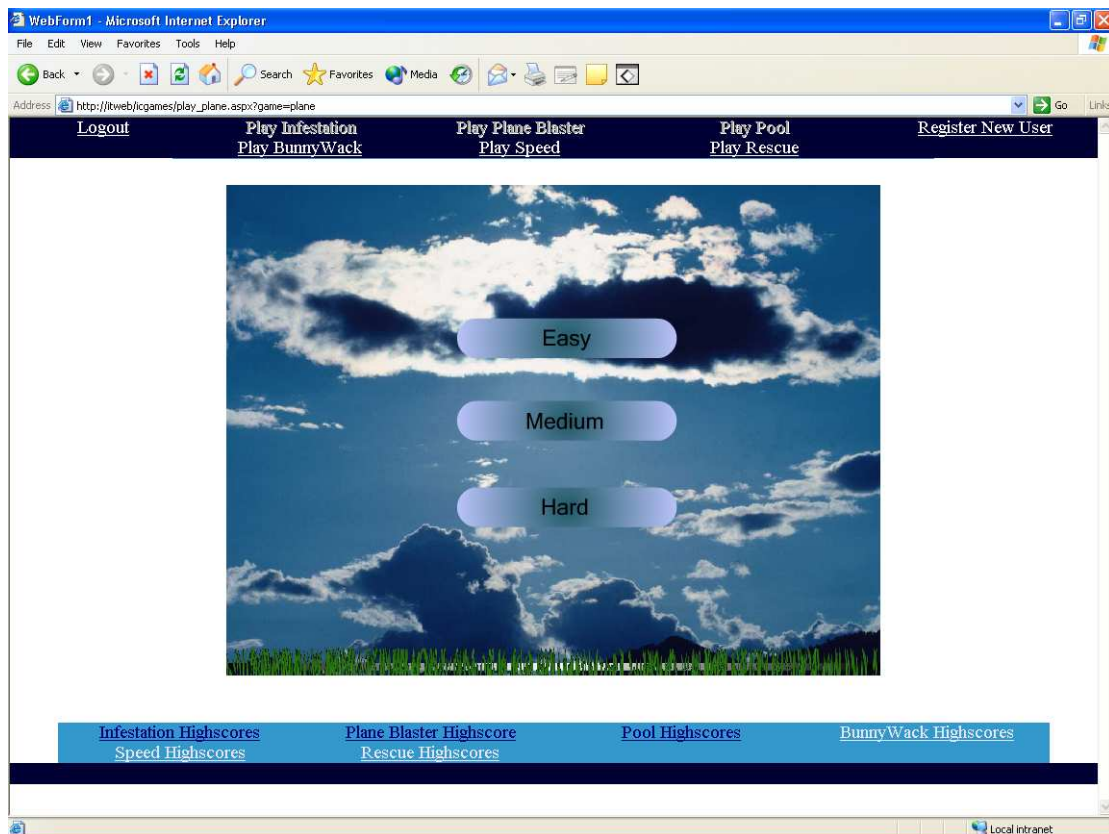Figure A.9: Game 2 – Plane Blaster screen 1

Figure A.10: Game 2 – Plane Blaster screen 2

In Plane Blaster there are three difficulty levels as seen in Figure A.10. The only difference between the difficulty levels is the speed at which the planes move. Even an experienced computer mouse user, a gamer, for instance, will find it difficult to shoot down all the planes on the hardest level. The points allocation, per difficulty level, is discussed at the end of this section in Table A.2.

The playing screen can be seen in Figure A.11. The planes can fly randomly from either the left hand side or right hand side of the screen.
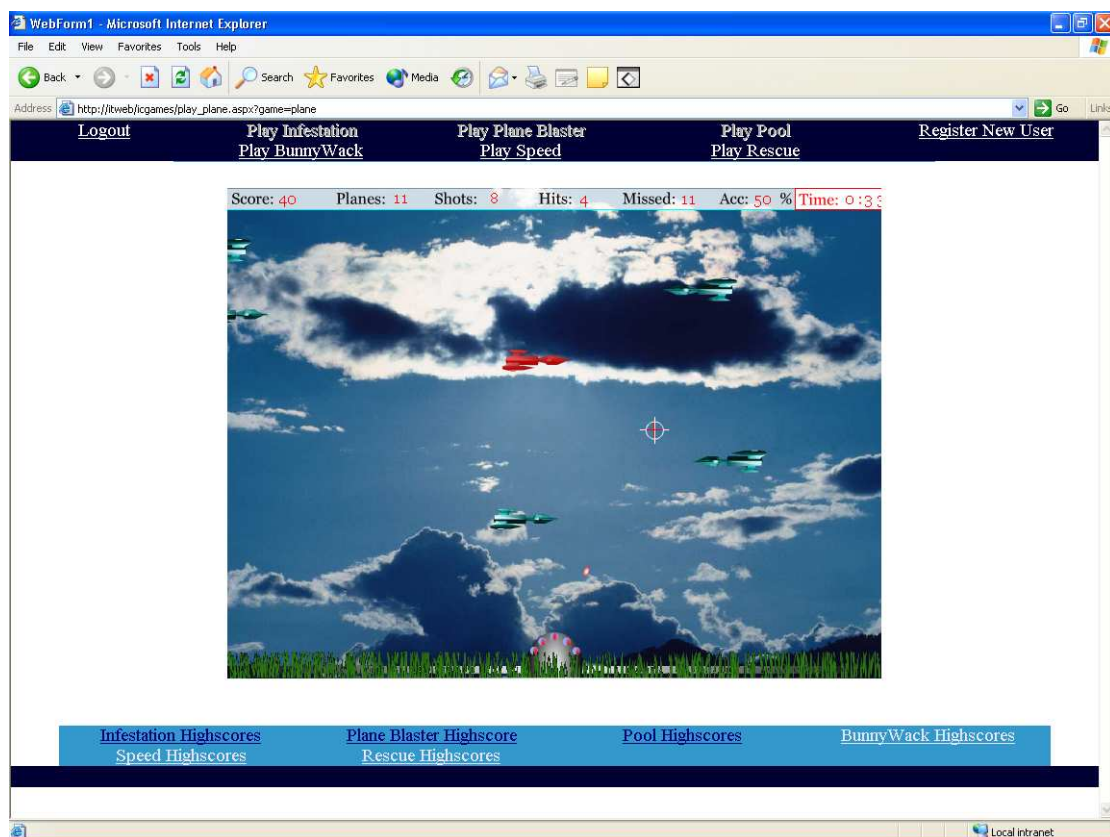

Figure A.11: Game 2 – Plane Blaster screen 3

There are a total of 6 planes at a time on the screen. When a plane is shot down or flies off the screen a new one will fly in. What makes the game difficult is that there can only be two bullets at the same time on the screen. Plane Blaster is effective in determining whether the user is capable of combining his/her mouse skills with estimation skills, to determine where the plane will be,

so that he/she knows in which direction to fire the bullet, in order to hit the moving plane. When a plane is hit, the plane will turn red and disappear as seen in Figure A.11.

The statistics of the player can be seen at the top part of the screen (Figure A.11). From left to right the statistics are: Score, Planes, Shots, Hits, Misses, and Accuracy. At the right hand side of the screen is the time left before the game ends. The player has only 40 seconds to shoot down as many planes as possible. The playing time for all three difficulty levels is the same. When the timer reaches zero the game will stop automatically and the user will see his statistics as depicted in Figure A.12. Different points are given on different difficulty levels (see Table A.2).
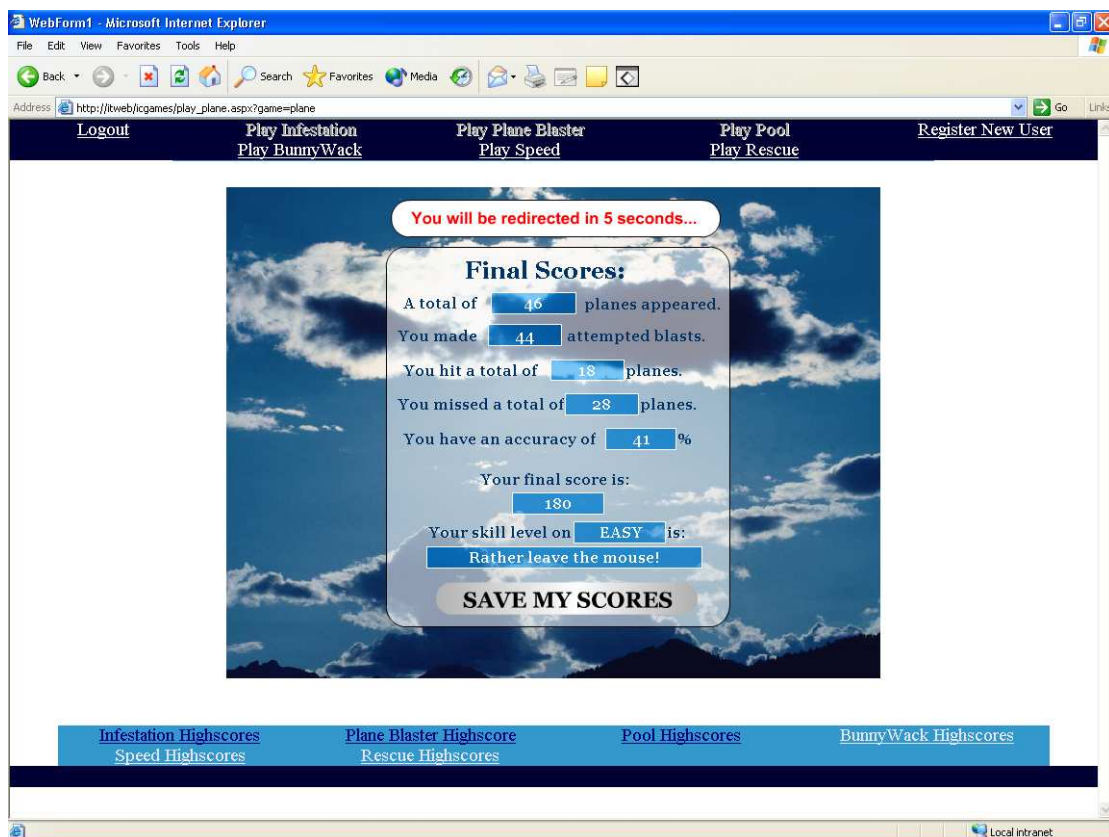

Figure A.12: Game 2 – Plane Blaster screen 4

After five seconds, if he/she has not clicked on the "Save my scores" button first, the user will automatically be redirected to the high scores page where

he/she can see his/her ranking amongst the rest of the players. This figure looks the same as Figure A.8. The only difference is the contents of the table.

The scoring per difficulty level for Plane Blaster is shown below in Table A.2.

	Plane score	Playing time (Seconds)
Easy	10	40
Medium	15	40
Hard	20	40

Table A.2: Plane Blaster scores per difficulty level

A.2.6 Pool (Game 3)

This is a well-known game and needs little explanation. In this pool game the user must pocket 10 balls within a certain time limit. This game measures the ability of the user to estimate angles on the screen by using only the mouse cursor. *Mouse functions point, click and mouse speed are measured here.*

In the opening screen of Pool (Figure A.13) the user can select the difficulty level and see the rules of the game. Again there are three difficulty levels: Easy, Medium and Hard. The difference between the difficulty levels is the allocated time per game and the points that are deducted if the white ball is sunk. The points allocation is discussed at the end of this section in Table A.3. Figure A.14 shows the playing screen.
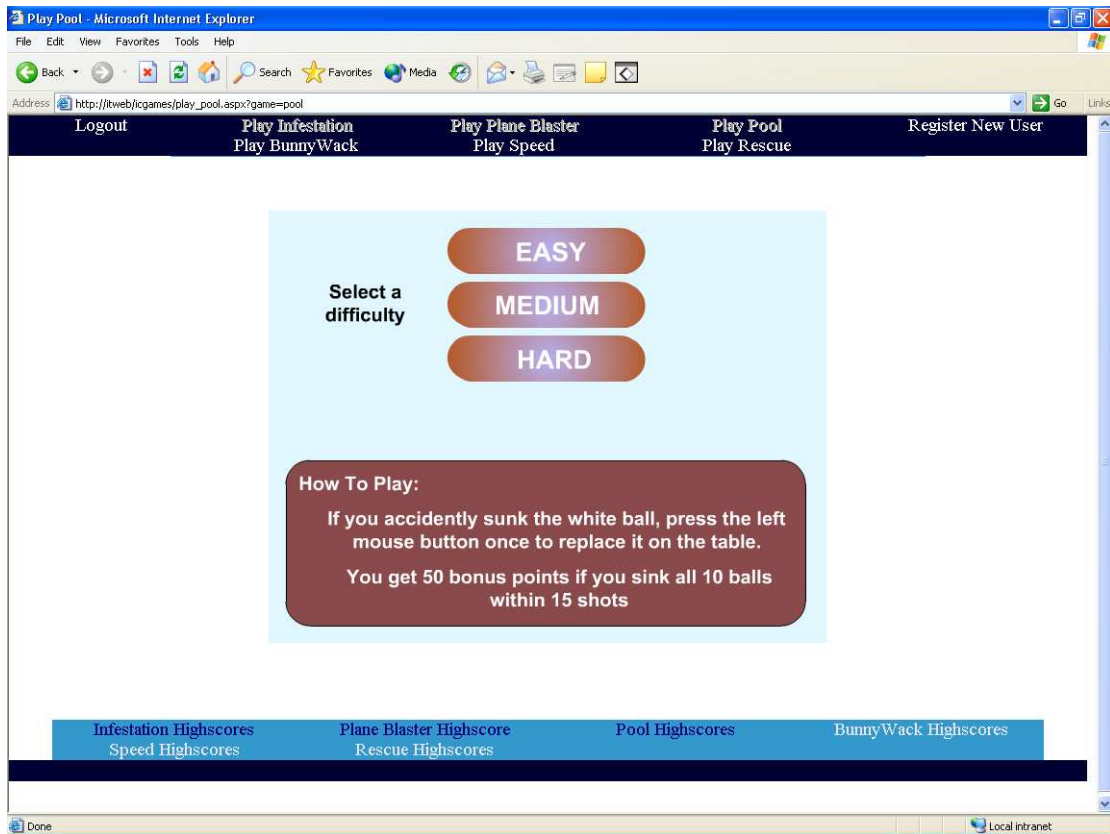
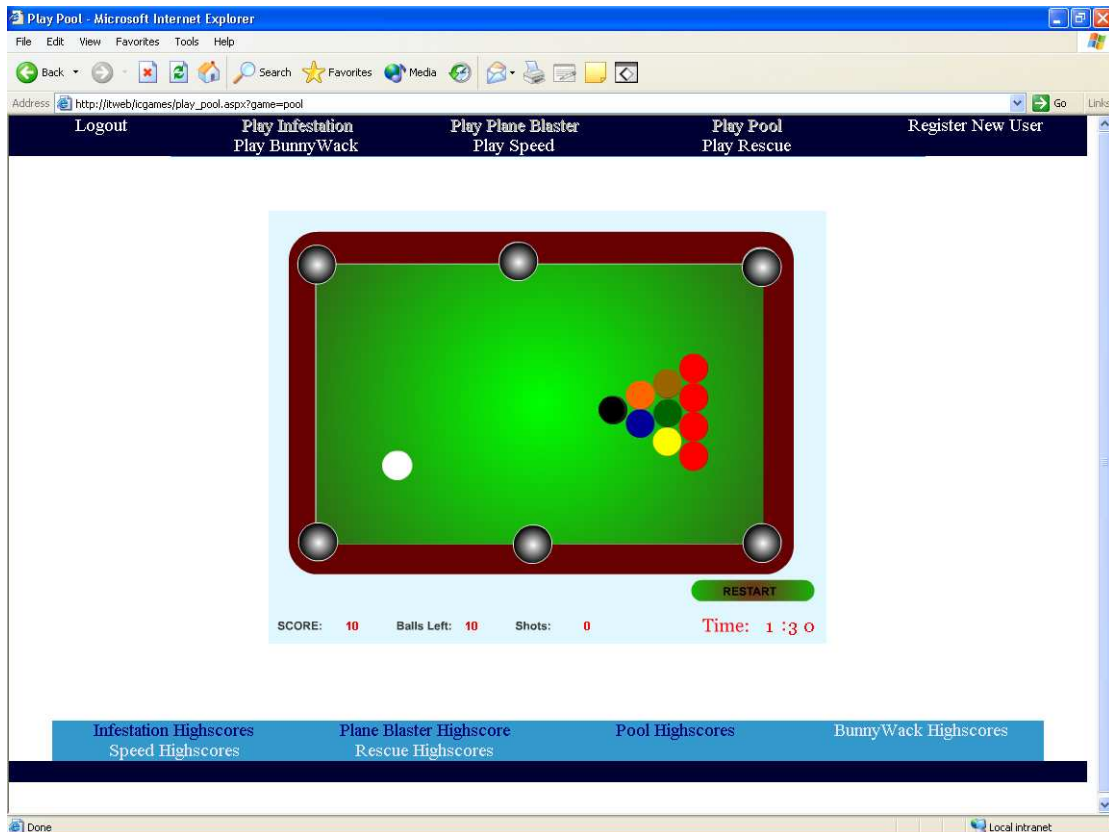Figure A.13: Game 3 – Pool screen 1

Figure A.14: Game 3 – Pool screen 2

The user sees the table from the top and the whole game is also played in this view.   There are 10 balls on the table excluding the white ball.   The rules are simple: the user only has to sink the balls.   The balls can be sunk in any order. The user will get the same points (Table A.3) for any coloured ball that he/she sinks.   To play the game the user points the mouse cursor in the direction he/she wants to shoot, and then clicks, keeping in mind the angles that play a role when trying to sink a ball.   The user cannot control the power of the shot. On the bottom of the screen the following statistics are shown: Score, Balls Left, Shots and Time Left.

Figure A.15 shows the table while the user is busy playing the game.   Two balls have already been sunk.
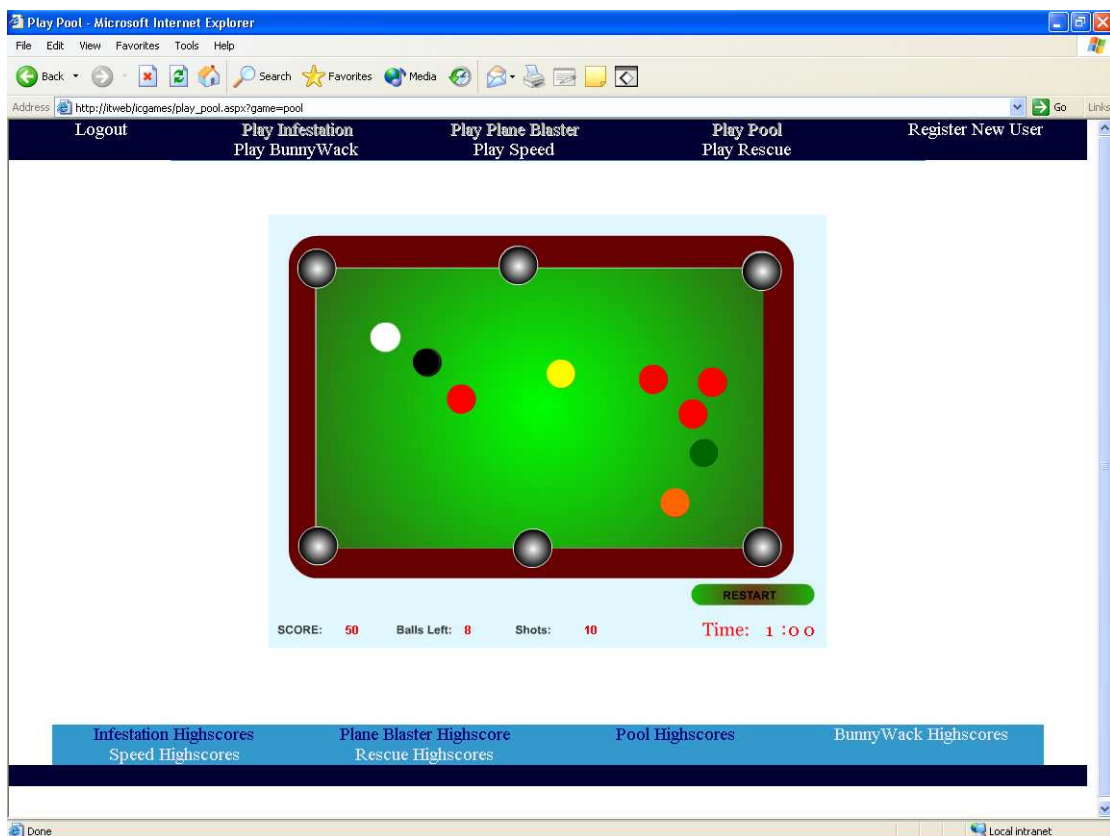

Figure A.15: Game 3 – Pool screen 3

When the time expires the game will end automatically and the user will see his/her statistics as seen in Figure A.16.   After five seconds, if he/she has not

clicked on the "Save my score" button first (refer to Figure A.8), the user will be redirected to the pool high scores page.
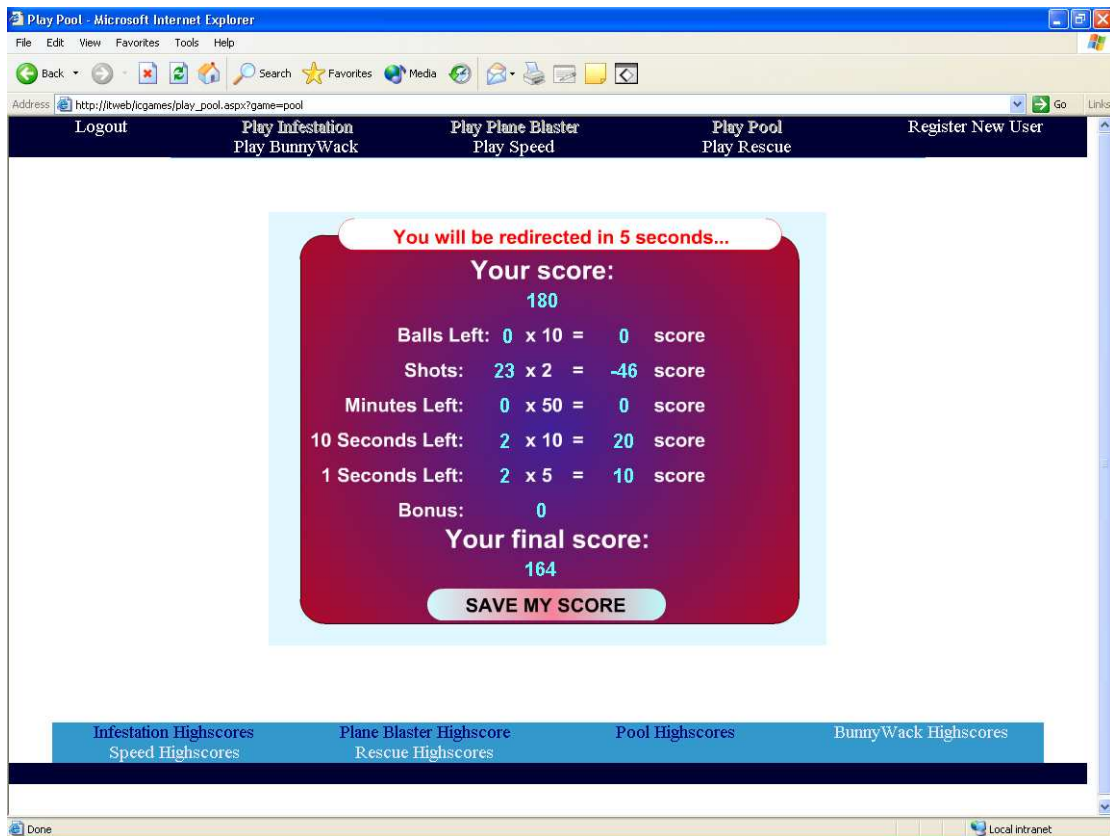

Figure A.16: Game 3 – Pool screen 4

Scores are calculated according to the balls pocketed, time remaining and a bonus. The more difficult a level you select, the less time you get to sink all the balls - the greater the reward, however. The scoring of the game is shown in Table A.3.

	Point per sunken ball	Penalty for sunken white ball	Playing time (minutes)	Bonus*
Easy	20	-15	1:30	50
Medium	20	-20	1:15	50
Hard	20	-25	0:45	50

* 50 bonus points are allocated if the user sinks all the balls within 15 shots.

Table A.3: Pool scores per difficulty level

A.2.7 Bunny Wack (Game 4)

Bunny Wack is seen as the easiest game to play. The user needs to hit as many static bunnies as possible within a specific time limit. *Mouse functions point, click and mouse speed are measured here.* The opening/playing screen can be seen in Figure A.17.
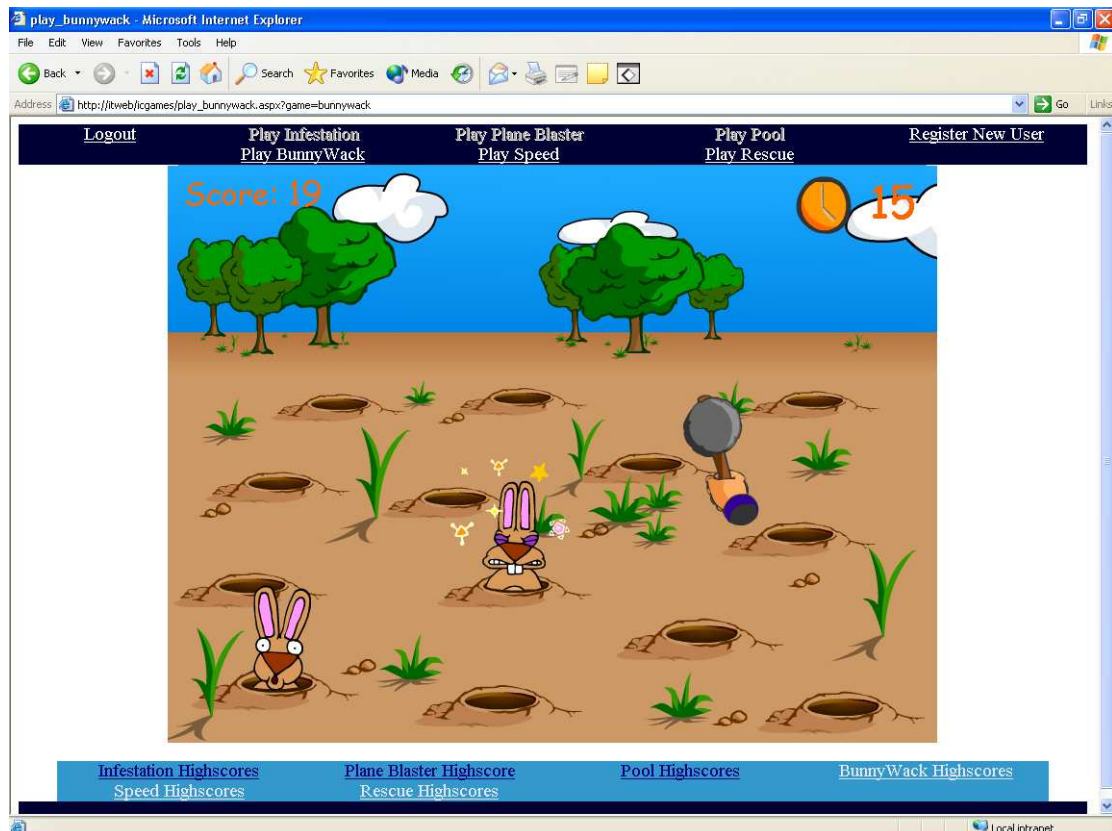
Figure A.17: Game 4 – Bunny Wack screen 1

This game only has one level of difficulty. Bunny Wack starts off with bunnies that appear randomly, one at a time, from any one of 13 holes. The bunny remains visible until the user hits it on the head with a hammer. The bunny then disappears into the hole while at the same time another bunny appears randomly.   The score is shown in the top left hand corner and the time left is shown in the top right hand corner. The user has 30 seconds to play the game and receives 1 point per bunny that he/she hits. When the time expires the user can see his score, as seen in Figure A.18.
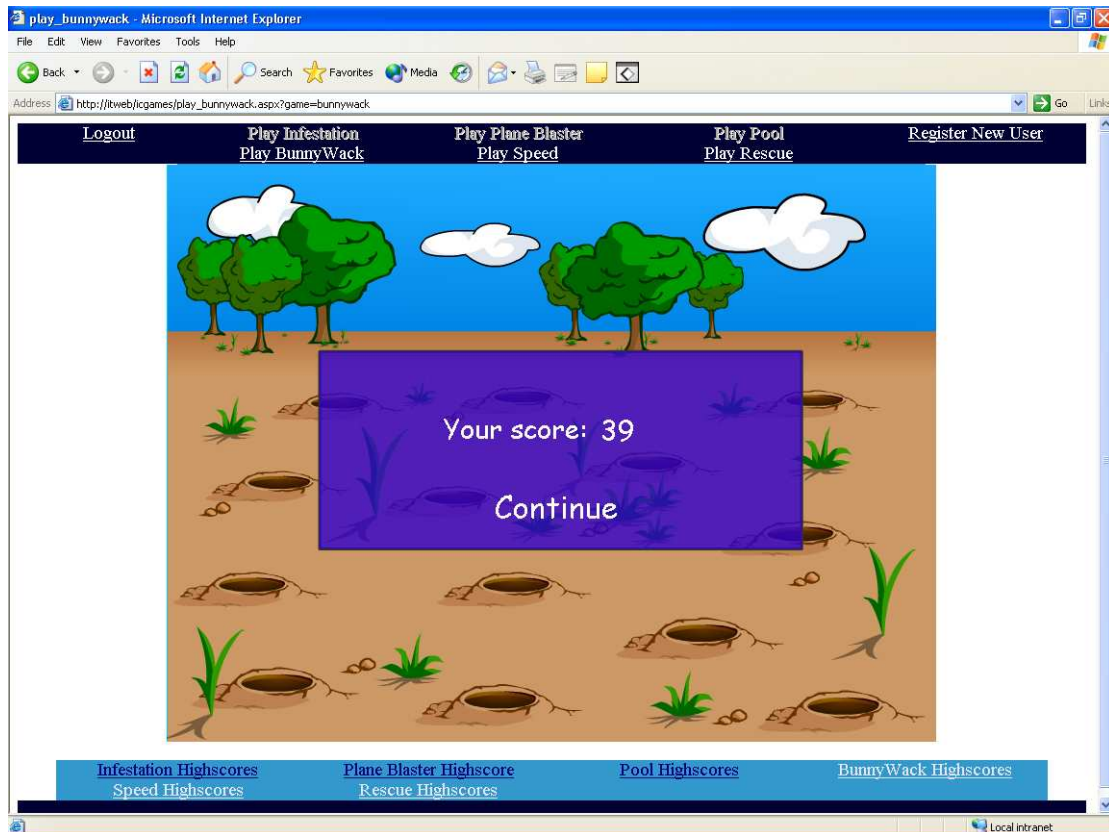
Figure A.18: Game 4 – Bunny Wack screen 2

On this screen the user must click on "Continue" before he/she can see the Bunny Wack high scores page (refer to Figure A.8). Table A.4 shows the scoring of the game.

	Point per bunny hit	Playing time (seconds)
Playing	1	30

Table A.4: Bunny Wack scoring

A.2.8 Speed (Game 5)

Of the games discussed so far, Speed is the most effective one in which to measure the user's ability to drag an object in various directions. In this game the user must drag a ball along a platform while picking up keys along the way, without falling off. All of this must be done as quickly as possible. *Mouse*

function drag and mouse speed are measured here. The opening screen can be seen in Figure A.19.
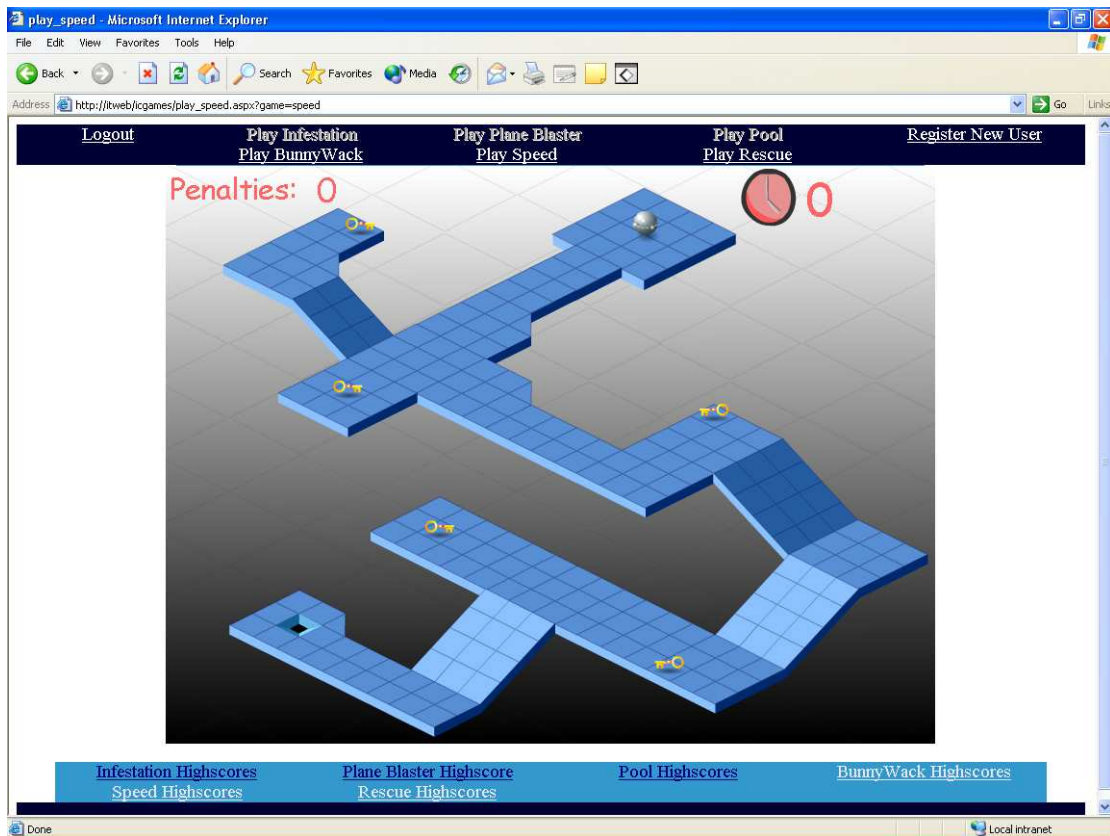
Figure A.19: Game 5 – Speed screen 1

In Speed, as in Bunny Wack, there is only one difficulty level. In the opening screen, Figure A.19, the penalties are shown at the top left hand side of the screen and the elapsed time is shown at the top right hand side of the screen. The timer starts counting from 0 as soon as the user starts dragging the ball. If the user drags the ball off the platform the penalties are increased by one, and the ball re-spawns on the platform where it fell off. All the keys, a total of five, must be picked up.

As soon as the user escapes at the end the timer stops and the user's time and penalties are shown, as depicted in Figure A.20. As soon as the user clicks on Continue, he/she is redirected to the high scores page of Speed where the top 10 scores are displayed (refer to Figure A.8).
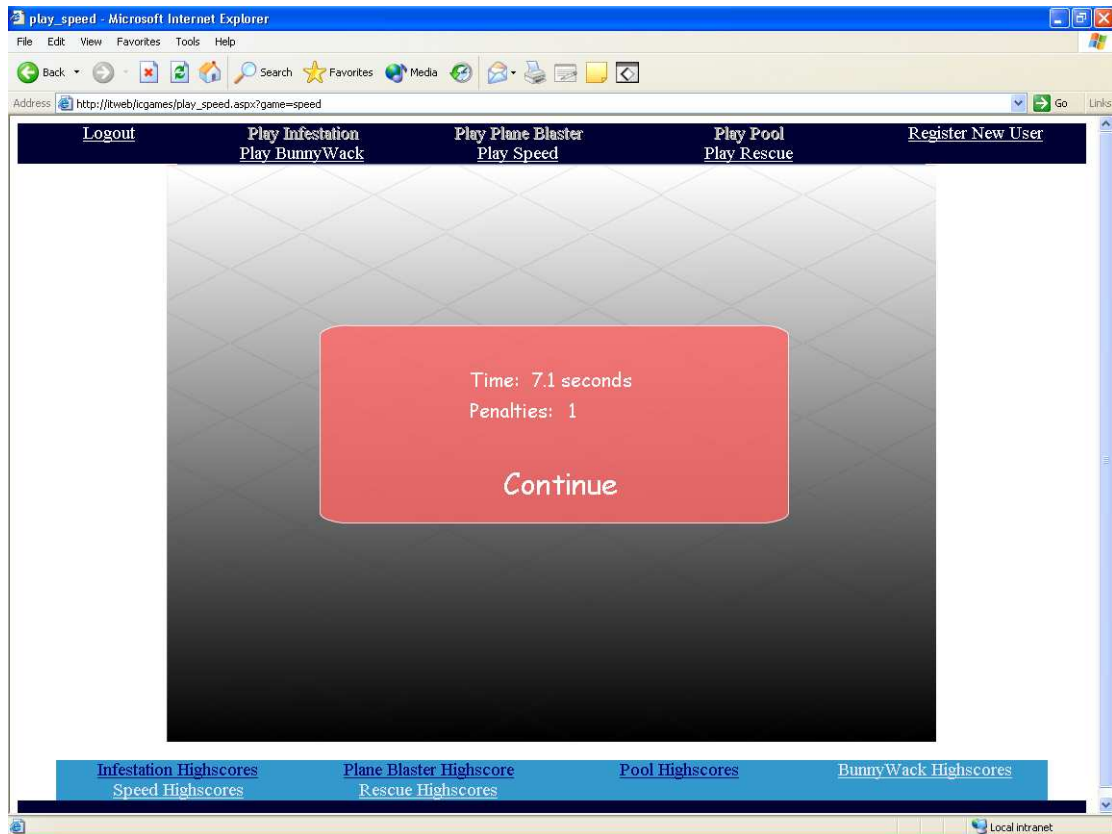
Figure A.20: Game 5 – Speed screen 2

Table A.5 shows the scoring for Speed.

	Penalty for falling off platform	Playing time (seconds)
Playing	1	User determined

Table A.5: Speed scoring

A.2.9 Rescue (Game 6)

Rescue is a game where the user must rescue astronauts in space, with a spaceship, while dodging asteroids. This game is designed to test the users' mouse moving abilities. This is the ability to move the mouse from location A to location B in an efficient manner. *Mouse function move is the only function measured here.* The game has three difficulty levels as seen in the opening screen in Figure A.21.
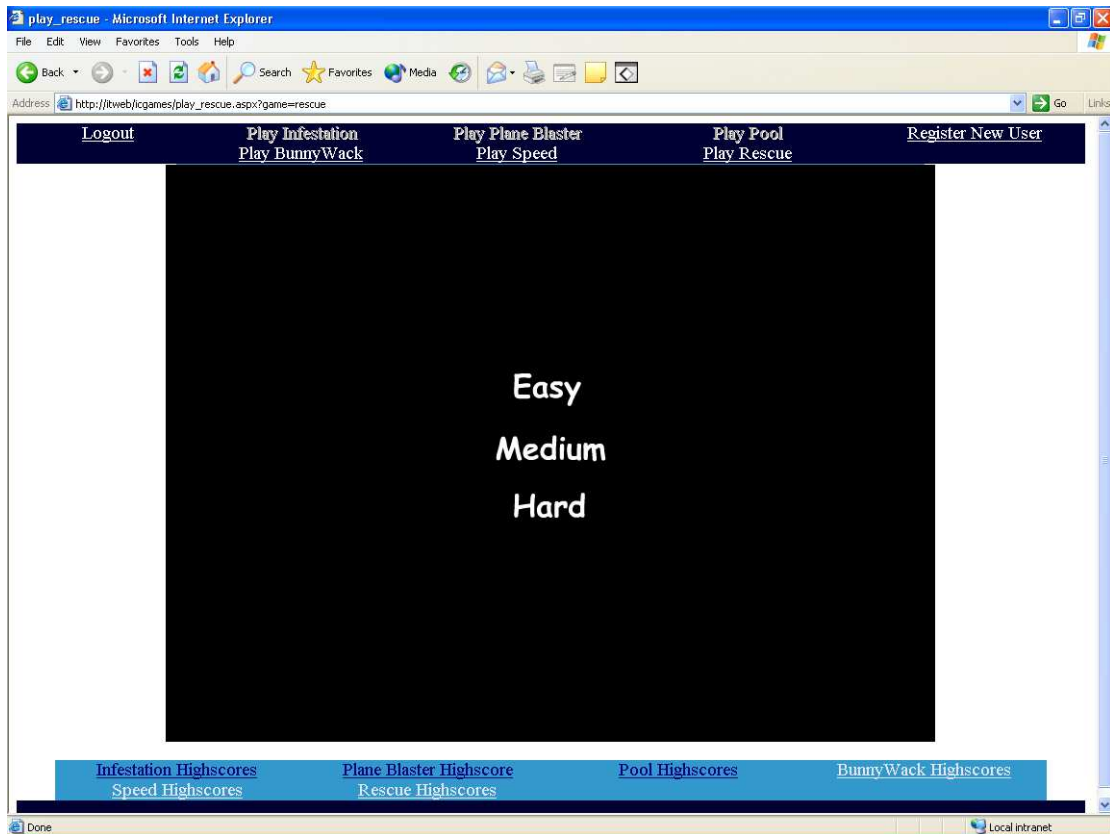
Figure A.21: Game 6 – Rescue screen 1

Even a first-time player can easily play Rescue on difficulty level Easy. The higher the difficulty level the faster the spaceship flies and the faster the user's reactions need to be. The points per astronaut and per asteroid hit vary according to the difficulty levels. The points allocation is reported in Table A.6 at the end of this section. After the user has selected the difficulty level the game starts (Figure A.22).
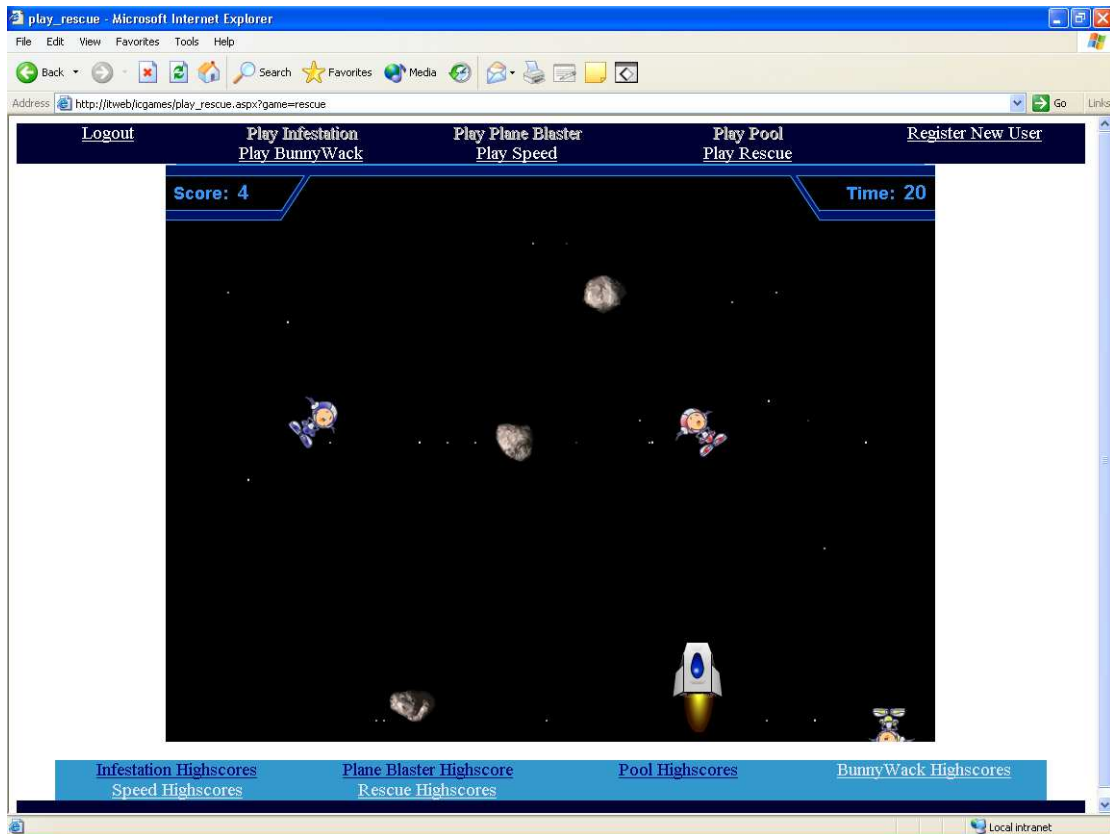
Figure A.22: Game 6 – Rescue screen 2

At the top left hand side of the screen the score of the user is displayed and at the top right hand side of the screen the time left is displayed. The user controls the spaceship by moving the mouse. The spaceship can only move left and right, along the bottom of the screen. There is a total of six objects (3 astronauts and 3 asteroids) on the screen at all times. As soon as either the astronaut is rescued or the astronaut or asteroid leaves the screen, a new one appears at the top of the screen.

The user can see his/her score as soon as the playing time expires (Figure A.23).
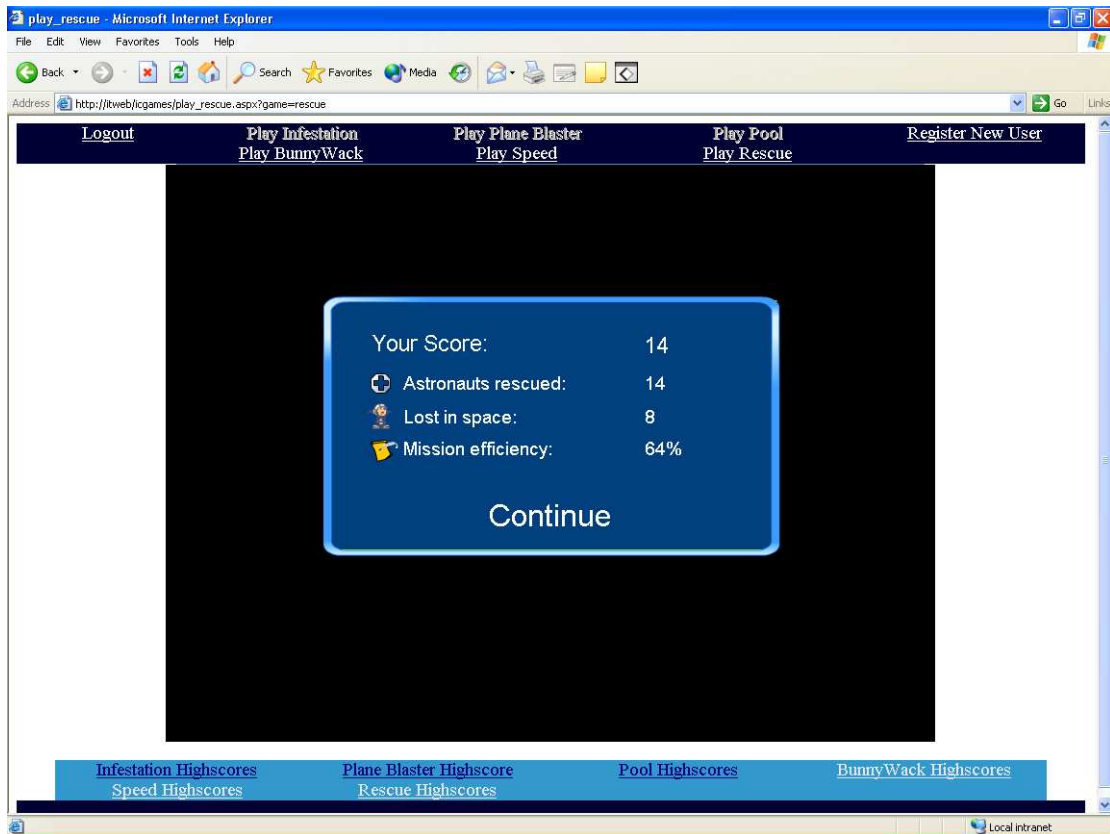
Figure A.23: Game 6 – Rescue screen 3

On this screen the users' statistics (the number of astronauts rescued, the number of astronauts lost in space and the mission efficiency) is shown. When the user clicks on "Continue" he/she will be redirected to the high scores page (refer to Figure A.8) of Rescue.

The scoring of the game is shown in Table A.6.

	Point per astronaut rescued	Asteroids hit	Playing time (Seconds)
Easy	1	-1	30
Medium	2	-2	30
Hard	3	-3	30

Table A.6: Rescue scores per difficulty level

A.3 Summary

In this appendix all the measuring instruments (games) which were used to gather the necessary data for the analysis in Chapter 5 of this dissertation, have been discussed.

The various games measure different mouse functions, although certain mouse functions are repeated in some of the games. The mouse functions measured in the games are summarised in Table A.7.

	Move	Point	Click	Drag	Speed
Infestation	✓	✓	✓	-	-
Plane Blaster	✓	✓	-	-	-
Pool	-	✓	✓	-	✓
Bunny Wack	-	✓	✓	-	✓
Speed	-	-	-	✓	✓
Rescue	✓	-	-	-	-

Table A.7: Summary of mouse functions per game

Mouse function Drag is only measured in Speed, as seen in Table A.7. All the other mouse functions are measured in more than one game.

The various games all had different scoring methods. All the scoring information of the games is summarised in Table A.8.

		Easy	Medium	Hard
Infestation	**Playing time**	45s	45s	45s
	Small spider	15	22	42
	Medium spider	10	16	30
	Large spider	5	12	25
	A miss	-2	-3	-5
Plane Blaster	**Playing time**	40s	40s	40s
	Airplane	10	15	20
Pool	**Playing time**	90s	75s	45s
	Ball	20	20	20
	Penalty (Sinking white ball)	-15	-20	-25
	Bonus*	50	50	50
Bunny Wack	**Playing time**	30s	-	-
	Bunny	1	-	-
Speed	**Playing time**	-	-	-
	Keys	5	-	-
Rescue	**Playing time**	30s	30s	30s
	Astronauts	1	2	3
	Asteroids hit	-1	-2	-3

* 50 bonus points are allocated if the user sinks all the balls within 15 shots.

Table A.8: Summary of games scoring - points

The first group of research participants played all the games discussed in this appendix. The second group of research participants only played Infestation, Bunny Wack and Speed.

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Appendix B

Printed Microsoft Word test
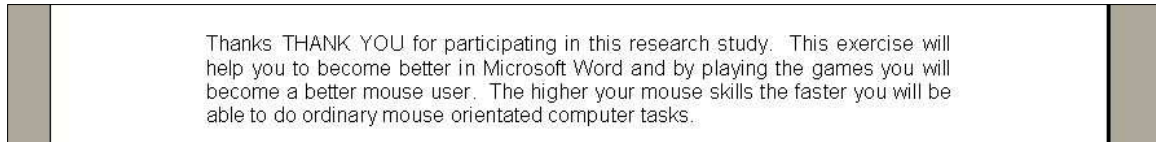
Microsoft Word test 1:

Instructions:
1. *The use of the keyboard is not allowed. Please make use only of the mouse when you do the following questions.*
2. *Do not turn over to page 2 until instructed to do so.*
3. *After turning over click the "Start" button at the bottom of the screen and then start with question 1.*
4. *All the questions must be done in order.*
5. *After finishing a question click the "Capture Time" button. This must be done after finishing each question.*
6. *Write down the time that you see at the bottom of the screen, next to each question (in the block provided)* **after completing all ten (10) questions***.*
7. *Write down the total time at the bottom of the page in the block provided.*
8. *Pictures will be provided with each question showing you what is expected.*

Please use your **student number** as your **User Number** for the Microsoft Word test and in the games. (DO NOT TYPE THIS NUMBER ANYWHERE)
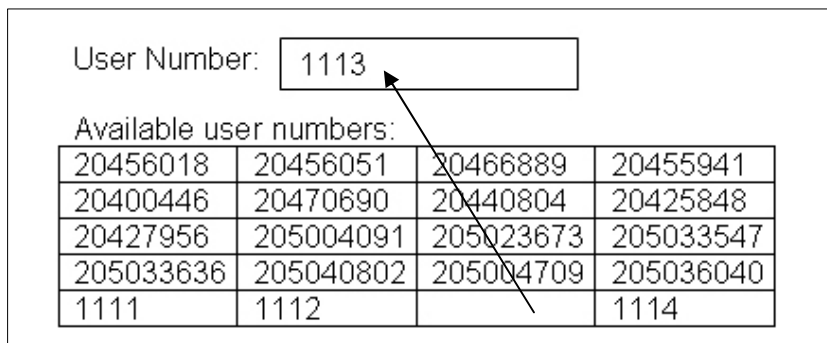
STUDENT NUMBER: _____

Click the "Start" button and then proceed to Question 1.

Question 1   **Time:**

Justify the text in the paragraph.

Thanks THANK YOU for participating in this research study. This exercise will help you to become better in Microsoft Word and by playing the games you will become a better mouse user. The higher your mouse skills the faster you will be able to do ordinary mouse orientated computer tasks.

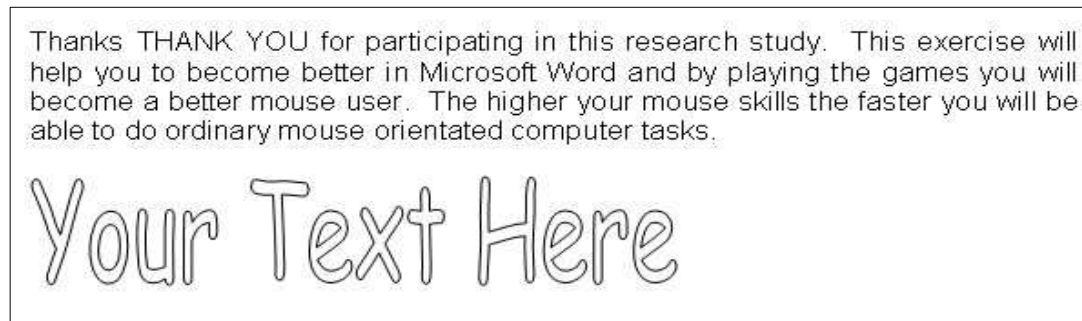Picture 1

Click the button "Capture Time".

Question 2   **Time:**

Drag <u>your user number</u> from the table "Available user numbers" into the textbox that is next to the words "User Number:"

User Number: 1113

Available user numbers:

20456018	20456051	20466889	20455941
20400446	20470690	20440804	20425848
20427956	205004091	205023673	205033547
205033636	205040802	205004709	205036040
1111	1112		1114

Picture 2

Click the button "Capture Time".

Question 3   **Time:**

Insert a WordArt object below the paragraph. Use the top left hand one. Keep the original text but change the font to "Comic Sans MS".

Thanks THANK YOU for participating in this research study. This exercise will help you to become better in Microsoft Word and by playing the games you will become a better mouse user. The higher your mouse skills the faster you will be able to do ordinary mouse orientated computer tasks.

Your Text Here
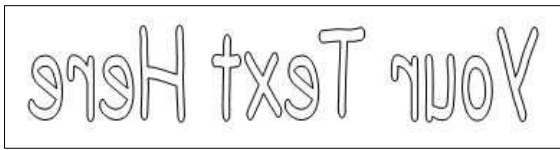
Picture 3

Click the button "Capture Time".

Question 4   **Time:**

Flip the WordArt text horizontally. *Tip: Make use of the Drawing Toolbar.*

Picture 4

Click the button "Capture Time".

Question 5   **Time:**

Insert a page number (left aligned) in the footer of the document.

Picture 5

Click the button "Capture Time".

Question 6   **Time:**
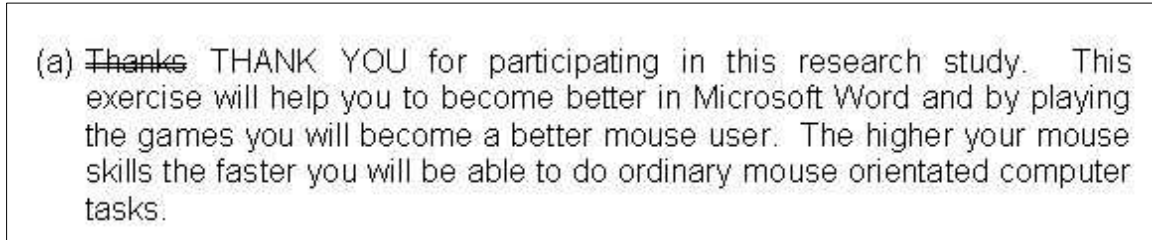
Use double strikethrough to draw two lines through the word "Thanks".

Picture 6

Click the button "Capture Time".

Question 7   **Time:**

Change the paragraph to a numbered list. Use the bottom right Numbering option (**(a)**).

Picture 7

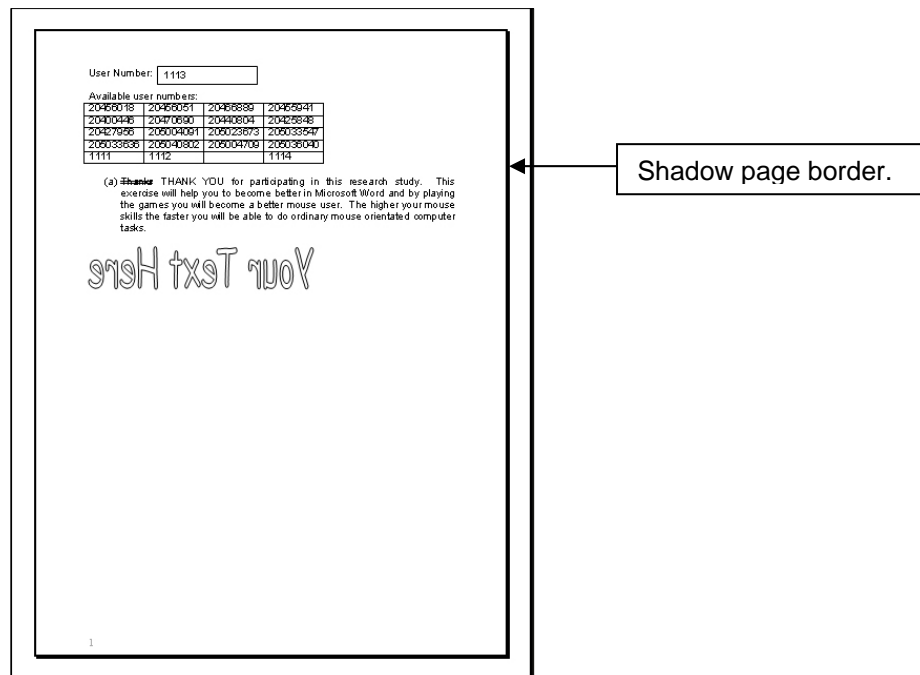**Click the button "Capture Time".**

Question 8   **Time:**

Add a "shadow page border" around the whole document and change the width to 3 pts.

Picture 8

Click the button "Capture Time".

Question 9   **Time:**
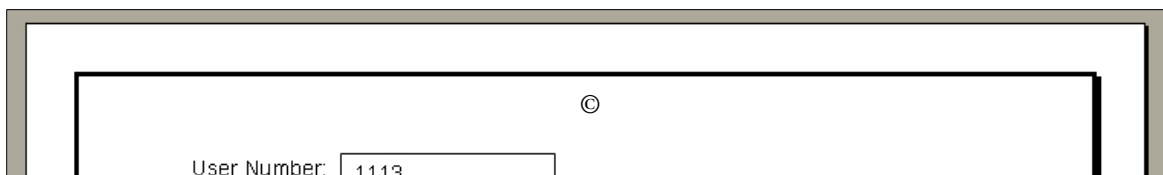
Change the "row height" of the whole table (Available User Numbers) to 1 cm.

Available user numbers:			
20456018	20456051	20466889	20455941
20400446	20470690	20440804	20425848
20427956	205004091	205023673	205033547
205033636	205040802	205004709	205036040
1111	1112		1114

Picture 9

Click the button "Capture Time".

Question 10   **Time:**

Insert the copyright symbol (©) in the header and centre align it.

©

User Number: 1113

Picture 10

Click the button "Capture Time".

Print your document and then write down all the times from the bottom window on the screen into the boxes provided next to the questions.

Total Time

Thank you for your participation.

Appendix C

Partially Completed Microsoft Word Document

User Number:

Available user numbers:

20456018	20456051	20466889	20455941
20400446	20470690	20440804	20425848
20427956	205004091	205023673	205033547
205033636	20459475	205004709	205036040
1111	1112	1113	1114

Thanks THANK YOU for participating in this research study. This exercise will help you to become better in Microsoft Word and by playing the games you will become a better mouse user. The higher your mouse skills the faster you will be able to do ordinary mouse orientated computer tasks.

Appendix D

Correct Microsoft Word Document

©

User Number: | 1113 |

Available user numbers:

20456018	20456051	20466889	20455941
20400446	20470690	20440804	20425848
20427956	205004091	205023673	205033547
205033636	205040802	205004709	205036040
1111	1112		1114

(a) ~~Thanks~~ THANK YOU for participating in this research study. This exercise will help you to become better in Microsoft Word and by playing the games you will become a better mouse user. The higher your mouse skills the faster you will be able to do ordinary mouse orientated computer tasks.

Your Text Here

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Summary

Computer use is transforming the lives of many South Africans and is fast changing the way organisations communicate and do business. It also means that thousands of people in South Africa, from different cultures, races and age groups, are coming into contact with and using computers, either at home, at school or university, at the office and even in shopping malls.

In order for a user to become computer literate he/she needs to know how to use the computer application effectively. This can only be achieved if he/she knows, *inter alia*, how to use the computer mouse as an input device.

It has been noticed that many previously disadvantaged students (this includes all people that were discriminated against according to race and include all black and coloured people) have no idea of how to use a computer mouse. Even after they have been shown how to hold and move the mouse, many of them still struggle for some time to use the mouse effectively. They find it difficult to master the movement of the mouse cursor and they struggle to click the mouse buttons. Such a user may fall behind the rest of the students in a computer literacy class and often hinders the progress of the class as the lecturer has to give special attention to the struggling individual.

The main focus of this study was to determine how long it takes a person to learn how to use a computer mouse effectively, and also, specifically in terms of mouse skills, whether *mouse-orientated computer games enhance the value that a user draws from an office package in a graphical user interface environment.*

This study was done in two phases. In phase one the students played six mouse-orientated computer games. Three questions were investigated in this phase:

- ❖ Does race play a significant role?

- ❖ Do difficulty levels play a significant role?

- ❖ Does computer use frequency play a significant role?

Phase two of the study focused on only three of the computer games used in phase one, and also on Microsoft Word tests. Six questions were investigated in this phase:

- ❖ Is there a difference between the average total completion times for the two MS Word tests within a session?

- ❖ Is there a difference in the average total completion times between the different sessions?

- ❖ Is there a difference between the average total marks for the MS Word tests in any session?

- ❖ Is there a difference in the average total marks between the different sessions?

- ❖ Does a student's score in any of the three games remain constant through different attempts and sessions?

- ❖ Is there a correlation between the score that a user obtains in one of the games and the total completion time for the MS Word test in the different sessions?

Various statistical tests were done on the captured data to answer the above questions. The tests included the Analysis of Variance (ANOVA), Tukey's test for the honestly significant differences and Spearman's correlation.

This study proved that playing mouse-orientated computer games improves a user's fine motor skills and enhances his/her computer mouse hand-eye coordination. Furthermore it proved that three of the six mouse-orientated computer games enhanced the value that the users drew from the MS Word tests. A positive relationship between the scores of the games and the completion time of the MS Word tests was encountered indicating that a high score in the games compared with a short completion time in the MS Word tests.

The games provide a relaxed and enjoyable environment for users to improve their computer mouse skills, and users are able to gain more value from an office package within a short time.

Keywords: computer games, computer literacy, mouse proficiency, office package, computer mouse hand-eye coordination, graphical user interface, input device, fine motor ability, reaction time.

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Opsomming

Die gebruik van rekenaars is besig om die lewens van baie Suid-Afrikaners te verander en is vinnig besig om die manier waarop organisasies kommunikeer en besigheid doen, te verander. Dit beteken ook dat duisende mense in Suid-Afrika, van verskillende kulture, rasse en ouderdomsgroepe in kontak kom met rekenaars by die huis, skool of universiteit, by die kantoor of selfs by winkelsentrums.

'n Persoon moet weet hoe om 'n rekenaarpakket effektief te gebruik voordat hy beskou kan word as rekenaargeletterd. 'n Persoon kan slegs rekenaargeletterd word as hy/sy weet hoe die rekenaarmuis as toevoertoestel werk.

Dit is waargeneem dat heelwat voorheen benadeelde studente (dit sluit alle persone in waarteen gediskrimineer was ten opsigte van ras en sluit alle swart en gekleurde persone in) geen idee gehad het hoe om met 'n rekenaarmuis te werk nie. Baie van hulle sukkel nog steeds om die muis effektief te gebruik, selfs nadat hulle gewys is hoe om die muis vas te hou en te beweeg. Hulle sukkel om die beweging van die muisloper en die druk van die muisknoppies te bemeester. So 'n gebruiker raak agter in 'n rekenaargeletterdheidsklas en strem somtyds die vordering van die klas, aangesien die dosent spesiale aandag aan die sukkelende student moet gee.

Die hooffokus van die studie was om te bepaal hoe lank dit 'n persoon neem om te leer hoe om 'n rekenaarmuis effektief te gebruik. Die studie het verder ook gepoog om, spesifiek in terme van muisvaardigheid, te bepaal of muis ge-oriënteerde rekenaarspeletjies die waarde wat 'n gebruiker uit 'n kantoorpakket in 'n grafiese koppelvlakomgewing verkry, verhoog.

Die studie is in twee fases gedoen. In die eerste fase het die studente slegs ses muis georiënteerde rekenaarspeletjies gespeel. Drie vrae is in die fase ondersoek:

- ❖ Speel ras 'n beduidende rol?
- ❖ Speel moeilikheidsgraad 'n beduidende rol?
- ❖ Speel die frekwensie van rekenaargebruik 'n beduidende rol?

Fase twee van die studie het gefokus op drie van die ses rekenaarspeletjies sowel as op Microsoft Word (MS Word) toetse. Ses vrae is in die fase ondersoek:

- ❖ Is daar 'n verskil tussen die gemiddelde totale afhandelingstye van die twee MS Word toetse in 'n sessie?
- ❖ Is daar 'n verskil in die gemiddelde totale afhandelingstye tussen die verskillende sessies?
- ❖ Is daar 'n verskil tussen die gemiddelde totale punte vir die MS Word toetse in enige sessie?
- ❖ Is daar 'n verskil in die gemiddelde totale punt tussen die verskillende sessies?
- ❖ Bly 'n student se punt in enige van die drie speletjies konstant oor die verskillende pogings en sessies heen?
- ❖ Is daar 'n korrelasie tussen die punt wat 'n gebruiker verkry in een van die speletjies en die totale voltooiingstyd vir die MS Word toets binne 'n sessie oor die verskillende sessies heen?

Verskeie statistiese toetse is op die versamelde data gedoen om die bogenoemde vrae te beantwoord. Die toetse sluit variansie-analise, Tukey se toets vir die werklik beduidende verskil en Spearman se korrelasie in.

Die studie het bewys dat die speel van muisge-oriënteerde rekenaarspeletjies 'n gebruiker se fynmotoriese vaardighede en hand-oog koördinasie m.b.t. die rekenaarmuis verbeter. Verder het dit ook bewys dat drie van die ses muis ge-oriënteerde rekenaarspeletjies die waarde wat die gebruiker van die MS Word toets gekry het, verhoog het. 'n Positiewe verwantskap tussen die punte van die speletjies en die voltooiings tye van die MS Word toetse is gevind, wat aandui dat 'n hoë punt in die speletjies ooreenstem met 'n kort voltooiingstyd in die MS Word toetse.

Die speletjies voorsien verder 'n ontspanne en genotvolle omgewing vir gebruikers om vinnig hulle rekenaarmuisvaardighede te verbeter. Binne 'n kort tyd kan gebruikers meer waarde uit 'n kantoorpakket put.

Sleutelwoorde: rekenaarspeletjies, rekenaargeletterdheid, muisvaardigheid, kantoorpakket, rekenaarmuis hand-oog-koördinasie, grafiese gebruikerskoppelvlak, toevoertoestel, fynmotoriese vermoë, reaksietyd.

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