COMPUTER GAMES USE IN AN EDUCATIONAL SYSTEM

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ABSTRACT

Teaching a subject which involves a long process and inter-related problems can sometimes be difficult through conventional classroom activities. This is particularly difficult at the UK Key Stage 3 (13-14 years) where students are only beginning to understand the processes of reason. Often what the teacher would like to encourage is group discussion but for many reasons, young students may be reluctant to put forward ideas in a conventional classroom setting. An area where this becomes less of a problem is once they get involved in playing a game together.

In addition to this certain subjects are difficult to teach because they involve complex interactions that are largely outside the general knowledge of young students. An example of this is the issue of human contributions to climate change. The subject is one of recent heated debate, much of which involves complex arguments on the relationship between the natural contribution to climate variation and those produced by human beings. In the work reported here a computer game has been developed which tries to incorporate the various processes involved in a realistic way. In principle this game can be used individually. However, it also provides the opportunity for generating group discussion and reasoning processes. The game which has been developed uses a non-player character which is controlled by the teacher. The game is played in a networked environment with a number of teams of two players each trying to provide solutions to a complex climate issue. The non player character is able to monitor the performance of the different teams and provide feedback that will be of a more realistic/less predictable nature.

This thesis addresses the design and the implementation of the game as a tool for teaching and learning purposes for learning about the human contribution to climate change. Three experiments have been done using this computer game to investigate the effectiveness of game-based learning towards tackling these issues. The first two studies were carried out in the UK while the third study was carried out in Malaysia to investigate educational cultural background. The initial study involved two groups of Key Stage 3 children in a Geography class. The study was undertaken in the normal teaching sequence. The children were divided into pairs during game-play and each session lasted about one hour. The behaviour of the whole group and individual teams was monitored throughout the game-play. Analysis of this shows that the game not only allowed the students to investigate the science but also to communicate with each other during the process. Overall, it is felt that by introducing an environment with which they were sufficiently familiar (playing a game together) the normal inhibitions to communication were removed. The control based experiment reinforced these findings.

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LIST OF ABBREVIATIONS

2D	Two-Dimensional
3D	Three-Dimensional
ADDIE	Analysis, Design, Development, Implementation and Evaluation Model
ARCS	Attention, Relevance, Confidence and Satisfaction
CD-ROM	Compact Disc Read-Only Memory
CO2	Carbon Dioxide
CSCL	Computer-Supported Collaborative Learning
DGBL-ID	Digital Game-Based Learning Instructional Design Model
EFH	Electric Field Hockey
GNP	Gross National Product
ICT	Information and Communications Technology
ID	Instructional Design
IT	Information Technology
MORI	Market and Opinion Research International
NFER	National Foundation for Educational Research
NPC	Non-Player Character
PC	Personal Computer
PhD	Doctor of Philosophy
Quasi-GBL	Quasi Game-Based Learning
SG-ISD	Simulation-Games Instructional Systems Design Model
VAP	Value At Plat
VRML	Virtual Reality Modelling Language
WWW	World Wide Web

CHAPTER I

INTRODUCTION

1.1 Research Background

Within the sphere of education, by the start of secondary school, children are beginning to engage with the idea of learning via experiments by constructing their educational ideas. This is often referred to by educationists as constructivism. There are many issues in trying to teach constructivist approaches to education and there many difficulties in getting children to contribute to discussion. Many other areas such as in physics are quite simple to do experiments where it is easy to set up the experiments. To be constructivist about a subject like physics is straight forward but to be constructivist when it comes to social debate is more difficult. It is more difficult because many of the issues involved are quite complex and difficult for children to begin to comprehend. There are also issues where a lot of children do not want to take part in classroom debate. It is proposed that this can be done through the medium of games. This is because constructivist thinking can be incorporated into the games and the students able to experiment with the social issues. This approach can also try to bring the students into the debate area through the medium of social games because games have the ability to make children take part in discussion.

1.1.1 Why use computer games to teach and learn?

Researchers, teachers and designers of learning resources claim that computer games can be used to support children's learning (Shaffer, Squire, Halverson & Gee 2005; Klawe, 1999; Williamson, 2009). Computer games provide a suitable environment for learning because they are able to give instant feedback to the players, and this is highly beneficial to learning (Prensky, 2001). A well-designed computer game will encourage interaction, visualization, experimentation, exploration, expansion of thought and creativity in the virtual playing environment (Kirriemuir, 2002). Mayo (2009) concurs with this by explaining further that the game-based format has many advantages over the traditional school approach. For example:

a) Games can be adapted to the individual pace of the learner.
b) Games can give learners immediate and continuous feedback.
c) Through games complex tasks can be broken down to guide players through a series of small steps.
d) Learners are able to control navigation.
e) Game-based tasks may require learners to formulate hypotheses and to experiment.

Throughout the literature, an assumption is commonly made that the rationale for using games for learning is that games are intrinsically motivating (Bixler, 2006; Klien & Freitag, 1996; Shaffer, 2006; Thatcher,1990). Motivation is one of the most important features in learning and the element of "fun" in a game situation will be a key factor in motivating current and future learners (Prensky, 2002; Ke, 2008; Papastergiou, 2009). Motivation is also referred to as a driving agent underlying participation, progression and retention in gaming environments (Konetes, 2010).

This research focuses on how computer games can be used as an additional tool in the educational sector, specifically within the school's curriculum. More importantly, an investigation is conducted into the way in which computer games can help students to construct critical thinking and knowledge about the complex relationships of an issue, while at the same time promoting motivation and learning. The research is affiliated with Don Schauder's teaching model, which is discussed in Chapter 2. Computer games are important because they encourage people to participate in virtual worlds and to learn by integrating thinking, social interaction and technology (Shaffer et al, 2005). Computer games that encourage exploration may be principally engaging to students (Kinzie & Joseph, 2008).

1.2 Research Hypotheses and Objectives

1.2.1 The hypotheses of the research

The hypotheses of the research are:

a) Games, because of their intrinsic motivational nature, are a valuable mechanism for engaging children in constructivism.

b) The gamer activity of sharing progress and ideas transfers to educational game-play and can therefore be exploited to engage players in debate about educational outcomes.

c) Adding edutainment components (mini games) which do not necessarily require completion of the stated educational aims will nevertheless improve engagement and therefore lead to increased motivation and enhanced learning.

1.2.2 The objectives of the research

It was necessary to develop a set of objectives in order to test these hypotheses:

a) First, an educational aim had to be identified that would benefit from a constructivist approach and that would be amenable to a computer game in which the game mechanic can embody the teaching objectives. The subject chosen for this study was Geography, as will be explained below.

b) Next, a suitable game genre was identified for this process and a game designed and developed to implement the teaching. The game genre chosen is SimCity-like because this game mechanic could effectively include the learning objectives (see Chapter 5).

c) The experiments were devised to test the hypotheses, using the game. At first a version of the game was tested on two groups of students and the effectiveness of this assessed to establish the value of the game (see Chapter 7).

d) This required the design of a valid game and a process of evaluation and modification.

e) A control-based experiment was devised to enable comparison with an alternative approach to teaching the learning outcome of the game. This experiment is recorded in Chapter 7.

f) The third study was to make a comparison between the educational culture in Malaysia and the educational culture in the United Kingdom (UK). The study was devised to investigate whether a gaming activity

can enhance and promote collaborative learning even in a culture where this is seldom engaged in. This study is reported in Chapter 7.

1.2.3 Why choose Geography as the subject for this research?

The geography curriculum in schools offers students a unique opportunity to learn about the planet earth. Geography is the study of the earth landscapes, people, places, and environments (Tuan, 1991), serving as a bridge between physical sciences, social sciences and humanities (Liverman, 1999). It has been suggested that teaching the geography curriculum to 11-15 year old children tends to be difficult not only because of their age (Piaget, 1952) but also because geographic phenomena often develop over long time-scales. For example, the changes of physical events have taken place over millions of years and it is not easy to conduct experiments to show young students this process of evolution. Even socio-economic developments such as population growth and other demographic changes occur over decades. Piaget's research on children's understanding of physical geography (1954) indicates that the early ideas of children tend to have animist or artificial characteristics which make it challenging for them to visualise or imagine what has been taught purely through fact-based learning.

It is also difficult to teach a subject such as geography because most geographical events occur as a result of complex interactive relationships which cannot be easily isolated. Global warming is one such example which is likely to include multiple linked variables, hence an attempt to eliminate a single problem would create or have an impact on other variables.

Innovations such as websites, videos and computer animations offer students more visual information, but provide little opportunity to encourage

them to create thought-provoking experiences of concepts which involve related non-prescriptive and complex issues.

Researchers have asserted that students should learn through their own experience, using resources that are engaging, immersive and interactive in order to challenge their thoughts and beliefs, particularly when involved with open-ended and multiple interacting problems (Prensky, 2002; Gee, 2003). Computer games have the ability to provide such opportunities (Mitchell & Savill-Smith, 2004).

1.2.4 Why choose global warming as the example topic to determine if a computer game is a beneficial approach to teaching and learning?

Global warming, or climate change, is said to be the most significant physical issue currently facing the world (Foeeurope, 2007). Global warming refers to the increase in the earth's temperature caused in part by the greenhouse effect, and is attributed to the excessive release of gases such as carbon dioxide (CO2), methane and nitrous oxides, as well as to the depletion of the ozone layer, which in turn is mainly the result of the release of chlorofluorocarbons and halocarbons into the atmosphere (NASA, 2008).

Global warming is a very complex issue because it involves an extensive cluster of interrelated elements which are very difficult to separate. An attempt to solve a problem may eventually trigger a further problem, and the chain of events will ultimately continue. For example, installing a solar panel on top of a home does save energy, but the initial cost of installation is high, thus it would in fact be cheaper to pay monthly for energy supplies. Solar panels are potentially energy-saving compared with production from a coal plant, which consumes energy, but this saving takes place over a very lengthy period of time and

householders might not live to enjoy the benefits. Such issues which interact in a non-predictable or less predictable way present a challenge (NASA, 2008).

The United Nation Climate Reports (2007) claim that continued global warming could have many damaging effects. For instance, it might harm plants and animals that live in the sea, or drive animals and plants at present living on land to new habitats. Changing weather patterns could cause flooding, droughts and an increase in violent storms. Global warming could melt sufficient quantities of polar ice to raise sea levels. Furthermore, in certain parts of the world, it could lead to the spread of human disease and to a decline in crop yields.

The concept of global warming is difficult to teach, especially to children, because it involves critical thinking and an understanding of long term events. It also requires abstract thinking, as solving one particular problem does not solve the whole problem. There are extensive resources on the subject, including Internet-based materials, books, videos and worksheet scenarios, but none of these encourage critical thinking. Current information being presented to children suggests that changes produce correct solutions, but, it is claimed, this is not the case when a set of interactions which are not easily isolated are involved. For instance, a climate change game named 'Ben & Jerry EcoMission' (Lick Global Warming, 2008), as shown in Figures 1.1 and 1.2, has simplified all its features to such an extent that it has become prescriptive. The task is to drive around a road map choosing from a set of options, one of which is whether or not to pick up friends (carpooling). According to the game, the more friends who are picked up, the more a player's global health will rise, because of the savings in emissions of gas and fumes from their car. However, such a scenario would not easily fit in the real world, where social pressures make it difficult for people to organize their lives around others. A more satisfactory solution might be to use public transport, where people could travel together; nevertheless, it could

be argued that investment in the infrastructure and maintenance of trams, for instance, could have an impact economically.

Figure 1.1: The main menu from Ben & Jerry Eco-Mission game (Lick Global Warming)

Figure 1.2: Ben and Jerry Eco-Mission game-play screen

A prescriptive solution, it is claimed, would have a negative effect on children's ability to learn. What children really need to learn is that global warming issues interact with one another. The solution to the problem is not simple and cannot be prescribed. It is difficult to present to children a set of issues that they can explore in turn in order to gain understanding of how they interact. It is essential to ensure that children are able to make decisions and to differentiate between objective and subjective issues.

1.3 Challenges of Teaching Geography

Geographical studies, and in particular global warming issues, lend themselves well to an investigation into the effectiveness of computer games for solving interacting problems in which there are no clear cut solutions. This would include an exploration into how far constructivist learning, especially that which involves the solving of non-prescriptive problems, improves progression.

It is necessary also to find out if computer games can contribute to teaching evaluative thinking - valuing, assessing, justifying, criticizing and judging - thus helping students to move from fact-based learning into more evaluative study in which they can construct new information themselves through game play. This would also enable students to recognize the complexity of issues that do not offer simplistic solutions. The Key Stage 3 National Strategy Handbook (2005) indicates that 11-14 year old students are able to enhance their reasoning and critical and evaluative thinking, one of its main objectives being to ensure that the majority of students by the age of 14 have learned how to reason and to think logically as well as creatively. It can be argued that by the time they reach a later stage of their educational development, students might already have adopted facts-based learning by memory, *'spoon feeding'* and non-critical thinking, and it might therefore at that stage be too late to encourage evaluative thinking.

1.3.1 Current methods of teaching

Teachers use different types of teaching materials such as handouts, worksheets, datasheets, concept maps and visual aids. The highly experienced geography teachers who were interviewed at the Nottingham Girls High School believed that it was both essential and valuable to build into their teaching interactive and engaging elements to ensure learning. A survey carried out by UK-based Ipsos MORI (2006) as part of the Teaching with Games study reveals that 59% of teachers wanted to use computer games for educational purposes. Fifty-three per cent said they would do so because of the interactive approach of games in motivating and engaging of students. Another part of the Ipsos MORI survey which investigated students' attitudes to the use of computer games in class reveals that 89% of students who said they would like to use games at school agreed that this would make lessons more interesting.

> *"More than two-thirds of respondents thought that games would improve their computer skills and just under half thought that they would help to improve strategic thinking skills such as problem solving."*
>
> (Ipsos MORI Survey, 2006)

A more recent survey regarding the use of computer games in the classroom was conducted in 2009 by Futurelab in collaboration with the National Foundation for Educational Research (NFER). Futurelab is an independent not-for-profit organization dedicated to transforming teaching and learning, making it more relevant and engaging to 21st century learners through the use of innovation practice and technology, while the NFER is the UK's largest independent provider of research, assessment and information services for education, training and children's services. The research, conducted by the NFER, includes a self-completion survey of over 1,600 practising classroom teachers in English state primary and secondary schools, with questions designed and provided by Futurelab (Futurelab-NFER Survey Report, 2009).

> *"The teacher survey shows that 35% of the samples of UK teachers have already used computer games in their teaching and 60% of teachers would consider using computer games in their teaching in the future."*
>
> (Futurelab-NFER Survey Report, 2009)

Digital information such as found on the Internet was once the most innovative technology to aid teaching and learning. However, the teachers who were interviewed drew attention to the limitations of current Internet-based materials, suggesting that these are simply books in a digital form involving little or no interactivity. Most of the Geography websites analysed (e.g. Learning on the Internet: Internet Geography Key Stage 3, 2008) reflected this complaint, as they are presented in a similar way to a book. For example, clicking the "next" button on a web page replaces turning a page in a conventional book. Even the structures and styles used in presenting information are the same. It can be asserted that material most available on the Internet is little more than an online book and generally less valuable especially for inter-related complex problem. Race (2005) concurs with this, also arguing that the majority of online learning programmes today are in fact little more than well-presented online information resources. This is because insufficient thought is put into the development of curriculum materials. There is a preference for creative ways of displaying materials, prioritising features such as design, colour and aesthetics, to be enjoyed in hyperspace.

It can therefore be concluded that, although there are abundant resources in the global network, the current use of electronic materials does not fully explore the potential of digital information. Very few of the websites demonstrate interactivity or realize their potential for drawing new and current information from other electronic sources. The geography teachers interviewed criticized the way in which information is presented and the effectiveness of the design for the target group of students, arguing that it does not emphasize the

correct learning style for their age group (12-13 years). Students of this age prefer responsive and interactive approaches in order to learn more effectively (Sandford, 2006).

These students are seeking not only to absorb facts, but also the opportunity to investigate. Subjects such as Geography require investigation in order fully to understand the sequence of events. Digital learning resources should exploit the opportunities provided by Information and Communication Technology (ICT) to enhance learning.

Another issue raised by the teachers was the level of restriction on Internet access in their own school in line with the Information Technology (IT) policy in schools which seeks to avoid unsuitable content becoming available to children. The search engine used by the students was often blocked from using sites with active content, thus limiting the Internet as a resource for information.

Resources such as videos have no interactive or responsive elements and are also very expensive to produce, especially when content has to be updated. The teachers interviewed indicated that some videos have been in use for more than five years. Video resources are more suitable for subjects like Chemistry or Physics in which the fundamental core does not change over a long period of time; nevertheless, videos are a non-interactive resource. Karthik and Lau (2002) assert that a student's perception of education today is simply not challenging or interactive enough. They also mention that:

> *"The students lose interest because the excitement is not there to motivate them to learn"*.
>
> (Karthik & Lau, 2002)

The new generation of students need a greater challenge than that presented by fact-based learning. Because they have a high exposure to

computers in their daily lives, it therefore seems appropriate to introduce a new learning support tool into the school's curriculum through the use of computer games to promote interest and motivation for students in reaching a predetermined educational learning outcome. Students will enhance their learning capabilities and retain more knowledge when actively and fully engaged in computer games that allow players to participate and interact, and that provide instant feedback on their actions (Prensky, 2001).

1.3.2 Research contributions

This research aims to make the following contributions:

Firstly, fulfilling the demands of game-based learning in modern educational technology;

Secondly, facilitating the teaching of subjects which are traditionally not easy to deliver, especially through paper-based materials;

Thirdly, attempting to re-introduce the fun factor into the classroom; and

Fourthly, giving teachers the opportunity to choose a variety of tools for their teaching in order to make their lessons more interesting and enjoyable and to introduce collaborative learning

Furthermore, it is envisaged that the Ministry of Education in Malaysia will introduce this learning approach to its schools, teacher training colleges and universities because of the potential in using games for collaborative learning.

1.4 Summary

This research focuses on the use of computer games as an effective tool to extend knowledge and to encourage discussion of open-ended interacting issues. It also seeks to encourage students to move from the prescriptive nature of fact-based learning towards being evaluative learners, valuing, judging, criticizing and constructing new information for themselves. Global warming as a sub-topic within the range of Key Stage 3 Geography subjects is a suitable context in which to investigate the potential of computer games in motivating and developing critical thinking and acquiring an understanding of open-ended, interacting complex issues.

Some problems cannot easily be separated into independent variables because these variables intrinsically interact with each other. It is believed that the use of computer games can help students to extend their knowledge, to think more creatively and to understand the complex relationships of an issue, although it would not be possible to construct all the information required to solve the problem. At the same time, using an appropriate approach to computer games can promote collaborative learning among students and also between students and teachers.

Furthermore, very little teaching and learning of Key Stage 3 Geography has hitherto been achieved through game play, so this approach offers the opportunity to participants to be exposed to a new teaching and learning environment.

The next two chapters will look respectively at why games are being looked to as a good method of promoting learning and how this can be done for subjects like global warming.

CHAPTER II

THE THEORETICAL FRAMEWORK FOR CONSTRUCTIVIST EDUCATION

2.1 Introduction

The main aims of this thesis are to investigate the value of using computer games in education, particularly in promoting constructivism and collaboration in the early years of secondary schooling. In order to do this it is first necessary to review the relevant educational theories in order to inform the design. Many aspects have been taken into consideration from previous research studies in order to extract the key features in this area - for example, factors affecting motivation and learning styles.

2.2 Definition of Play, Games, Computer Games, Computer Simulation, Educational Games, Serious Games and Casual Games

Prensky (2001) states that *play* is where someone chooses to do an activity for entertainment or pleasure, whether individually or in social groupings. He also suggests that it can create the 'fun factor' which increases our involvement, thus helping us to learn. Fabricatore (2000) defines play as:

> *"An intellectual activity engaged in for its own sake, with neither clearly recognizable functionalities nor immediate biological effects …and related to exploratory processes that follow the exposure of the player to novel stimuli".*
>
> (Fabricatore, 2000 p.2)

Games, on the other hand, refer to a subset of both play and fun which gives pleasure or enjoyment (Prensky, 2001). A *game* is usually a set of activities which involve one or more players (Dempsey et al, 1996). Games also can be defined as playful activities, with or without a computer, that have essential characteristics (Dempsey et al., 1996). Game characteristics can include: competition and goals, game rules (Alessi & Trollip, 1991; Derryberry, 2007), challenging activities (Malone & Lepper, 1987), risk and consequences (Derryberry, 2007), choices (Hannafin & Peck, 1988; Derryberry, 2007), fantasy elements and entertainment aspects (Cruickshank & Telfer, 1980). Randel et al. (1992) insist that players will be motivated via challenge, fantasy and curiosity, thus prompting an awareness of learning, while Juul (2005) states that a game also can be defined as:

> *"A rule-based system with variable and quantifiable outcomes, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels emotionally attached to the outcome, and the consequences of the activity are negotiable".*
>
> (Juul, 2005 p.36)

A *computer game* is a game played on a computer carried out with the help of a computer program (Smed & Hakonen, 2003). It requires display hardware (i.e: television, monitor), and input devices (e.g. mouse, keyboard, joystick) for interaction (Kirriemuir, 2002). Christopher (1999) proposes that computer games consist of four key elements:

a) a setting that represents reality, but is not necessarily realistic;
b) roles or agendas for the participants;
c) rules for achieving some goals or outcomes;
d) scoring or monitoring, some kind of feedback or indicator.

Furthermore, according to Prensky (2001) and Derryberry (2007), *computer games* can be divided into several classes which, when combined, strongly engage the player:

a) Representation and storyline

   Most computer games have a storyline in order to stimulate the players; this storyline is not the game play itself, but rather the rationale for the game play.

b) Game mechanics

   Game mechanics refer to the fundamental core which handles all the specific functions within a game, including how the physical game world behaves.

c) Rules

   The rules of the game are the constraints in game-play on every player's actions and abilities.

d) Goals and objectives

   Goals and objectives are the targets which motivate the players to achieve.

e) Conflict / competition / challenge / opposition

   This is the manner in which the game is played; the competition might be against the game, against oneself or against other players.

f) Risk and consequences

These are involved in every challenge, but they exist in a safe game environment where the consequences of an action or decision do not impact on the real world.

g) Interaction

This focuses on the impact of a player's actions on the game environment which includes issues of persistence and player interaction.

A *computer simulation* is a software program that attempts to represent real world scenarios and is the imitation of some event that is real. William et al. (2006) suggest that computer simulations operate to imitate complex technology of the real-world, such as jet fighters and tanks; they also simulate the operation of particular objects. Simulation is used from many perspectives, including the modelling of natural or human systems in order to gain insight into their functioning. Glasa (2009) observes that computer simulations are often used as a substitute for prediction (such as forest fire behaviour in a given region), if the real event is dangerous or impossible to be worked on by humans. Faria (1998) states that computer simulations can maintain all the characteristics of a computer game, including rules, winning and losing scenarios, and aspects of competition. Confusion exists between games and simulations because of the nature of the underlying model of many computer games. Some examples of games which are also simulations are car racing games, business simulations and sports games. Others also include adventure and fantasy games.

Jacobs and Dempsey (1993) argue that the difference between games and simulation is often unclear and that many articles in this area refer to a single simulation game entity. O'Neil, Wainess and Baker (2005) also believe that terms such as 'computer games', 'video games', 'simulations, 'simulation games', and 'simulation-games', are interchangeable among researchers due to

the unclear distinctions among these various terms. There is little consensus in the education and training literature on how these terms (e.g. game, simulation and simulation game) are defined.

An *educational game* is a game designed for learning purposes which combines the elements of play, fun and learning simultaneously. It is a melding of educational content, learning principles and computer games (Prensky, 2001). Digital game-based learning is structured to provide both education and pleasure. One of the advantages of play is that it can relax participants, inducing a receptive state for learning.

Another term used by researchers is *serious games*. A serious game is a type of computer game that is typically a simulation of real-world events or processes (Cameron, 2008) with the intention of improving a certain aspect of learning (Derryberry, 2007). Serious games use game-like elements to provide education and training within an 'enjoyable' experience. Most serious games simulate a 'world' in which activity takes place. The learner may assume a first-person perspective and interact with other characters – either artificial or other real-life players. Serious games are usually composed of a main task or goal to be achieved, with one or more subtasks that lead towards the accomplishment of this main task. In serious games, players also have the ability to manipulate the setting according to the rules of the games and the environments.

A *casual game is* designed and developed purely for entertainment purposes (Derryberry, 2007). Playing a casual game does not require long-term time commitment or special skills and comparatively low production and distribution costs are incurred for the producer. Casual games usually are played on personal computers (PCs) and via web browsers, although currently they are becoming popular on game consoles and mobile phones. Microsoft's Solitaire is widely considered as the first successful casual game (Morrison, 2007).

In conclusion, games have long been used for instructional purposes. Any games, whether paper-based, board-based or digital-based, usually involve a set of rules, objectives and purposes, and also provide entertainment. The entertainment factor was said to be the distinguishing element that could motivate and stimulate students' learning capabilities. Computer games today have potential as a valuable supporting learning medium, particularly when they involve open-ended and complex interactive issues. It should also be noted that the terms 'computer games', 'simulation games', and 'serious games' have now generally become synonymous because of the uncertainty of the boundaries between those terms.

2.3 Motivation to Learn

Motivation has long been considered as an important step in learning. According to Bixler (2006) there are many definitions of motivation, but most of these can be divided into two categories: physiological and psychological. Physiological definitions of motivation involve facts concerning measurable bodily functions which use the term 'energized' to describe motivation. Psychological definitions of motivation refer to '*the process whereby goal-directed activity is instigated and sustained'* (Pintrich & Schunk, 2002). It is the incentive that keeps us going, moving and trying to complete a task. Pintrich & Schunk, (1996) also claim that motivation can influence how and why people learn as well as how they perform.

According to the literature, student learning styles, motivation and attitude seem to be associated with achievement. Carver and Enfield (2006) believe that a desire to learn is the most important attitude that can be formed. The more motivated a person is about a given subject, the more likely that individual will be to learn about it. Malone (1981) indicates that students who are intrinsically motivated may spend more time and effort in learning.

Most researchers concur that learner motivation is an important element that needs to be considered when developing, monitoring and assessing the instructional effectiveness of educational games. In order to motivate a person to learn, it is necessary to provide them with an incentive to engage in the act of gaining knowledge (Paras & Bizzocchi, 2005).

2.3.1 Components of the motivation to learn

According to Frith (1997) there are six major components of motivation to learn: a) curiosity b) self-efficacy c) attitude d) needs e) competence and f) external motivators.

a) Curiosity

People are naturally curious and often seek new experiences, perfecting skills and developing competence. A curious person tends to enjoy new learning and gains satisfaction when solving puzzles.

b) Self-efficacy

Self-efficacy is the belief and conviction held by an individual about their ability to be effective and to control actions or outcomes. Bandura (1997) observes that self-efficacy plays a major role in the extent to which individuals can produce crucial results in their lives. In order to achieve self-efficacy, the individual should acquire knowledge, challenge their own assumptions, plan and prepare, and observe how other people accomplish tasks independently and achieve success.

c) Attitude

Attitudes are an integrated set of beliefs that influence how an individual responds to or approaches a learning situation. Some

learners may see a particular learning situation as a test of their ability, while others may view it as an opportunity for learning and improvement.

d) Needs

The needs of individual students can vary greatly. For example, children who are sent to school hungry are not motivated to learn; their lower needs must first be met. The most well-known and respected classification of human need is Maslow's hierarchy of needs, discussed later in this chapter.

e) Competence

Competence is the combination of knowledge, skills, and behaviour leading to an individual being able to perform a certain task to a given level.

f) External motivators

External motivators refer to an individual's motivation to attain a goal from an outside source - for example, seeking good grades, receiving praise from teachers, or earning more money. However, it is claimed that it would be more difficult to remain highly motivated in circumstances where the individual has only external reasons for being in that situation.

2.3.2 Theoretical views of motivation

Numerous factors will determine whether a student is motivated to learn. Motivation theories comprise four major categories: a) the behavioural view b) the cognitive view, c) the humanistic view and d) the achievement motivation theory (Biehler & Snowman, 1993).

a) *The behavioural views* of motivation are based on B. F. Skinner's behavioural learning theory which focuses on the reinforcement of desired behaviour through the use of extrinsic reward. Biehler and Snowman (1993) observe that behavioural views of learning help to explain why some pupils react favourably to particular subjects and dislike others. For example, a student who observes an older brother or sister gain benefits from earning high grades may attempt to do the same with the expectation of experiencing the same benefits. Similarly, a student who notices that a classmate receives praise from the teacher after acting in a certain way may decide to imitate such behaviour to win similar rewards. This shows that reinforcement can raise an individual's sense of self-motivation for a particular task, which in turn leads to a higher level of motivation.

b) *A cognitive view* focuses on how human behaviour is influenced by the way in which people view themselves and their environments (Biehler & Snowman, 1997). This behaviour can be explained by four influences:

i. the inherent need to construct an organized and logically consistent knowledge base;
ii. one's expectation for successfully completing a task;
iii. the factors that one believes account for success and failure;
iv. an individual's belief about the nature of cognitive ability.

The impact of cognitive development is based on Jean Piaget's principles of equilibration, adjustment, and accommodation (Flavell, 1996). Piaget identifies that children have an inherent desire to maintain a sense of organization and to balance their conception of the world (equilibration), as observed by Biehler and Snowman:

> *"A sense of equilibration may be experienced if a child assimilates a new experience by relating it to an existing scheme, or the child may accommodate by modifying an existing scheme if the new experience is too different. Individuals will repeatedly use new schemes because of an inherent desire to master their environment"*
>
> (Biehler and Snowman, 1997)

This helps to explain why young children can, with no loss of enthusiasm, sing the same song, tell the same story, and play the same game over and over again.

c) *A humanistic view* of motivation focuses on the learner as a whole person and examines the relationship between physical, emotional, intellectual and aesthetic needs (Eggen & Kauchak, 2006). Perhaps the best known theory of motivation in this category is Abraham Maslow's (1954) "Hierarchy of Needs", which proposes a five-level hierarchy of needs:

i. Physiological needs

Physiological needs are the most basic human needs and include hunger, thirst, and shelter.

ii. Safety needs

Safety needs refer to the desire to find a safe and secure physical environment.

iii. Belongingness needs

Belongingness refers to an individual's desire to be accepted by his peers.

iv. Esteem needs

Esteem needs refer to the desire to have a positive self-image and to receive recognition from others.

v. Self-actualization needs

Self-actualization needs are at the top of the pyramid and represent the concern for the development of full individual potential.

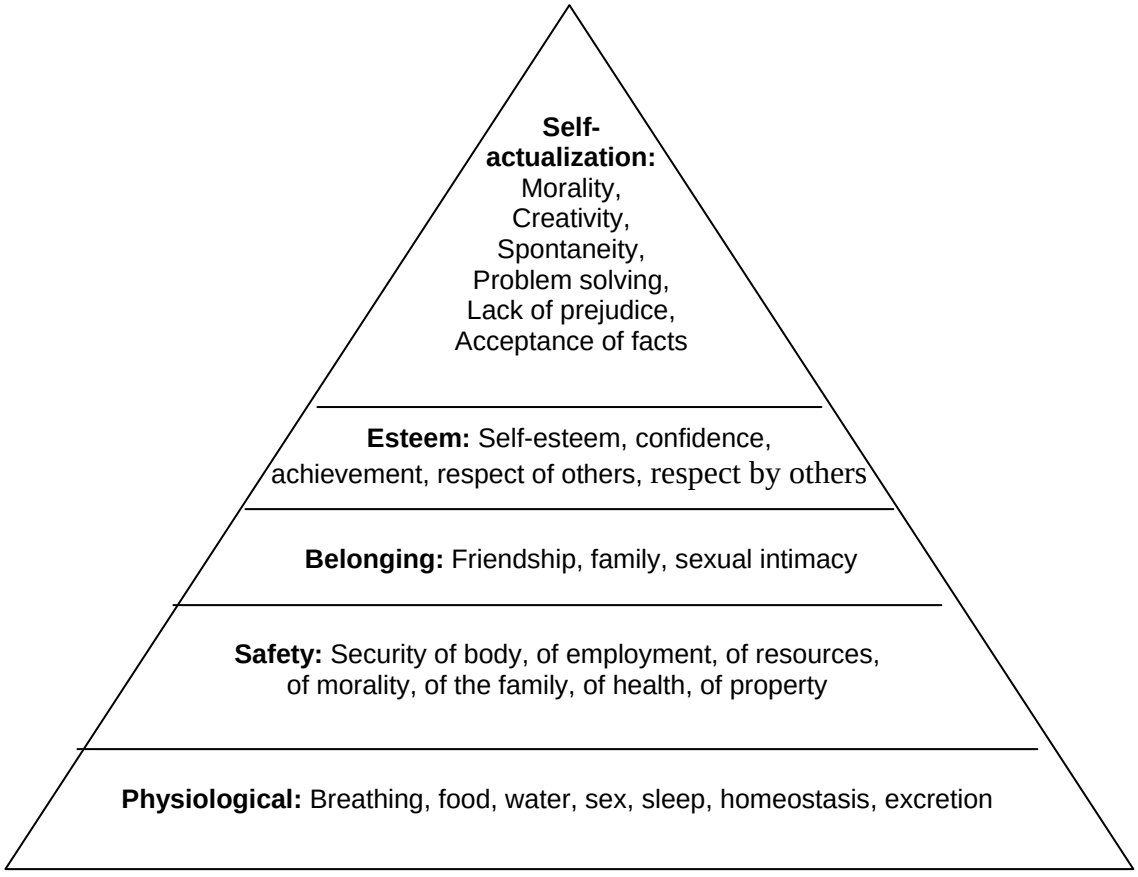


Figure 2.1: The Hierarchy of Needs (Maslow, 1954)

In the educational setting, students will be led to seek satisfaction and self-actualization if their basic needs for safety, relaxation, belongingness and a clean and orderly environment are addressed.

d) *The achievement motivation* theory refers to an individual's desire to perform well, master skills and reach success by persistence and effort in the face of difficulties (McClelland, 1965). This is related to the difficulty of tasks people choose to do. Individuals with low achievement motivation may choose very easy tasks, in order to minimize risk of failure, or highly difficult tasks, such that a failure would not be embarrassing. On the other hand, individuals with high achievement motivation tend to choose moderately difficult tasks, feeling that they are challenging but within reach. These groups of individuals are characterized by a tendency to seek challenges and have a high degree of independence. Their most satisfying reward is the recognition of their achievements.

2.3.3 Motivation models / frameworks

There are several models/frameworks which describe the components for developing and assisting learner motivation. These include: a) the ARCS Model, devised by John Keller (1987a), b) the Time Continuum Model of Motivation, recommended by Raymond J. Wlodkowski (1985), c) the Motivational Framework for Culturally Responsive Teaching, also created by Wlodkowski (1999) and d) the Taxonomy of Intrinsic Motivations for Learning, developed by Thomas W. Malone and Mark R. Lepper (1987).

a) Keller's ARCS Model

   ARCS model represents its four main factors: Attention, Relevance, Confidence and Satisfaction, concepts which were developed by John Keller over a period of ten years. Keller received his Ph.D from Indiana University in 1974 with a major in instructional systems technology and minors in research and evaluation and organization behaviour.

i. Attention

Gaining and retaining attention is a teaching prerequisite and sustaining this is essential. One technique to gain and keep attention is through the use of innovation or a different strategy (Travers, 1982). Attention involves engaging the learners by the use of interesting graphics, stimulating animations and even rich quality sounds (Ritchie & Hoffman, 1997). However, Keller and Suzuki (2004) warn that the user will lose interest over a certain period of time once they are well familiarized with the subject.

ii. Relevance

Relevance is perhaps the most interesting part of this model, in which Keller claims that relevance not only comes from 'what' is taught, but also from 'how' it is taught. Wagner (1998) also states that curiosity, creativity and higher-order thinking are stimulated by relevant and authentic tasks of optimal difficulty for each student. Hodges (2004) also advises that students should be kept informed of their progress towards achieving their goals.

iii. Confidence

Confidence helps students to establish positive expectancies for success. Travers (1982) believes that confidence is a motivational element in instruction. His model describes three ways of building confidence in learners:

- Expectancy for success

  Make learners aware of performance requirements and evaluative criteria.

- Challenge setting
  Provide multiple achievement levels that allow learners to set personal goals.

- Attribution Moulding
  Provide feedback that supports a student's ability and effort as the determinants of success.

iv. Satisfaction

Satisfaction refers to how satisfied people are about their accomplishments. The model describes three ways of enhancing satisfaction:

- Natural consequences
  Provide opportunity to use newly acquired knowledge or skill in a real or simulated environment.

- Positive consequences
  Provide feedback and reinforcements which will sustain the desired behaviour.

- Equity
  Maintain consistent standards and consequences for task accomplishment.

b) Time Continuum Model of Motivation (Wlodkowski, 1985)

While it has many similarities to the ARCS model, this focuses more on the role that motivation plays at different stages of the learning process (Hodges, 2004). The time continuum model divides the learning process into three critical stages:

i. The beginning of the learning process

   This process concentrates on ‘attitudes’ and ‘needs’. Motivational strategies during this stage include icebreaker activities and the statement of well-defined objectives and other strategies to assist learners in developing a clear understanding from the beginning. For example: Value – Is the learning important?

ii. During the learning process

   This process focuses on ‘stimulation’ and ‘effects’. Motivational strategies during this stage include encouraging learner participation via questions, humour, variety of presentation style or the use of different modes of instruction. For example: Appeal – how stimulating is the learning?

iii. The end of the learning experience

   This last stage emphasises ‘competence’ and ‘reinforcement’. Motivational strategies in this stage include giving frequent feedback and communicating their progress to learners. For example: Perseverance – how well do the students maintain their involvement and motivation using what they have learned outside the learning experience?

According to Wlodkowski (1985), in order to maintain learner attention, the materials must provide a variety of activities and different presentation techniques that stimulate the learners. It is essential to make sure that the learner is an active participant and maintains positive attitudes in the learning process so that their effort to learn will persist.

c) The Motivational Framework for Culturally Responsive Teaching (Wlodkowsi, 1999)

This framework was developed for the purpose of examining and fostering motivation with the integration of cultural sensitivity into the teaching process. The framework has four key components:

i. Establish inclusion

Create a feeling of respect and connectivity between teachers and students.

ii. Develop attitude

Ensure personal relevance and choice.

iii. Enhance meaning

Create challenging experiences that include learners' values and perspectives.

iv. Engender competence

Create an understanding that learners' requests for new knowledge will be met

d) The Taxonomy of Intrinsic Motivations for Learning (Malone & Lepper, 1987)

The Malone and Lepper (1987) taxonomy is based on several cognitive theories of motivation. They identified two main sections in their taxonomy:

i. Individual motivation

This consists of four further elements:

- Challenges

  Challenges refer to goals, uncertain outcomes, performance feedback and self-esteem. Learners must have the ability to vary the difficulty of the game. There should also be sufficient randomness in the action and constant feedback about their performance so that learners can evaluate it and proceed to take necessary actions.

- Curiosity

  Curiosity refers to ‘sensory’ curiosity and ‘cognitive’ curiosity. Sensory curiosity occurs when physical factors such as changes in tone of voice, light or sound attract the attention of learners (for example: a teacher speaks in a low tense voice to catch the attention of her students). Cognitive curiosity is evoked when learners believe that it may be useful to modify existing cognitive structures (for example: a teacher presents information in such a way that students consider it to be mere interest.)

- Control

  Control involves contingency, choice and power. Learners should feel in control of their activity and at the same time be able to make choices. Learners should also be able to witness the effects of such choices. When the options are unclear, the learners should be able to gather information in order to make an informed choice.

- Fantasy

  There are emotional and cognitive aspects of fantasy. Emotional aspects refer to the ability to personalize fantasies which can be beneficial in increasing intrinsic motivation. A

fantasy can fulfil a learner's emotional needs, especially when it provides imaginary characters that are familiar or comfortable to the learner by incorporating information about their background and interests into the fantasy environment.

ii. Interpersonal motivations

This process consists of three elements - cooperation, competition, and recognition.

- Cooperation

  This refers to the learner's satisfaction with his/her contribution towards the group goal (e.g. working as a team to achieve certain aims or objectives).
- Competition

  Competition can motivate learner behaviour, especially when learners can enhance their own self-esteem and make comparisons of their own performance with others (e.g. gaining a higher mark than others in a quiz or test).

- Recognition

  Receiving recognition and approval by others for his /her effort and accomplishment can motivate learners (e.g. being praised for their outstanding work).

2.3.4 Comparison of motivational models / frameworks

Table 2.1 illustrates a comparison of the above four models in integrating motivational constructs into the instructional design process. The four models/frameworks provide a foundation for comparison and contrast between the different motivational aspects. They have a great deal in common; all four

models agreeing that obtaining and maintaining attention, relevance, competence and satisfaction are important motivational aspects. Each model presents a unique insight that may not be evident in the brief overview provided in the table. Malone and Lepper's Taxonomy, for instance, is unique in including the fantasy element.

ARCS (Keller)	Time Continuum (Wlodkowski)	Cultural Responsive Teaching (Wlodkowski)	Taxonomy of Intrinsic Motivation (Malone & Lepper)
• Attention – Obtaining & sustaining	• Appeal – How stimulating is the learning?		• Provide optimally-challenging activities.
• Relevance – meet the needs of the learners. • State goals.	• Value - is the learning important? • State goals. • Continuing motivation – use what was learned outside the learning experience.	• Establish the relationship of instruction to learners' lives. • State goals. • Create an understanding that learners will study a topic about which they want to extend their knowledge. • Develop attitude by ensuring personal relevance and choice.	• State goals or allow goals to emerge.
• Confidence – Develop an expectancy for success.	• Use clear examples. • State criteria for evaluation. • Provide performance feedback. • Reduce or remove failure-causing components.	• Establish inclusion of learner with teachers and other students. • Indicate and demonstrate commitment to help students to learn. • Clearly state the rules and procedures of the class/course.	• Provide an optimal level of challenge. • Provide performance feedback.
• Satisfaction – how good do learners feel about their achievements? • Give learners control over reaching goals that are intrinsically motivating.		• Enhance meaning by creating challenging experiences that include learners' values and perspectives.	• Provide control over the learning environment.
			• Use fantasy to help the student experience power, success, fame and fortune. Also help learners relate new learning to a past experience.

Table 2.1: A comparative overview of four motivation models/frameworks (Bixler, 2006)

2.3.5 The concept of flow

As well as the models/ frameworks regarding motivation and learning, the concept of flow must also be taken into consideration. Flow refers to the mental state of operation in which a person is fully immersed by their involvement and success in the process of an activity (Csikszentmihalyi, 1990). If learners give their complete attention to the task they have been given, they may become very focused on the learning environment and be unaware of time passing. Flow may be described as an optimal motivating experience in which the learners are immersed in the learning environment. When concentrating fully on a challenging task, people use relevant physical, mental and emotional skills. Jones (1998) believes that the element of flow could be integrated into educational games. Csikszentmihalyi proposes that, in order to achieve flow, a learner must experience eight criteria, which appear to be easily adapted into computer games education. These are:

a) 'clear goals' which are well defined and establish what needs to be done;

b) 'a merging of action and awareness', referring to an individual's awareness of their own actions but without realizing it;

c) 'direct and immediate feedback' which allows the individual to know whether they have succeeded or not;

d) 'a balance of challenging activity', which refers to the level being neither too easy nor too difficult;

e) 'concentration on the task at hand' is when an individual is thoroughly absorbed in an enjoyable activity, leaving no room for distracting thoughts;

f) ‘a sense of control’, which refers to the ability to be in charge of the situation or activity;

h) ‘a loss of self-consciousness’ is when an individual feels he or she is immersed in the activity;

i) ‘an altered sense of time’, when time seems to pass more quickly.

Not all of these eight features of flow are needed, the most relevant for learning purposes being the definition of clear goals, direct and immediate feedback and a sense of control.

2.4 Learning Styles

Learning styles describe the way in which a person prefers to learn and how they learn most effectively. This includes how they approach and experience learning and how they utilize information (Duckett and Tatarkowski, 2004). Dunn and Dunn (1999) believe that the effectiveness of an individual in the learning process depends on their preferred learning style, which may or may not change over time. Boon and Ragbir (1998), indicate that each individual has their own preferred learning styles which depend both on their personality and on their capability in processing the information that is given to them. Learning styles exist at a very young age and are influenced by a series of factors including cultural background, gender, age, personality and environment.

Keefe (1987) suggests that learning styles are the methods by which learners process and respond to information. He reports on experiments conducted by researchers as far back as 1892 to establish how far memory could be increased. More recently, there has been a significant effort to study

learning differences and abilities in order to improve learning performance. Most learning styles can be categorised as: a) visual learning (achieved by looking at images, mind map demonstrations and body language b) auditory learning (through hearing the spoken word) and c) kinaesthetic learning (by doing and interacting).

a) Visual learning

Visual learners learn most effectively when they are able to view or read information. They prefer information to be presented as text, symbols, charts, diagrams and pictures (Felder & Silverman, 1988).

b) Auditory learning

Auditory learning refers to the learning style of a person who depends on hearing and speaking as a main way of learning (Kostelnik, Soderman & Whiren, 2004). According to Vincent and Ross (2001) auditory learners learn best through hearing in order to understand the information that is communicated to them by using their listening and repeating skills. They suggest that auditory learning should include:

i. making tapes of class notes and listening to them;
ii. remembering details by trying to ‘hear’ previous discussions;
iii. participating in class discussions;
iv. asking questions and volunteering in class;
v. reading assignments aloud.

c) Kinaesthetic learning

Traditional teaching and learning methods represent a process of transferring knowledge from the expert to the novice (e.g. teacher to student) while constructivist pedagogy emphasises learning by doing, learning from experience and also learning through developing problem-solving skills: students must not simply read from a textbook

or listen to a lecture; instead they must engage with the curriculum to enhance their learning capabilities. Bruner (1966) was interested in ‘knowing as doing’ and ‘understanding by doing something other than just taking’. The learner should be encouraged to discover things for him/herself through engagement and interaction.

2.4.1 Factors that influence learning style

Dunn and Dunn (1999) suggest five factors that influence an individual’s learning: emotion, environment, psychology, physiology, and sociology.

a) Emotional factors

This refers to the intrinsic motivation of an individual (their inner motivation, increased by e.g. receiving a compliment when answering a question) or their extrinsic motivation (their outside motivation e.g. receiving a reward when winning a contest). When motivated, the individual will become more determined and make more effort to achieve a goal.

b) Environmental factors

The elements that contribute to the environmental factors include the arrangement of tables and chairs in a classroom, extremes of temperature and the noise level during learning. For example, some learners are accustomed to a noisy environment, while others would find learning uncomfortable if the level of noise is high. Lighting also can be a factor that influences learning: one learner may prefer a really bright environment while another may opt to learn in surroundings with a medium level of brightness.

c) Psychological factors

The psychological factors refer to features such as being impulsive or reflective, being analytic or possessing dominant left or right brain processes. An impulsive or reflective individual usually makes decisions spontaneously and irrationally (Dunn & Dunn, 1999). Analytic individuals approach a given task or problems quite differently. They are usually keen to evaluate and analyse in depth before making a decision. The dominance factor refers to features of the left and the right human brain: the left side of the brain is capable of processing information such as numbers, logic and language, while the right side of the brain is creative and imaginative and able to recognize patterns and colours (Felder & Silverman, 1988).

d) Physiological factors

This involves the time at which learning takes place, movement and eating. The time of learning recognises the time of day when an individual learns the most effectively. Some people may choose to learn earlier in the day because they feel more refreshed, while others may prefer to learn at night when it might be less noisy and more peaceful for them. Movement can also affect an individual's learning ability. For example, a person may wish to move around to avoid boredom when learning, while others may favour the opposite. Another physiological element is the consumption of food and drink. In this case, some individuals are seen to prefer to keep food and drinks next to them while learning (Dunn and Dunn, 1999).

e) Sociological factors

The elements that contribute to the sociological factors include self-learning, learning with one or more colleagues or learning with older people. Self-learning implies that an individual learns most effectively when they are alone in a room or in a library, the reason being that

they do not wish to be disturbed. Learning with colleagues suggests that an individual learns best with their friends or within a group; learning with more than two people may develop into a discussion or brainstorming session. Furthermore, other learners may achieve more with help from older people, such as parents, teachers or a mentor (Dunn & Dunn, 1999).

In conclusion, while learners usually have a preference for their own learning style, there is little research supporting the idea that there are certain categories of learners. For example, a student may prefer not to listen to a lecture if they feel its delivery did not hold their attention; the same student may prefer to learn by listening to a more engaging speaker. It is apparent that individuals have learning preferences, but it can be argued that this is not due to their being a specific type of learner. Without valid evidence, the tendency to label learners may be counter-productive and as a result successful learning could be restricted.

2.4.2 Collaborative learning

Collaborative learning involves participation in a range of instructional activities designed to promote students working together to answer questions, solve problems or create a product (Colbeck et al., 2000). Burfee (1984), quoted by Yamane (1996), defines collaborative learning as:

> *"A form of indirect teaching in which the teacher sets the problem and organizes the students to work it out collaboratively"*
>
> (Burfee, 1984)

According to Schaffert et al (2006), collaborative learning encourages independence and positivity among group members, as well as a sense of individual credibility, face-to-face interaction and an appropriate use of collaborative skills. Collaborative learning enables teams and other groups to achieve higher levels of thought and to retain information for longer periods when compared with students who work individually (Johnson & Johnson, 1986). Collaborative learning also becomes more influential when it takes place in the context of a community of practice in a shared domain (Parker & Chao, 2007).

Among other potential benefits of collaborative learning is the ability of students to apply knowledge in other contexts and to improve their retention of knowledge, especially in collaborative problem-solving which promotes 'deep learning' (Johnston et al, 2000). These researchers go on to claim that collaborative learning also enhances critical thinking and interpersonal skills that the student might not otherwise have developed. A further benefit of collaborative learning is the increased likelihood of students taking risks when they are working with colleagues, as their environment is more supportive and less threatening. Renzulli (2000) believes that group work offers students the opportunity to share valuable feedback and to learn to work together in teams. Students can achieve more through collaborative learning because of the challenge it presents. Many jobs require people to work together, so the experience of collaborative learning at school or university can provide valuable preparation for employment.

However, collaborative learning does cause issues such as a failure to contribute, disagreement among participants, ownership (e.g. who initiated the idea?) and different levels of ability. Moreover, members of collaborative groups can at times feel left out by other group members and as a consequence become de-motivated.

2.5 Summary

This chapter has provided an overview of the literature relating to constructivist teaching and other educational issues that will have a bearing on the design of a game to use constructivism in teaching about the human contribution to climate change. In particular the chapter has been concerned with how motivation to learn affects the ability to learn and also how computer games can enhance motivation. Lastly, this chapter has explained the importance of how collaborative learning can encourage students to work in groups in order to solve problems effectively which will enhance both critical thinking and interpersonal skills. It is thus reasonable to expect games to promote learning at least in some groups. Clearly different games may have different value for different subjects. The next chapter thus looks at how games have been used specifically for teaching subjects related to the sorts of task found in learning about the human effects on global warming.

CHAPTER III

COMPUTER GAMES IMPLEMENTATION OF CONSTRUCTIVISM IN EDUCATION

3.1 Introduction

This chapter discusses the effects of computer games on motivation and learning as well as several limitations on the use of computer games for teaching and learning, including technical restrictions, gender issues and the physical setting, especially in the classroom environment. This chapter also examines and tries to evaluate current examples of computer games available on the market and online.

3.2 Tools for Teaching and Learning

Teaching and learning can be more effective and meaningful with the aid of teaching tools. These tools are used by the teacher in order to assist students to develop more understanding of the topics being studied. The teacher has first to plan in detail how these teaching tools can be used to their maximum potential in assisting the teaching process (Sinayah, 1995). According to Kamaruddin and Ee (1995) and Omardin (1999), several criteria should be met in order to achieve this: tools should be relevant and appropriate to teaching content, facilitate understanding, give spiritual encouragement to learn, attract attention, motivate, and be enjoyable to use.

Omardin (1999) also recommends that teaching tools for classroom use should not be too expensive, and should be easy to obtain, safe to use, save learning time and be suitable for the ability, age, and size of class for whom they are intended. By using tools that combine all these features, the teaching and learning process can be mastered quickly and easily.

3.2.1 Teaching tools

Teaching tools are considered an important aspect of the teaching and learning processes, not only because they help the student to understand more easily and quickly but also because they lead to a creative and effective learning environment. Teaching tools are useful to:

a) reinforce what the teacher is saying;
b) ensure that the teacher's point is understood;
c) signal what is important or essential;
d) enable students to visualize or experience something that is impractical to see or do in real life;
e) engage students' other senses in the learning process;
f) facilitate different learning styles.

Kamaruddin and Ee (1995) explain that use of an appropriate teaching tool can avoid the learning environment becoming boring. Coombs (1995) adds that by selecting and using an accurate teaching tool in a suitable situation critical, analytical and creative thinking is activated and developed, thus making learning itself a challenging, pleasant and valuable experience. There are many teaching tools available to assist teachers in the classroom, including:

a) Paper-based materials, images and graphics

Paper-based materials have long been used for teaching and learning purposes. Some of these are:

i. Textbooks

Textbooks are usually used as the main reference for gaining information and facts (Omardin, 1999) and can be used repeatedly (Pierce & Lorber, 1977). Nevertheless, teachers should always ensure the content of the book covers the syllabus and is suitable for use by their students, by modifying, changing, eliminating or adding to the material in the textbook.

ii. Notes and white/blackboards

Notes provided by teachers are usually an extra source of information and facts regarding specific topics not covered in books; they help to explain the topic more easily and effectively (Coombs, 1995).

One advantage of using a white/blackboard as a teaching tool is that no advanced preparation is required. Moreover, the tool is not affected by electrical faults or other possible malfunctions and can be used by students, for instance, for problem solving. However, the use of white/blackboards has drawbacks: it is time consuming if the teacher has a lot to write; handwriting may be difficult to read because of its size or there may be glare from the board; the board needs to be cleaned, incurring problems with chalk dust or permanent markers; and the teacher turns their back on their audience.

iii. Worksheets and puzzles

Rault (2008) suggests that some students are enthusiastic about worksheets and puzzles because it gives them the opportunity to think deeply without being graded. Worksheets and puzzles are also an excellent way of encouraging group problem-solving; further, they are effective when there is a low student-teacher ratio.

iv. Images

Images are used to illustrate further description and convey information; they can make a deep impression on a student's perceptions (Omarudin, 1999). Colourful images can magnetize and stimulate attention (Pierce & Lorber, 1977).

v. Charts

Charts, typically flip charts and pocket card charts, are normally used to explain abstract or chronological facts or ideas. Flip charts explain continuous ideas and events and usually consist of a set of large papers clipped together so that pages are light and easy to turn. Their use enables students to illustrate group reports; they can be used if electricity is unavailable; and they can provide a written record of points made by students.

Pocket Card Charts consist of more than one piece of pocket-sized card containing pictures or words, making them valuable as prompts to memory (Rabiatul & Leela, 1992).

vi. Maps, atlases and graphs

These types of paper-based material explain the position and condition of a country, describing, for instance, its climate, terrain and sovereignty (Pierce and Lorber, 1977). This teaching tool is

more suitable for delivering subjects such as Geography, Social Science and History.

vii. Tables

Tables usually consist of figures, numbers and other data: for example, they can illustrate the population of a particular country or the amount of income in a specific sector (Pierce and Lorber, 1977). Tables can give a clear and meaningful overview and be easy to interpret.

b) Projection materials

Two types of projection materials are used most often by teachers, both of which require a low light environment:

i. Overhead projectors

An overhead projector is typically a large box containing a very bright lamp and a fan for cooling (Crystal, 2003). Students take notes on what they consider to be important content from the projection (Pierce & Lorber, 1977). Advantages of using overhead projectors include allowing the teachers to prepare all the slides in advance; building information point-by-point through the use of overlays (particularly suitable for complex diagrams, charts and illustrations); and teachers can face their audience. Even so, a blown bulb or power failure can spoil careful preparation; other disadvantages include poor quality images which can be difficult for an audience to discern; further, it may be disorientating to manipulate transparencies on the projector plate.

Overhead projectors were once a common fixture in most classrooms, but today they are gradually being replaced by more

advanced technology such as interactive whiteboards and computer projection systems. These new technologies allow the teacher to give animated and interactive presentations with movement and video, using software such as Microsoft PowerPoint.

ii. Slide projectors

A slide projector is used to view photographic slides, usually projecting the photographs in sequence to explain an event. These slides can be stored easily and are attractive to students because they appear more realistic than printed photographs (Pierce & Lorber, 1977).

c) Listening materials

Examples of listening materials include radios, audio tapes and compact discs.

i. Radios

Since the 1920s, radios have been widely used as an educational tool. Radio broadcasts can be either live or consist of daily 'ready-made 20-30 minute' direct teaching and learning exercises in the classroom (Tinio, 2003). These radio lessons are developed to follow specific learning objectives in particular subjects such as maths, science, health and languages. They are often accompanied by printed materials.

ii. Audio tapes / Compact Disc (CD)

Audio tapes or CDs are more suited to subjects that involve literacy, such as language learning, media studies and English literature. Audio tapes also can be used as background music

before the start of class and during group activities. As with radio broadcasts, printed materials are usually provided for use alongside audio tapes or CDs.

d) Audio-visual materials

Films, television and videos are examples of audio-visual materials, adding a dimension which is not available through audio alone by helping students to visualize. This is especially essential when seeking to illustrate actions or events that are impractical to enact in real life.

e) Computer-based materials

These include the Internet, multimedia applications and animations that combine text, sound and colourful and moving images, and can be used to introduce challenge and authentic content that seeks to engage the student in the learning process. Computer-based materials can be a powerful tool for teachers in supporting teaching and learning experiences (Tinio, 2003). For example, the Internet and the World Wide Web (WWW) provide a wealth of learning materials in many diverse subjects using a wide variety of media types, and which can now be accessed from most of location by an unlimited number of people. One of the most significant features of computer-based technologies as a learning tool is that they are not only easy to obtain and use but also relatively cheap and present a vast number of information resources.

f) Computer game-based materials

In recent years, there has been a rapid increase in the volume of studies that claim the usage of computer games-based materials as a teaching and learning tool were proved to be positive. It was claimed that the use of such games can stimulate the enjoyment, motivation and engagement of users, aiding recall and information retrieval and also encouraging the development of various social and cognitive skills. Computer game-based tools can provide rich visual and aesthetic content which can be valuable for modern teaching and learning.

3.3 Overcoming Blockages to Learning

At times, individuals, for one or more reasons, experience a block to their ability to learn. Prensky (2006) identifies five levels of learning by doing, elaborated in Table 3.1, which he claims will aid in unblocking students ability to learn:

Level of Learning	***Descriptions***
How….?	How to do something
What….?	What to do (and what not to do)
Why….?	Includes cause and effect (long term achievement vs. short term goal, using obstacles as motivation, second order consequences)
Where…?	Encompasses the vast amount of cultural and environmental learning that is integrated into video and computer games
Whether…	Players learn to make value-based and moral decisions about whether doing something is right or wrong

Table 3.1: Prensky's five levels of learning (Prensky, 2006)

Gee (2003) insists that words, symbols, images and artefacts have meanings that are specific to a particular situation (context). He argues that video games can provide a learning environment that is set up to encourage active and critical, not passive, learning. He later asserts (2004) that an effective game can provide a context within which the player can make sense of how they will participate. Gee believes that active critical learning is based on experiencing (seeing, feeling and operating on) the world in new ways. He offers the following guidelines (2005) for providing students with a context for learning:

a) Give people well-designed visual and embodied experiences of a domain, through simulations or in reality (or both).

b) Help them use these experiences to build simulations imaginatively which they can think about and use to test out future actions and hypotheses.

c) Let them act and experience consequences, but in a protected way as learners.

d) Then help them to evaluate their actions and the consequences of these (based on the values and identities they have adopted as participants in the domain) in ways that lead them to build better simulations for better future action.

Although these guidelines could serve as a scheme for the intensive teaching of a subject such as Geography, they also offer opportunities for devising engaging and enjoyable games. It should be the same in schools. Shaffer asserts (2004) that new technologies make it easier for students to learn about the world by participating in meaningful activity. He also later explains (2006) that video games on computers can change education by enabling people to participate on a far wider scale in simulated real-life out-of-school

events. Schafer states that 'with video games students can learn by doing rather than learning first and doing later'.

3.4 Genre of Computer Games

Before the game is developed it is necessary to establish what genre would be suitable for the specific purpose. According to Rollings and Adams (2003), the computer games genre can be divided into eight main categories as shown in Table 3.2:

No.	***Genre of Computer Games***	***Characteristics***
1.	Action Games	Reaction-time and hand-eye coordination under pressure
2.	Strategy Games	Feature a core management mechanics
3.	Role-Playing Games	Configurable player-characters that improve with experience Strong storylines
4.	Sports Games	Simulate real sports game or non-real sports game
5.	Vehicle simulation	Try to create the feeling of driving/flying a vehicle, real or imaginary
6.	Construction and Management Simulation	A game involving on-going processes
7.	Adventure Games	Involves exploration, collection, puzzle solving, action
8.	Artificial Life, Puzzle Games	Often simulate the life cycles of living things Puzzle solving

Table 3.2: Genre of computer games and its characteristics (Rollings & Adams, 2003)

From this table it can be seen that a combination of the strategy game scenario and construction and management simulation would be particularly suitable. In games like SimCity a player has the opportunity to develop a strategy to manage the construction of a city. The game mechanic requires the player to analyse needs identified by the game and select the most appropriate response. Teachers who are using SimCity in their class found that constant feedback on particular matters can be immersive and stimulate players in the

game environment. Managing a scenario in SimCity gives players a degree of control over how fast they take on new challenges, but also gives an actively responsive system to keep players engaged. This is a valuable and natural way to introduce complexity to the players.

3.5 Current Research in Development Methodology of Educational Games

According to Smith and Ragan (2005), Instructional Design (ID) is a systematic and reflective process of interpreting principles of learning and instruction in order to create plans for instructional materials, activities, information resources and evaluation. Instructional designers need to be able to analyze, plan, implement and evaluate for ID to be successful.

Referring to game development methodology, Thompson et al. (2007) explain that the digital games development process consists of new game proposals, multiple ideas, concept selection, game development, game testing and game launching. On the other hand, Co (2006) states that the digital games development process consists of pre-production, document design, prototype/demo, production, alpha testing, beta testing, final candidate and the final version release.

Currently, there are only a few studies on methodology development for educational games. Simulation Games-Instructional Systems Design (SG-ISD) is a model proposed by Kirkley et al. (2005) which supports the integration between the development process of Instructional Systems and game development. The phases of SG-ISD consist of analysis, concept, design and quality assurance. They have studied the Analysis, Design, Development, Implementation and Evaluation (ADDIE) model, the spiral design approach, user-centred instructional design and the Waterfall development model for a

game. There are no other details given after the design and quality assurance phase.

According to Han and Zhang (2008), Quasi Game-Based Learning (Quasi-GBL) is an instructional method which integrates game elements with role play in collaborative learning for the undergraduate course ‘Software Engineering’. In Quasi-GBL, seven basic elements, including goal, rule, competition, challenge, fantasy, safety and entertainment, are embedded into role-play and manifest themselves in the form of real problems, individual tasks and group collaboration, scores, puzzles, awards and replays. However, the usage of Quasi-GBL processes is quite confusing, and the activities or steps involved in all phases are not well explained.

Ho et al. (2006) have studied the games-based e-learning design and development of Virtual Filial Piety Legend which consists of an ‘analysis phase’ (learning goal and learner analysis), a ‘development phase’ (deciding the learner’s role and situation, demonstrations of problem models) and a ‘creative phase’ (problem analysis and selection as well as evaluations). However, they do not explain the methodology of the game development process.

Flanagan and Nissenbaum (2007) have studied a methodological framework entitled Value at Play (VAP) which was developed to promote values integration into the design process through the creation of a toolkit. The VAP framework has been further developed through work with ‘Rapunsel’, a dance game to teach girls about programming. The VAP approach comprises three ‘constitutive’ and ‘iterative’ activities named ‘discovery’, ‘translation’ and ‘verification’. On the other hand, this methodology does not explain the instructional principles for the game design methodology.

Hays (2005) proposes a systematic approach for instructional game design, involving three main parts: ‘understanding the instructional environment’ (develop problem statement and instructional objectives and select game strategy); ‘develop the game’ (develop game model and role of students in game and develop rules, events and winning criteria); and ‘implement and evaluate the game’ (develop supporting game resources, evaluate game compared with alternative instructions and modify game based on results of evaluation). The weakness in this approach is that the methodology is simply a linear path; there is no iterative process to deal with problems which occur during any of the steps.

The principles of successful game design and learning have been studied by Rothschild (2008). Instructional and game design results are merged in the JUMP Into Reading for Meaning (JUMP) game. Content specialists have created and organized the instructional content to support the program requirement, while specialists in game and instructional design have integrated the content into a game design that uses the key game characteristics of fantasy, rules and goals, sensory stimulus, challenge, genre and form mystery, and control and mystery.

An outline of the development process for GeoEmission, based on these current research studies in development methodology for educational games, is discussed in Chapter 5.

3.6 How Can Computer Games Be Engaging?

Becta (2001) indicates that computer games use technology to represent reality or to embody fantasy and can be seductive with their rich visual and spatial aesthetics. Winning is the key motivation during game play and motivation is a part of the natural learning process in human development (Bisson & Luckner, 1996).

Prensky (2001) also suggests that ambience information creates an immersive experience which can maintain interest in the game. He has identified a combination of twelve elements that make computer games engaging, as shown in Table 3.3:

Characteristics of Computer Games	***How characteristics contribute to players' engagement***
Fun	Enjoyment and Pleasure
Play	Intense and Passionate involvement
Rules	Structure
Goals	Motivation
Interaction	Doing (i.e. Activities)
Outcome and Feedback	Learning
Adaptive	Flow
Winning	Ego Gratification
Conflict/competition/challenge/opposition	Adrenaline
Problem solving	Sparks creativity
Interaction	Social groups
Representation and Stories	Emotion

Table 3.3: Elements that make computer games engaging (Prensky, 2001)

3.7 Computer Games Studies: Effects on Motivation

Motivation is one of the key elements in most learning theories. According to Pintrich and Schunk (1996), there are two elements of motivation: active goal pursuit and sustained goal pursuit. Further, it is suggested that motivation can be viewed from two other perspectives, intrinsic and extrinsic (Deci et al., 1991).

As mentioned in Chapter 2, intrinsic motivation is a response to needs that exist within the student such as curiosity and feelings of competence or

growth. Intrinsic motivation is connected with the behaviours that are performed for internal reasons (inner rewards) such as self-joy and self-satisfaction (Byrne, 1999; Spaulding, 1992). When intrinsically motivated, students find a subject interesting and will want to be engaged in the learning activities. Intrinsic learners will relentlessly seek challenges even when faced with difficulty; this is called an ‘adaptive motivational pattern’ (Dweck, 1986).

Extrinsic motivation refers to behaviours that are performed for external reasons (such as for rewards) for the task (Spaulding, 1992). For example, a child is extrinsically motivated to do his homework when promised a trip to the park with his father. In an academic context, a student is extrinsically motivated to study hard in order to achieve a high score in the examination. This shows that rewards will be received after completing certain tasks.

A study conducted by Dempsey, Haynes, Lucassen and Casey (2002) has discovered that certain motivational features are more meaningful than others. They have found that players strongly prefer challenging games that provide clear instructions, help functions and other user control settings such as difficulty, speed and timing.

Amory, Naicker, Vincent and Adams (1999) carried out research into the effectiveness of using a computer game called Zadarh as an instructional tool. Zadarh is a 3D-adventure game designed by Alan Amory, a lecturer in Biology. Among other questions, students were asked about their motivation in playing the game, and ‘curiosity’ and ‘interest in topic’ were reported as the strongest reasons (Amory et al, 1999). They found that the majority of students who played the game were intrinsically motivated to take part.

Clearly, both intrinsic and extrinsic processes are necessary for academic achievement (Ryan, Connell, & Deci, 1985). It is also evident that ‘fun’, ‘challenge’ and ‘fantasy’ elements appear to be the main motivators explaining

why students enjoy educational games. However, elements such as clear instructions, help functions and other settings also play a part in helping students to perform well in the game. Moreover, a good storyline can also increase motivation to sustain interest in the game, when players are curious to know what would happen if they completed further tasks or the next level in the game.

3.8 Computer Games Studies: Effects on Learning

Games were used for instructional purposes as far back as 3000 B.C. (Dempsey et al., 1996). Using games for instructional purposes potentially produces a variety of learning benefits. Research has shown that diverse types of games have improved student performance in many academic areas, in developing general reasoning and logic and by increasing learner motivation (Leemkuill, De Jong & Ootes, 2000).

3.8.1 Learning through content-driven didactic games

Traditionally, a ‘content-driven didactic’ game is a straightforward scenario whereby the game’s goals for ‘winning’ must match the learning goals. For example, if the learning outcome is to teach the student the basic mathematics of division, the student must then apply his/her knowledge of division to defeat the enemy. ‘Content-driven didactic’ games offer the player the opportunity to practise, increasing their concentration on the task and also encouraging motivation. Chambers and Sprecher (1983) and Steinberg (1990) state that ‘content-driven didactic’ games can enhance an individual’s lower level skills.

Klein and Freitag (1996) conducted a study to determine the effect of an instructional game on motivation and performance. The two treatment groups in this study consisted of seventy-five undergraduates. One group played an instructional board game to practise material presented in the previous lecture. The second group practised the material using a traditional worksheet. The results indicate that playing a relevant instructional game significantly increases students' motivation in terms of gaining their attention and instilling confidence and satisfaction.

White (1984) studied the effectiveness of a computer micro-world that incorporated game-like activities, 'ThinkerTools', to facilitate sixth graders in developing a conceptual model of the principles underlying Newtonian mechanics. The results demonstrated that the 'ThinkerTools' curriculum was equally effective for both males and females and that the sixth graders in the study were more successful in solving a set of classic force and motion problems than the high school students who were taught using traditional methods.

Another study carried out by Koran and McLaughlin (1990) compared the effectiveness of a maths drill and practice activity with that of a maths instructional game. The study consisted of two groups of twenty-eight fifth grade students where one group played an instructional board game practicing multiplication while the other used a traditional worksheet. The outcome of the study indicated the difference between the drill group and the game group was not significant, both groups performing well on both occasions.

Miller, Lehman and Koedinger (1999) used the Electric Field Hockey (EFH) to study the effects on learning through the use of a micro-world that uses game oriented strategies. The objective of the game is to score goals by propelling the puck into the goal. The catch of the game is that the puck has a positive charge and is influenced by other charges (both positive and negative)

that need to be placed onto the playing surface. Performance is enhanced by knowledge of Coulomb's Law and 'electric fields'. The study involved three groups of students; results show that the group that was told to first explore the micro-world and also the group that was shown the correct path of the particle both performed better than the third group of students who simply began playing the game activities without any prompts. It can therefore be concluded that the entertaining games aspect can be motivating but should be supported with teacher monitoring, guidance and assessment of the learning outcome.

Lepper and Malone (1987) discovered that when the game activity and the learning activity are harmonious, learning will improve. On the other hand, when the game activity and the learning activity are mutually exclusive, learning will not improve even though the learner may perform well in the game. Lepper and Cordova (1992), Lepper and Hodell (1989), and Parker and Lepper (1992), have all indicated that when games appeal to students their intrinsic motivation will rise, leading to an increase in learning. Lepper and Cordova found that both boys and girls who learned from a fantasy programme showed greater learning when they were able to choose the game they most preferred than when they were assigned a game randomly.

It is concluded that content driven didactic games provide a good opportunity for learners, especially for increasing their motivation to learn; nevertheless, the game must be carefully monitored and guided by the teachers or instructors. It is also recommended that the game's full potential can be realized when both game activity and learning activity are integrated harmoniously.

3.8.2 Learning through business / training simulations and recreational games.

Thatcher (1990) asserts that the learning environment in business/training simulation and recreational games is different from that of 'content-driven didactic' games. It provides a greater gaming and learning experience, including strategies for improving management, diagnosis and problem-solving. Gredler (2003) also argues that business/training simulations can aid teamwork learning and demonstrate how to effectively plan, execute and monitor solutions to a problem. This shows that the skills and knowledge required for such games would not fit easily into the content driven didactic game types because the latter rely on practice; this is not the case for business/training simulation and recreational games.

Laveault and Corbeil (1990), have investigated how students learned when playing a history-based game which relied more on creating a gaming and learning experience. Their study involved college students who were divided into nine teams, each team representing one of the great political powers at the beginning of the 20th century. The teams participated in a history-based game that had five different scenarios. It was observed that the students gained valuable knowledge and experience throughout the game.

A series of sixty-eight studies of educational simulation-games from the years 1963-1991 was carried out by Randel, Morris, Wetzel and Whitehill (1992). They evaluated the effectiveness of simulation games on student performance compared with that of conventional instruction. They reported that thirty-six studies (56%) found no difference, twenty-two (32%) found preference for simulation/games, five (7%) preferred simulation games, three (5%) preferred conventional instruction. Additionally twelve out of fourteen studies measuring the motivational effects of simulation games revealed preferences for these rather than for conventional games.

An evaluation of student knowledge completed by Henderson, Klemes and Eshet (2000), identified increased awareness of scientific concepts gained from a simulation named "*Message in a Fossil*" (MIF). MIF is a microworld simulation in which the student imitates a palaeontologist who excavates virtual dig sites, discovering plant and animal fossils. In this interactive environment, the student exploits scientific method and thinking skills. The results obtained from this study demonstrated an overall improvement by students of 24% between pre- and post-tests: the teachers who were involved reported that "low achieving students" gained an average increase of 42% while "high achieving students" demonstrated an average improvement of 14%.

Reiber, Smith and Noah (1998) describe how a high school teacher used the 'SimCity' game in his economics lessons. The teacher stated that the students were very excited about building their city. The course objective required the student to create plans for a virtual city and its transport and services, indicating that computer games can offer the possibility of constructing a new learning environment that integrates motivation, regulated learning and the principle of constructive philosophy of instruction.

To summarize, computer games, simulations and other experimental methods of instruction have an impact on the effectiveness of teaching and learning. There are many tools for learning nowadays, especially for pedagogical purposes. Given suitable tools and facilities, people will learn by these methods as well as by more traditional approaches. Jayakanthan (2002), observes that pedagogical knowledge of a subject not only focuses on content but also on its presentation in a form that will reach the learner in an effective and entertaining way without any 'noise' creeping in the communication and without vital information getting lost. The computer game is seen as a platform in delivering that knowledge.

3.9 Global Warming Games On and Off the Shelves

A global warming or a climate change game is a type of serious game in that it attempts to simulate and explore real-life scenarios in order to educate players through an interactive experience. There are a number of games available on this subject both on the market and also through the internet. The basic storylines usually concern energy efficiency and the implementation of 'green technology' as a method of reducing greenhouse gas emissions.

3.9.1 Objectives of global warming games

The objectives of most global warming games are 1) to develop the player's familiarity with the related issues of global warming 2) to make the player aware of the challenges and problems that arise when addressing global warming and 3) at times, to encourage players to develop ideas and solutions for global warming issues.

The first objective focuses mainly on the issues surrounding global warming, which commonly include emissions of CO2 and other greenhouse gases, natural disasters, the melting of the polar ice caps, the rise in sea levels and the ensuing dramatic changes to lifestyles.

The challenges of confronting global warming are addressed by the second objective. For example, the difficulty in seeking international cooperation is explored - players represent different countries and have to conduct negotiations in order to fulfil the game objectives. The game may include navigating challenges involving interrelated problems such as building 'green factories', a more expensive project compared with the construction of heavily polluting factories.

The last objective usually gives players the freedom to create their own options to integrate into their strategy while playing the game. Players are offered a variety of options so that they may arrive at a number of different creative solutions. Developing solutions to global warming includes two major types of response: 1) mitigation of emissions and global warming effects and 2) adaptation to live sustainably in a new climate.

3.9.2 Examples of global warming games

There are several notable examples of global warming games that are currently available in the market.

a) LogiCity

LogiCity, produced by Logicom and the National Energy Foundation (a UK charitable organisation), is a 3D virtual city in an interactive Flash-based virtual reality-based computer game, as illustrated in Figures 3.1 and 3.2. The game is part of the Climate Change programme introduced by DEFRA (Department for Environment, Food and Rural Affairs) to increase public awareness of climate change across the UK country. LogiCity is considered suitable for most children from the ages of 10 or 11 upwards (English KS3+), although it is targeted at young adults aged between 16-26 years. The game involves five main activities in which players are set the task of reducing the carbon footprint of an average resident. These five activities include:

i. finding and selecting energy efficient and renewable energy options in a home, but within a strictly limited budget;

ii. taking part in a role play to select the best travel options for three generations of a family;

iii. a race against time switching off equipment left on by careless users in a virtual reality home;

iv. choosing a holiday from a virtual travel agent, but with the risk that climate change may have led to unexpected changes at the destination;

v. taking part in a quiz about features they have to find in a low energy building.

Figure 3.1: Main menu screen in LogiCity

Figure 3.2: Game-play screen in LogiCity

As players negotiate their way through the game by attempting to reduce their carbon footprint, they are taken forward to the year 2066 to see whether they have taken adequate steps to save England from the worst problems relating to global climate change. The game attempts to focus on the impact on the players' actions throughout their virtual lifetime. The game can be played online or distributed across a network from a CD-ROM; there are no licensing implications as it has been publicly funded, although players might have to download additional software plug-ins such as a VRML viewer and a recent version of Flash player.

The game has received criticism because it applies only to the UK, due to limitations imposed by its funders, so it is unlikely to appeal widely in North America or other parts of the world. Furthermore, the computer hardware specification needs a high-end capability to run LogiCity, otherwise the game would become sluggish and deter players. Some users have commented that download times for each module can take up to a minute, and Firefox users are unable to run

the game unless they switch to Internet Explorer; this, however, can be overcome by using the CD-ROM.

b) Climate Challenge

Climate Challenge is an environmental serious game produced by the BBC (British Broadcasting Corporation) and developed by Red Redemption. It is another Flash-based global warming game, designed to develop players' understanding of the science behind climate change as well as the options available to policy makers and the difficulties in implementing these. The main objectives of Climate Challenge are to manage the economy and resources of the 'European Nations' as its president, while reducing Co2 emissions and managing crises, as illustrated in Figures 3.3 and 3.4.

The game uses 'policy cards' depicting the strategies, which are separated into five categories: national, trade, industry, local and household. The game starts in the year 1990 and ends in 2100, and is divided into turns for every ten years. At every turn players may choose up to six 'policies' to implement.

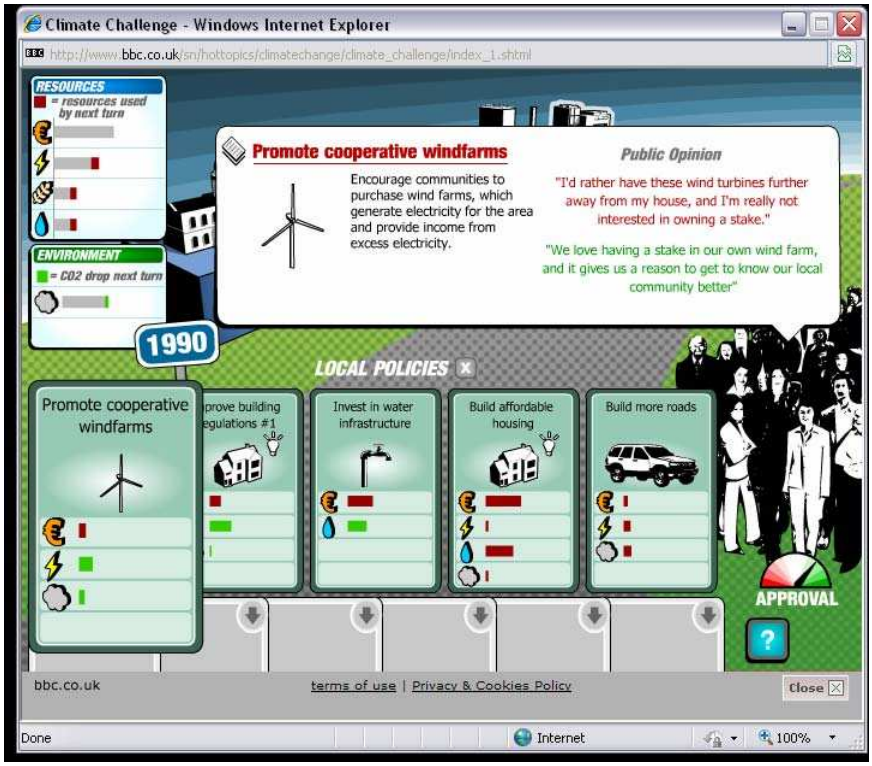


Figure 3.3: Game-play screen in Climate Challenge

Figure 3.4: Negotiation scenario screen in Climate Challenge

The game has four resources: money, power, food and water. Each turn, depicted by a red section on the grey bar, shows the estimated amount by which the resources will be reduced, while the green section shows the estimated growth. These bars adjust themselves to the selected policies as they become affected. Most policy cards deplete or grow different resources, and if any of the resource bars are reduced to zero or are entirely 'in the red', policy cards require that resource to become unavailable. When a resource is exhausted by the end of the turn, players must manage a corresponding disaster in the following turn.

The game has come under heavy criticism because its mechanism to measure wealth, or the health of the economy, is faulty and unrealistic. The developers have explained that the game was intended to incorporate a different system for measuring the health of the economy; however, they experienced deadlines which prevented the final version from including the more accurate system (Andi, 2010).

c) Stabilization Wedge (board game)

The Stabilization Wedge game is a team-based exercise produced by the Carbon Mitigation Initiative at Princeton University, depicted in Figures 3.5 and 3.6. It is hoped to demonstrate through this game that global warming is a problem which can be solved by implementing current technologies to reduce CO2 emissions (Hotinski, 2007). The objective of the game is to keep the next fifty years of CO2 emissions stable, by using seven wedges from a variety of different strategies which fit into the stabilization triangle.

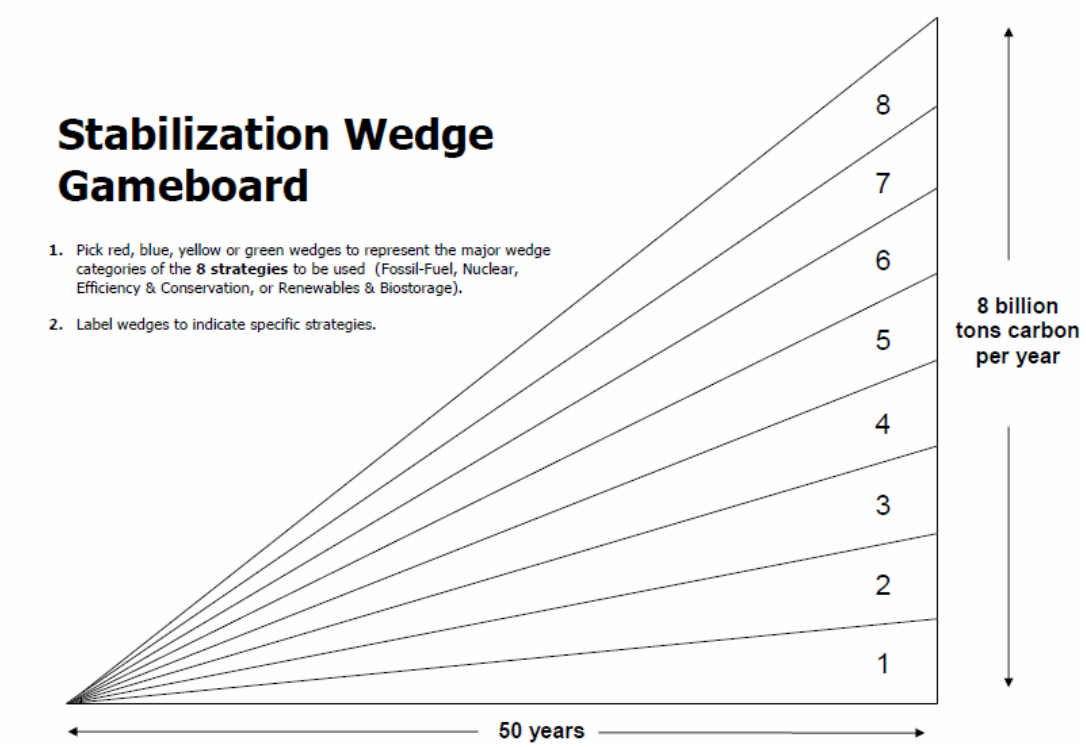


Figure 3.5: Game board concept for Stabilization Wedge

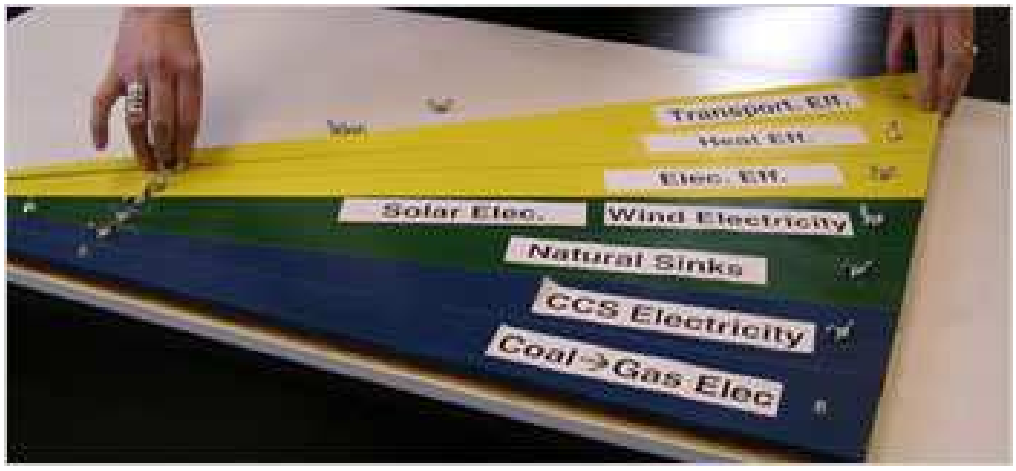


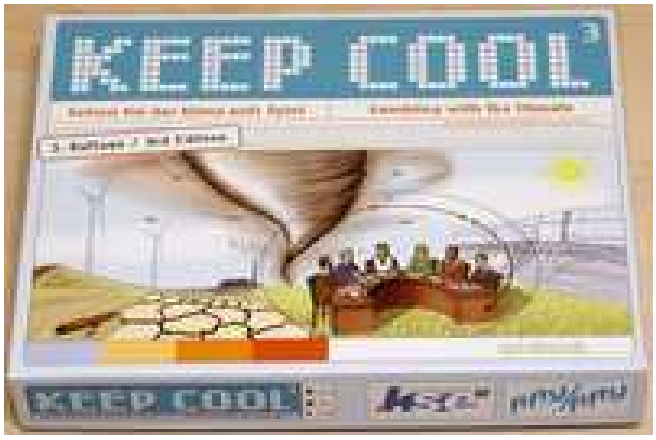
Figure 3.6: Game board implementation for Stabilization Wedge

The main criticism of the Stabilization Wedge game is that it is too simplistic, especially regarding the economic aspect of global warming mitigation, and that this lack of economic precision in the game could create misconceptions. Another criticism is that the Wedge game

focuses on technological solutions rather than on the fundamental challenge presented by the endless growth economy which is at the heart of global climate change.

d) Keep Cool (board game)

The Keep Cool global warming board game (as shown in Figure 3.7) was created by Klaus Eisenack and Gerhard Petschel-Held of the Potsdam Institute for Climate Impact Research. It was published by the German company Spieltrieb in 2004. The game can consist of up to six players who represent the world's countries, competing to balance their economic interests while at the same time negotiating the world's climate. The objective of Keep Cool is to promote general understanding of climate change, the difficulties involved and the obstacles to be overcome.



3.7: Keep Cool board game.

The Keep Cool game-play involves players choosing a country they want to represent, each country having a distinct starting position and special abilities. For example, the United States begins the game with the most factories on the board (five black and one green) while Europe starts with three black factories and one green. At each turn, a player must draw a greenhouse card – this is a random generator of a

disaster which affects a particular region (e.g. a malaria pandemic in China, a rise in sea-level or a severely cold winter in Europe).

The black and green factories do not correspond to any real-life factories, rather they are symbolic of different types of energy generation. Black factories represent power energy from non-renewable energy resources such as fossil fuels (e.g. oil and coal) while green factories depict renewable ‘green-energy’ resources such as the sun, wind and biomass.

e) V GAS

V GAS is a serious game in a 3D computer environment where the players explore and live in a house built to mirror their own house. Most other global warming games focus on the energy efficiency of industries, but the V GAS game explores the attitude of the average person towards scenarios in their own household. At the beginning of the game, a player is required to build their profile, which includes variables such as water use and transportation behaviour, heating and cooling practices, food purchases and electrical appliance usage. Once the player has built a profile, they can begin the simulation, whereby they navigate through different rooms in the house. Each room corresponds to a set of variables which affect the amount of greenhouse gases produced in the user’s account. For example, in the bedroom, the user inputs the lighting settings, including the number and type of light bulbs and the heating and cooling systems, while the living room consists of settings for home appliances such as the television.

Figure 3.8: 3D concept of V GAS game

The game records each action the player chooses (e.g. in the kitchen, the player inputs information for major appliances such as those needed for cooking or laundry), then computes possible outcomes that would contribute towards global warming.

f) Climate-Poker

The Climate-Poker game as shown in Figures 3.9 and 3.10 is a card game with players taking turns. The game comprises sixty country cards, each with three icons depicting the country's level of CO2 emissions, the deaths per 100,000 inhabitants and the percentage loss of Gross National Product (GNP).

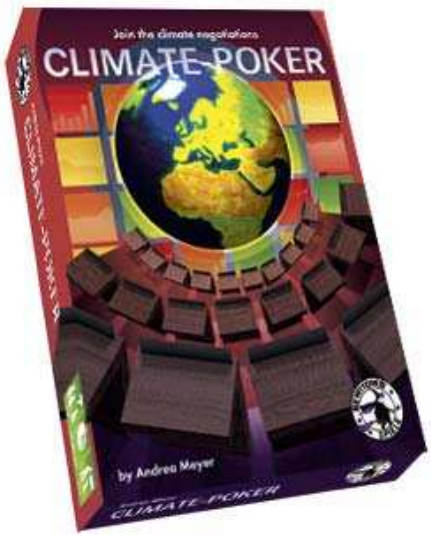


Figure 3.9: Climate-Poker game board

Figure 3.10: Climate-Poker country cards

At the beginning, players have a hand of country cards, each player representing a different country at a climate conference. The starting player on a turn plays a country card face-down and names the category to be compared. The other players follow in turn, and whoever plays the best-ranking country keeps one of the cards played by an opponent, with the rest of the cards being added to that player's discard pile.

In terms of the theme, the countries come to an agreement on an environmental policy, at which point the two worst-ranking countries (i.e. the ones likely to be hardest hit by the agreement) withdraw and return to the bargaining table.

g) Internet flash-based global warming games

i. Starbuck's Planet Green

The Planet Green game as shown in Figure 3.11 is a fact-filled, flash-based multimedia experience that contains information regarding global warming issues. The objective of the game is to make home, transportation and town greener by correctly answering quiz questions, matching identical items or clicking on specific objects.

However, since its introduction, the game, which incorporates a simple representation of facts about conservation and climate change has ultimately been outplayed by mini games and PowerPoint presentations. It could be suggested that Starbucks introduced this game as part of their overall eco-friendly branding policy in an attempt to raise customer awareness on such issues and to improve the company's image.

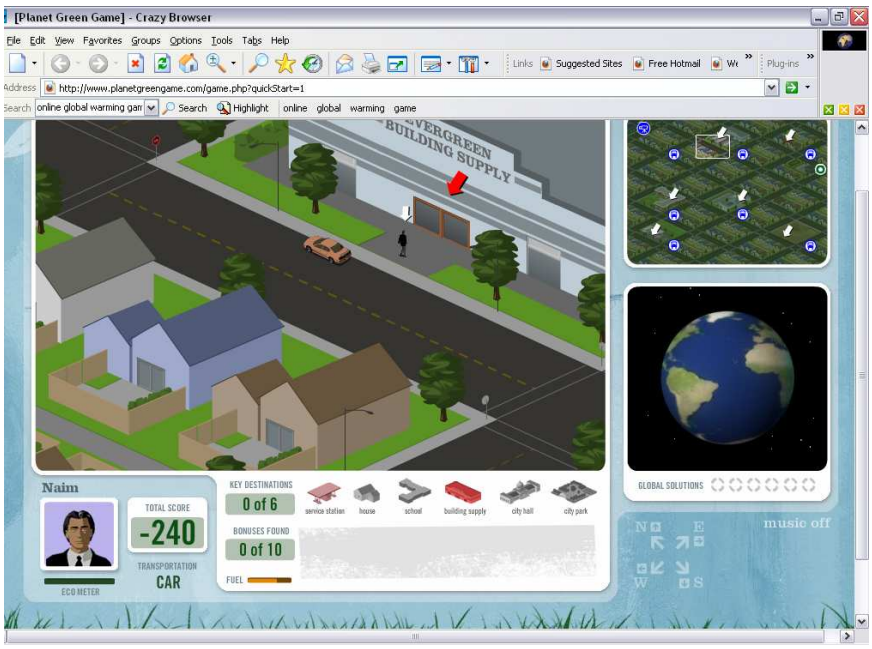


Figure 3.11: Starbuck's Planet Green game-play screen

ii. Eco-ego

Eco-ego game is another example of a flash-based global warming game which focuses on households and their natural ecological surroundings, illustrated in Figure 3.12. Its attractive graphics would appeal to most viewers.

The condition of the game's surroundings is influenced by the positive and negative outcomes of a player's actions: the red and the green meters indicate the player's progress during the game. Each game-play lasts for six minutes, at the end of which the player's actions are computed to give an overall result (shown in Figure 3.13). The game claims to reward the player with smart, eco-friendly choices such as turning off household lights, properly regulating the thermostat, opting for alternative modes of transportation, eating healthily and re-cycling shopping bags.

Figure 3.12: Flash-based Eco-ego game-play screen

Figure 3.13: Flash-based Eco-ego end game conclusion

The trick in winning this game is to remain outside the house, thus removing the need to turn on any electrical equipment. However, this can be considered an illogical move, and indeed has raised

some alarm because most web games do not reflect real-life scenarios.

3.10 Computer-Supported Collaborative Learning

Developments in Information and Communication Technology (ICT) offer possibilities for collaborative learning, such as the Computer-Supported Collaborative Learning (CSCL) initiative which is capable of improving teaching and learning. Stahl, Koschmann and Suthers (2006) define CSCL as a method enabling people to learn together with the aid of computers. It proposes the development of new software and applications that bring learners together and offers creative activities for intellectual exploration and social interaction.

Previous literature has revealed that use of collaborative techniques with technology can increase high level thinking skills, social interactions, critical reflective capabilities and creativity (Lehtinen, Hakkarainen, Lipponen, Rahikainen & Muukkonen, 2003; Smith, 2003; Warschauer, 1997). Introducing a computer environment to collaborative learning can also improve the quality and extent of social interaction both among learners and between educators and learners, as these tools make the sequence of interacting events more visible for participants, creating greater possibilities for mutual understanding. Kreijins & Kirschner (2002) have reported that it is possible to create interactive processes in which learners deliberately construct new knowledge on an inter-subjective or social level, aided by technology.

3.11 Game Interface Design

Fox (2005) defines a game interface as the connection between the user and the game. Interaction distinguishes a game from a movie, a criterion which enables the user to make choices and respond to events. Similarly, Murdock (2005) states that a user interface defines the user's interaction with the game. She also asserts that games with a well-designed interface can succeed even if other aspects of the game are unsatisfactory, while games with high quality content can fail if the interface design is poor. Commonly, a successful game will be visually appealing and artistically inspired (Krieger, 2001). Krieger believes that a game with a well-designed interface will be easy to learn, fun to use and stand up well during the game, while a poorly designed interface will lead to frustration, and thus likely discourage players from continuing with the game. Fox (2005) concurs by commenting that a well-designed interface makes the experience of the game more enjoyable. He later claims that insufficient time is scheduled for interface design because managers give little credit to the skills involved.

3.11.1 Colours

Murdock (2005) also believes that colours are an important element of design. She emphasises that the colours used should match the feel of the game (e.g. light and bright for children's games; dark and subtle for more ominous aggressive type of games). Fox (2005) states that colours are often linked to the expression of emotions and can set an atmosphere. For example, a design that uses a predominance of neutral grey and de-saturated colours can create a sad feeling, while bright yellows and blues are often associated with cheerful scenarios. He also claims that colours can be used to highlight important objects to make them stand out. Even a simple use of colour can

attract attention, as illustrated in Figure 3.14, in which a white outline is used to focus attention first on the title and then on the highlighted button.

Figure 3.14: Colours can attract attention.

Omernick (2004) has also stated that colours play a powerful role in defining mood in a scene. However, he advises that they should be chosen carefully to balance the scene since too many powerful colours can be chaotic and over-stimulating; too few colours may make the game dull.

3.11.2 Animations

Chapman and Chapman (2004) define animation as the creation of moving pictures one frame at a time. Animation, or movement, can attract far more attention than other techniques (Fox, 2005). Fox also asserts that movement can enliven the interface.

It can therefore be concluded that colours and animation are valuable tools in that they can make a game more engaging and more effective. However, as with any tool, colours and animations can only be an asset when they are needed, otherwise the player can be easily distracted from other important elements on the screen.

3.12 Reasons why Teaching with Computer Games Fails

Egenfeldt-Nielsen (2004) has listed some of the practical barriers in using computer games for learning purposes: limited time schedules, unsuitable physical setting, low class expectations, teachers' background, lack of genre knowledge, technical problems, lack of experience with group work, inadequate teaching preparation, low perception of games, unsuitable class size and other priority issues.

He undertook an empirical study for a history course using a commercial history strategy game (Europa Universalis II). The study involved two teachers and eighty-six male and female students aged between 15-17 years. The researcher had difficulty in introducing the game, requiring more than one hour to launch it. The researcher also reported that a lack of computer equipment was a common problem. Watson and Tinsley (1995) had previously warned that it was unwise to believe that the lack of equipment was a temporary problem, as this might continue for many years. Dorn (1989) has expressed the fear that the attitude of the teachers towards games influences the outcome, and so the teacher's knowledge and skill in using the game is an important factor.

Jenkins (2002) argues that most educational software on the market is poor in quality, badly edited and unprofessionally presented. One way of addressing this issue may be a trend towards modifying many existing software

games (such as Europa Universalis II) for educational use (Freitas, 2007). Furthermore, most educational computer games are currently designed for a single player, whereas it is recognised that collaborative and group work can dramatically enhance learning (Becta, 2001b). Jenkins (2002) also draws attention to the cost of producing computer game-based learning compared with entertainment software games.

It is clear that, even when a high-quality game is used in the classroom or indeed played at home, the fact cannot be ignored that a teacher's guidance is essential to ensure that the curriculum's learning outcomes and goals are met.

3.13 Gender Issues in Computer Games

Computer games have traditionally been targeted at male rather than female demographics. Table 3.4 below illustrates the differences between the preferences of boys and girls towards game play as identified by Cassell and Jenkins (1999). They observe, for example, that when using a computer game, boys play to win while girls prefer to explore and gain new experience. Furthermore, completing or succeeding in a mission for boys is to eliminate competitors while girls feel that teamwork and friendship are signs of achieving the mission.

Boys	***Girls***
Leading characters are fantasy-based action heroes with "super power" abilities.	Leading characters are everyday people that girls can easily relate to, and are as real to girls as their best friends.
Goal is to win, and the play is linear. Outcome is black and white; die and start over; one 'right' solution.	Goal is to explore and have new experiences, with degrees of success and varying outcomes.
Speed and action are key factors.	Play focuses on multi-sensory immersion, discovery and strong story lines.
Features non-realistic, larger-than-life settings.	Features everyday 'real life' settings as well as new places to explore.
Success comes through the elimination of competitors.	Success comes through development of friendships.

Table 3.4: Comparisons of gender preferences in computer games
(Cassell & Jenkins (1999)

Nevertheless, a few misconceptions have been identified about the observation that fewer girls play hard-core games than boys; a summary of these is provided by Rollings and Adams (2003), as illustrated in Table 3.5 below:

Misconceptions	***Descriptions***
"Girls don't like computer games because computers are techie"	This is clearly false. Although most girls and women are less fascinated by the technical aspects of computers than boys and men, this does not discourage them from playing computer games any more than automotive specifications preclude them from driving cars.
"Girls don't like violence"	Females do not approve of non-stop, meaningless violence because it does not hold their interest or stimulate their imaginations, but not because they find it repulsive.
"Girls want everything to be happy and sweet"	This is not true. Girls enjoy stories filled with mystery, suspense and even danger, as long as these features are relevant to the story, rather than merely included at random.
"Girls don't like to be scared"	This is only partially true if a distinction is made between the words 'spooky' (likely to startle or frighten) and 'scary' (likely to lead to injury or death). Girls enjoy events that are spooky but not those that are scary. The abandoned house that contains a clue to a mystery is spooky, while walking through dark streets with a murderer on the loose is scary.

Table 3.5: Misconceptions identified by Rollings & Adams (2003) about girls' attitudes towards computer games

3.13.1 Gender–based differences

There appears to be only a small gap between males and females who engage in computer games at an early age. However, during their secondary school years, the gap becomes wider. Boys seem to be comfortable in continuing to use computer games, while girls develop more interest in social activities or in fashion design (Fedorowicz, Vilvovsky & Golibersuch, 2010).

Subrahmanyam et al. (2001) indicate that the greatest gender disparity in the time spent using computer games is between 14-18 years old. There is also evidence that using computer game-based learning may discriminate against girls and may lead to aggressive or anti-social behaviours (Sandford & Williamson, 2005).

3.13.2 Gender preference for computer games

Previous research indicates that females prefer games which involve a storyline based on reality, with familiar characters, and which resolve emotional issues (Vail, 1997). Vail also speculates that while females are not as visually stimulated as males, they are more likely to be stirred emotionally. In resolving conflicts, males seek head-to-head conflict, while females look for compromise and diplomacy. Moreover, girls do not wish to be lone heroes in virtual reality, preferring companionship and to take their opponent's feelings into account. They seek engrossing storylines and characters, and the resolution of emotional issues which benefit both the player and the other characters in the game.

Girls appear to be more task-oriented than boys. The Barbie Fashion Designer computer game is a success among girls because it enables them to participate in task-based activities which are relevant to their interests. Vail (1997) suggests that this game does not need to highlight computer technology, but merely allow the use of the computer as a creative tool.

According to Inkpen et al. (1994), girls prefer playing computer games companionably in groups or pairs, in contrast to boys, who tend to play computer games alone (Heyman & Berstein, 1996). Griffiths and Hunt (1995) have also observed that male players are often motivated by an urge to challenge and impress their friends.

Research completed by Kafai (1996, 1998) into the design of computer games proposes that girls are more interested in storylines and character development. In her study, she asked elementary school students to design their own preferred games. The majority of the boys used “the good versus the evil” theme, which implies that boys prefer scenarios with a well-defined outcome.

3.14 Summary

This chapter has provided an overview of previous research on games that can influence the design and the implementation of the proposed game. The SimCity style of game is considered to be the most suitable gaming style for this particular research. One of the main reasons is that it appeals to both genders. Another reason to opt for this gaming style is that it has the appropriate game mechanic in which to embed within a well designed curriculum. Simulations can be effective for discussion between small groups, across the classroom and with their teacher.

CHAPTER IV

RESEARCH METHODOLOGY

4.1 Introduction

This chapter describes the method and procedures used to execute the study: a description of research design, location of the research, population sample studied, research instrument, method of data collection and analysis of data.

4.2 Research Design

This research involved three types of fieldwork: an empirical study (1st study), an experimental study (2nd study), and the third study (3rd study) which took place in Malaysia. All three (3) studies were carried out in a real-life teaching situations in schools. The first two studies were carried out in the UK while the third study (3rd Study) was implemented in Malaysia. The total number of students who participated in this research is 60 which are divided as follows :

a) Empirical Study (1st Study) – 20 students
b) Experimental Study (2nd Study) – 20 students
c) Third Study – 20 students

The purpose of the first two studies was to establish the validity or otherwise of the three hypotheses (see chapter 1) namely:

a) That a game could be written which incorporated constructivist learning,
b) That the interaction between players normally found when a group of young people play an entertainment game in close proximity would carry over to the educational game, and
c) That the presence of mini games not related to the learning outcomes would nevertheless engage the students in the game and thus motivate them to complete the game and thus interact with the learning outcomes.

Meanwhile, the Malaysian based study (3rd study) was to investigate the differences between Malaysian educational culture and the UK educational culture and whether a game that had worked in the UK culture would continue to work in the Malaysian setting. The lack of soft skills amongst Malaysian students is partly attributed to the 'rote learning' style adopted by Malaysian school children who are pressured by their parents, peers and school to excel academically as a result of the examination-based education system (Wong 2003; Vadivelloo & Vijayarajoo, 2004; Ismail 2005). Learning methods in Malaysia focus on memorization and students are constantly judged by how many A's they achieved in their examinations and test. In the process, they fail to develop an inquisitive mind and analytical skills as most of the time is spent preparing for many upcoming examinations. An investigation was carried out to see whether a gaming environment can also stimulate collaborative activities as well as the critical thinking skills amongst the students from this different educational culture.

In order to investigate these efficiently in the light of the difficult process of obtaining entry to schools and work with the correct age group, the experiments did not separate all of the variables as clearly as would have been desirable. Thus in the 1st study two groups of students of different abilities were chosen. There is some evidence that high achieving students will not be interested in using games in their learning because this is not necessarily efficient and they are already engaged with the process. However, it is commonly believed that the low achievers do not easily engage in the normal classroom activities and thus will benefit from the game based activity. Thus the level of engagement of the students with the game was a major element to be measured during the first two studies.

In the 2nd study the mini games were removed so it was possible to see if the students' engagement went down. However the second study did not separate the high and low achievers. This was not felt necessary as the first study had shown clearly that both groups engaged well with the game. It was thus important in the second study to measure any change in engagement from the first study which might then be attributable to the removal of the mini games.

For the 3rd study, an investigation was carried out to evaluate and observe if there are any effects on the student's engagement when the game was used in the Malaysia educational culture as compared to the UK educational culture.

The first hypothesis states that learning will take place in the game play. It was thus necessary to pre test the students for their level of knowledge in the subject. This was done by including a question and answer session in the initial interaction with the students. This was repeated in the post intervention discussion session. The level of knowledge gained was estimated from the quality of the students' responses for all three studies. The original study was carried out at the beginning of the period of the term at which the material was

first being introduced to the students. Thus at that point they had received little background in the subject and learning can be realistically ascribed as having come from the game. The second study was carried out at a later stage in the school term. At this point it would be expected that most students would have a degree of knowledge about the subject. Thus it was not certain that differences in their understanding from the pre to post intervention testing were due to the intervention. However, pre and post testing was still carried out. The pre testing was carried out in the mode normally used for discussion sessions in the classroom. Thus it was possible to compare the effect of the intervention on the performance of the students with respect to their involvement in discussion in a normal situation with that of the experimental situation. While the first study would show the effectiveness with respect to the normal classroom situation it was felt that it could not be guaranteed that it was playing a game that was improving the interaction between the children and the principal reason for the second study was to see if it was the nature of game play or being in a non standard classroom environment that was causing the improved interaction of the students. Thus the second study used a comparison of the normal classroom, the game play situation and a control group who used a computer lab with Internet access.

The purpose of the empirical study (1st Study) was to investigate an initial idea to use computer games in a Geography class, undertaken at a local high school and involving twenty (20) students at Key Stage 3 (13-14 years) and their subject teacher. The procedures implemented were as follows: consulting the teacher; using an area of study within the Key Stage 3 Geography curriculum; developing a lesson plan; developing a game based on the requirements of the curriculum; and producing a prototype in order to confirm with the teacher that the content was appropriate.

The empirical study (1st Study) allowed the teacher to control the session while the students played the game within sixty minutes. The researcher and a group of helpers observed the activity, made notes and voice-recorded the students' behaviour and feedback throughout the session.

The experimental study (2nd Study) was a control-based experiment, again undertaken at the same school and involving a further 20 students (separate set of students than from empirical study) at Key Stage 3 (13-14 years) and their geography teacher. The students were separated into two groups, one of which used the game and the other used the Internet, in an attempt to answer a question that they had been given. The purpose of this experiment was to test and evaluate the effect of the game environment on inter-student communication compared to the Internet-based activity.

The third study was carried out to investigate and evaluate the game environment on inter-student communication and collaboration to a group of students with a different educational culture background. The results of the empirical, experimental and the third study are reported in Chapter 7.

4.2.1 Why use experimental groups that are not consistence between the three studies?

The reason for this is that there are issues with the availability of schools, getting access into schools, and also getting the ethics clearance, all of which make it substantially difficult to run experiments. At the same time, contact with schools is difficult. Obtaining contact schools with the right age range pupils and available at the right time (by going into the school at the right time) for conducting the studies is difficult. As a result, it is necessary to do the experiments as efficiently as possible in looking at the variables the researcher can control. Therefore, though not ideal the important variables were changed

while others were not controlled so all of the hypotheses could be tested. Indeed the third study allowed the possibility of engaging students in inter-group interaction to be tested in an environment where group interaction is normally completely absent.

In the empirical study (1st study), the researcher distinctly separated the high achievers and the low achievers. In the experimental study (2nd study) and the 3rd study, the students consisted of mixed achievers. The first study had already indicated that both high and low achievers would engage. The objective of determining whether removing the mini games would affect engagement was thus combined with a comparison study of mixed ability students engaging in a non game based intervention in the second study. The third study was directed specifically at investigating whether the very different educational culture in Malaysia would prevent the students from responding to the game.

4.2.2 The way in which the three studies were implemented in schools

As mentioned above, there were twenty students and a geography teacher involved in the empirical study. These students were divided into two sessions in each of which sessions, the students were asked to work in pairs.

a) 1st session involved ten high achiever students,
b) 2nd session involved ten low achiever students.

For the experimental study (2nd study), another twenty different students and a geography teacher were involved. The session was divided as follows:

a) 1st session involved ten mixed achievers students of whom half played the game, while the other half was the control-group who used the Internet to answer the question posed in the session.

b) 2nd session again used the same method with another 10 different mixed achievers, of whom half played the game and the other half used the Internet.

In the third study because of a tight school schedule, the study was carried out after the school session. This had agreement from the teacher who was involved as well as the students' parents. Due to the limitation of obtaining a large number of handheld Microsoft XBOX 360 controllers (5 controllers available), the third study (3rd study) was carried out over a longer period of time to allow more students to be involved.

4.2.3 Justification of the location and timing of the study.

It was very important for all three studies to be carried out in a learning environment and with a teacher with whom the students were familiar, rather than in a laboratory or other location. This is related to the Hawthorne effect which refers to a temporary change to behaviour or performance of an individual or groups in response to a change in the environmental conditions (Fox, Brennan & Chasen, 2008). The results of the studies could have been affected if a different location or unfamiliar environment had been used in which students were unable to perform naturally. This was a particularly relevant consideration for the present research, which sought to establish whether the use of a computer game enhances collaborative learning.

Furthermore, the main purpose of this research was to investigate whether game-based learning can be used effectively in a classroom, so it was necessary to conduct these studies in the actual teaching/learning environment to take account of aspects such as noise levels within the class, the

arrangement of furniture, the overall physical environment in the classroom, and the length of learning time based on their actual curriculum time-table.

4.3 Research Instrument

The researcher introduced a game entitled GeoEmission - a game concerning global warming issues - to the teacher and students in all three studies. The researcher also developed a set of questions for observation and discussion regarding students' motivation and immersion in the activity, the clarity and achievability of the game, the extent of communication, and the game's learning outcome (see Appendices A and B).

4.4 Data Collection and Data Analysis

For the empirical study (1st study) the students were divided into three separate groups based on their gender (male and male, male and female, and female and female). It was hoped that this might reveal interesting gender differences in attitude and behaviour. However, there was no real evidence of any differences during game play. For all three studies, data was collected through observation in order to analyse student behaviour, motivation and levels of participation and collaboration within each group. The data was also gathered through voice recordings and discussion based on a set of questions provided by the researcher. Appendices A and B represent a list of key questions for the observation and discussion, each questions containing seven categories: *motivation, clarity, achievability, control, immersion, interest, purpose* and *communication.*

4.5 GeoEmission Game Interactions with Lesson Plan

The GeoEmission game was purposely integrated into the Key Stage 3 Geography lesson plan and the empirical study was conducted a week after the teacher had introduced the topic of global warming This offered students the advantage of using the game-based learning approach first-hand. It was a new experience not only for the students but also for their Geography teacher.

The experimental study (2nd study) was carried out just before the end of the school term. By this time, the students had already completed the global warming topic and had therefore gained some knowledge of it. Nevertheless, the experiment presented a new challenge for those students taking part in the game in asking them to apply their subject knowledge to the game, offering a comparison with their colleagues using the Internet.

The Malaysian (3rd study) as mentioned before was carried out after the school session due to their tight schedule. The Malaysian students had already completed the topic as was the case for students in the 2nd study. However, the third study promoted a new learning environment which is the game environment not previously tried in the School concerned.

The lesson plans A and B - for the empirical and experimental studies respectively - were divided into two sessions (see Appendices C and D). Each session was planned to take sixty minutes (the typical lesson time for a subject in the Key Stage 3 curriculum) consisting of fifteen minutes for setting up equipment and a further forty-five minutes for lesson delivery.

4.6 Evaluation Methodology

4.6.1 Approaches to evaluation

A simple question for any educational software should be: *"Can this product actually teach what it is supposed to teach?*" It is a simple question to ask, but often is difficult to answer because the product may have many other features. It requires the evaluator to identify the learning process in which students are engaged, and to recognize their reasoning skills, especially in dealing with open-ended and interacting complex issues.

The participants for this study were Year 8 Secondary School students (aged 13-14 years old). The evaluation methodology consisted of two major sessions: an 'observation' (observing reaction and behaviour / motivation during game-play) and a 'discussion' (with both teachers and students). These evaluations were intended to raise awareness among educators of how educational computer games can motivate students to learn more about the subject of Geography, and enhance their thinking skills when considering global warming, which is an example of an open-ended and interacting complex issue.

4.6.2 Data collection procedures

Procedures for data collection were carried out as follows:

a) Observe the students in a Geography lesson to determine motivation characteristics based on student-teacher interaction (both for Lesson 1 and Lesson 2);

b) Hold discussions with the students to determine their overall feeling about the game;

c) Hold discussion with the Geography teacher to determine the teacher's perception of the content, learning outcomes and the quality of the game/session;

d) Introduce GeoEmission to the students and observe motivational responses during use of the game;

e) Observe the students in a geography-based activity during an allocated period of forty-five minutes;

f) Hold discussion with the students to determine their perception of the effect of GeoEmission on their motivation / reasoning skills;

g) Hold discussion with the teacher to determine their perception of the effect of GeoEmission on students' motivation/ reasoning skills.

As stated previously the game was:

- Compared with the normal classroom situation thus allowing the effect of the game on inter student collaboration to be compared with the normal classroom situation,

- also compared with a separate control intervention which introduced an unconventional environment to see if it was in fact the game that was causing the increased interaction or it was only the unusual environment, and

- Allowed the comparison of the response to the game in the Malaysian educational culture with that of students in the UK educational culture.

In addition the pre and post testing of the students in the subject area allowed the effect of the game on learning to be gauged.

4.7 Summary

A total number of 60 students were involved in the studies both in the UK and in Malaysia. In the Empirical Study (1st study) 20 students were divided into two separate sessions each with high achiever and low achiever students. The purpose of the empirical study (1st study) was principally to investigate whether a gaming learning environment can promote collaborative learning amongst the students. In the experimental study (2nd study), another 20 different students consisting of mixed achievers were involved. Half of them were given the opportunity to play the game while the other half formed control groups and used the internet to try to answer the same question as given to the experimental group. There were two session involved in this study. A comparison on their behaviour especially on clollaboration was made between the two groups. The Malaysian study (3rd study) involved an additional 20 students. The study focused on the effects the educational system differences in the Malaysia context would have on the game play when compared to the response of the students in the UK. The collaboration between the students in a normal Malaysian classroom is less as is feedback to teachers and less non teacher directed activity takes place. The study tried to see if putting them in a game situation they might behave differently. The results for all three studies are discussed in Chapter 7.

CHAPTER V

COMPUTER GAME-BASED LEARNING DEVELOPMENT

5.1 Introduction

This chapter describes the process adopted for developing the GeoEmission game. This includes the choice of the game type, the overall game concept and the game-play mechanic.

5.1.1 GeoEmission development phase

It was decided from the outset to use Microsoft XNA Game Studio (which is based on Visual C#® 2008 Express Edition) as the main engine tool for the development phase of GeoEmission. Microsoft XNA Game Studio is a set of tools based on supported versions of Microsoft Visual Studio that allows students and hobbyists to build games for Microsoft Windows, the Microsoft Xbox 360 video game and entertainment system and Microsoft Zune. The XNA Game Studio also includes the XNA Framework, which is a set of managed libraries based on the Microsoft .NET Framework 2.0 that are designed for developing the game.

The GeoEmission development phase has made use of several versions of XNA Game Studio, starting with XNA Game Studio Express, released for public use in 2006, followed by XNA Game Studio 2.0, released in December

2007. In 2008, Microsoft released another new version, XNA Game Studio 3.0, which allowed production of games targeting the Zune platform (an entertainment platform and portable media player) and added Xbox Live community support. XNA Game Studio 3.1 was released in June 2009, with the Application Programming Interface (API) including support for video playback, a revised audio API, Xbox Live Party system and support for games using the Xbox 360 Avatars.

As well as the Microsoft XNA Game Studio, other applications were used as an additional tool for the development phase of the present research. One of these was Adobe Photoshop, the main purpose of which is to edit images and graphics. The application was chosen for its relative ease of use and its familiarity to the researcher. Its greatest advantage, however, is that it allows the editing, enhancement and manipulation of images with its wealth of powerful painting and selection tools, multiple layers, special effects filters and lighting effects. A further tool used in the development phase was Audacity, a digital audio editor and recording application. It is free, open source and cross-platform, available for Windows, Mac OS X and Linux. Some of its features include:

a) the ability to import and export *WAV, AIFF, MP3, Ogg Vorbis* and all file formats supported by *libsndfile* library;
b) editing via Cut, Copy, Paste (with unlimited Undo);
c) the ability to change the audio's pitch without changing the speed;
d) converting cassette tapes or records into digital tracks by automatically splitting one track into multiple tracks based on silences in the track and the export multiple option;
e) support for multi-channel modes with sampling rates up to 96 kHz with 32 bits per sample.

However, at the time it was used, Audacity was limited by its lack of dynamic equalizer controls, real-time effects and support for scrubbing.

5.2 DGBL Model for Geography (Global Warming) Educational Games Design

Several previous studies have indicated that there are a growing number of researchers exploring the potential of digital games for engaging students in the learning experience. They have investigated how to develop a model which can support Instructional Design (ID) for effective design and integration of game processes in a learning environment. Mat Zin, Jaafar and Wong (2009) proposed a Digital Game-Based Learning Instructional Design Model (DGBL-ID) which involves five phases (analysis, design, development, quality assurance and implementation & evaluation). Each phase consists of a number of steps to be completed in educational games, as illustrated in Figure 5.1. The phases include all the main activities for the instructional and game sections in order to enable students to learn during play.

Using the DGBL-ID Model, the quality and the content of the game was tested before being launched to users. After delivery, an evaluation of its effectiveness as an immersive game was undertaken to determine what modifications would be needed to ensure future learners make progress.

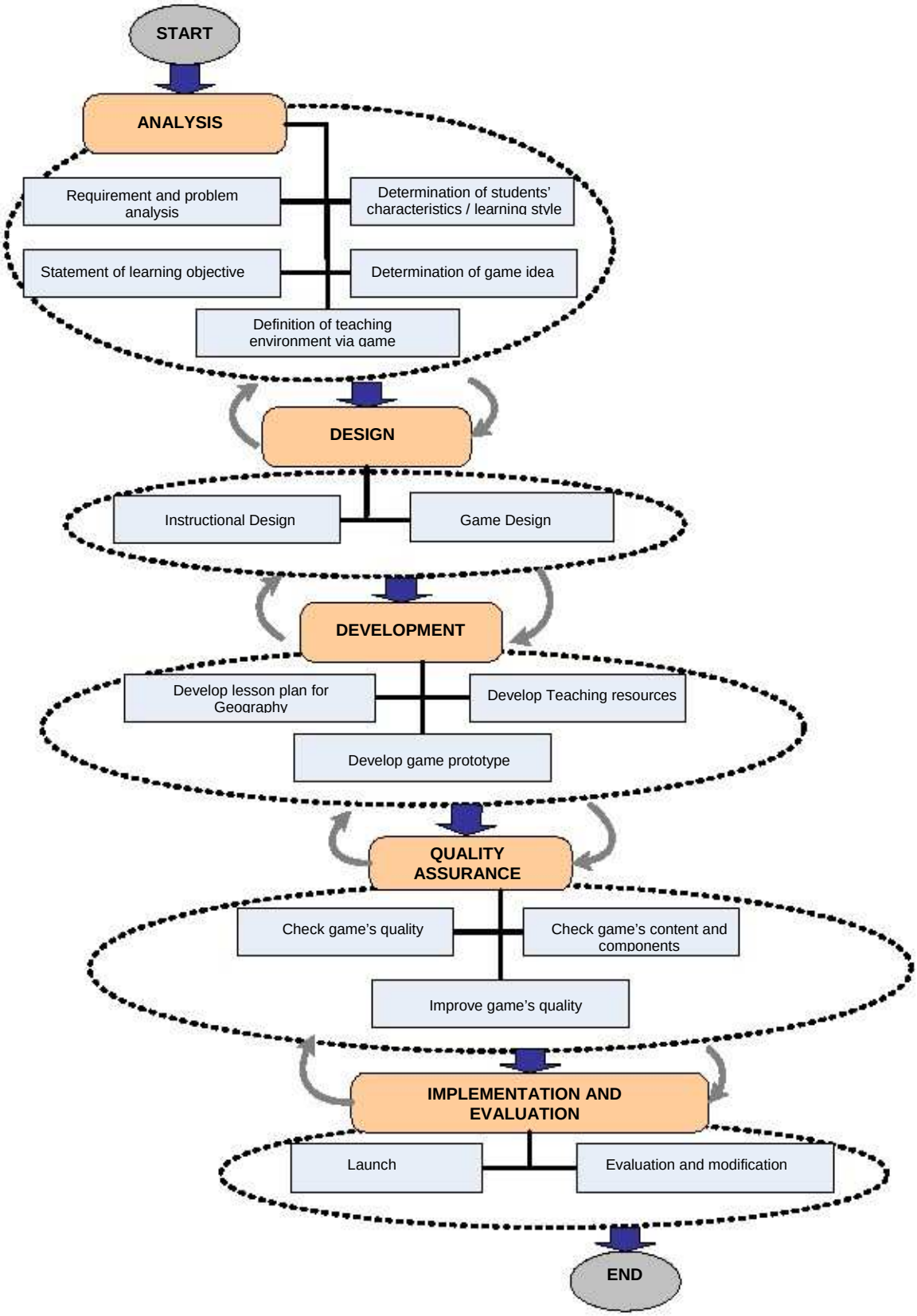


Figure 5.1: Digital Game-Based Learning– Instructional Design (DGBL-ID)

5.3 Game Design

The purpose of the GeoEmission game - developed as a supplementary learning tool for exploring global warming issues in Geography teaching - is to facilitate the ability of Year 8 students in developing complex problem-solving skills. It is not possible to solve any one aspect of the many global problems that exist independently of other features, as the activities involved interact in complex ways. The design motivation in developing GeoEmission follows the ideas of Fasli and Michalakopoulos (2006) who identify the principles of designing a successful computer game in a learning environment as:

a) to provide a challenge for students;
b) to motivate them to learn;
c) to improve their skills and knowledge;
d) to make learning itself enjoyable.

It can be claimed that students frequently learn best when facing challenges and given an opportunity to experiment with different approaches and strategies. The criteria proposed by Fasli and Michalakopoulos will lead to a higher level of active engagement, and the elements of curiosity, challenge and fun (Malone, 1981) are a major factor in motivating students to continue to learn.

5.3.1 The choice of game type

GeoEmission is a type of serious game which simulates and explores real life issues in order to educate players through an interacting experience. It is based on role-play and an adventure story-driven game environment that emphasizes the contribution to global warming made by a region's industrial activities. The adventure game genre was chosen because it can promote knowledge, strategic thinking and an inquiring attitude among players (Cacallari,

1992, Overmars, 2004). An adventure game type provides equal opportunities for both male and female students to gain the learning outcome of the curriculum. While both males and females enjoy games with an interesting storyline or scenario, Mitchell & Savill-Smith (2004) suggest that game types which contain aggressive and violent incidents tend to appeal less to most females. The element of curiosity also plays an important role in stimulating students' spatial awareness and cognitive skills (Frith,1997).

5.3.2 Overview of the GeoEmission game concept

The GeoEmission game concept is related to the use of energy efficiency and the implementation of green technology as ways of reducing greenhouse gas emissions and counteracting global warming. The concept is based on the SimCity gaming style which allows the player to choose several actions, the objective of which is to build and design a city with specific goals to be achieved at each level. Incorporating a SimCity gaming style in GeoEmission has proved to be a significant advantage for learning purposes, because of the high levels of interaction and resulting engagement. According to Shawn (2005), interactions of the type used in this game actively engage learners in the analysis, synthesis, organization and evaluation of content. As a result, learners construct their own knowledge. He also suggests that another advantage of the SimCity gaming style is that it not only allows learners to learn by doing, but to achieve this in a consequence-free simulated world. This type of gaming style allows the educators to simplify complex and long term situations, and offers learners the opportunity to solve problems, apply procedures and understand processes within a safe environment. The present researcher believes that these types of implementation set the stage for future learning, providing practice and an opportunity for knowledge integration by serving as concrete examples of complex and abstract concepts.

To enhance cooperative learning and maintain teacher interaction without overt influence, GeoEmission is played through a network where the teacher acts as the host and students are the clients. The game's ability to monitor student progress and action give the teacher the valuable opportunity to observe when groups of players are persistently making poor choices. In such cases the non-player character (NPC) – controlled by the teacher – can introduce helpful comments. As the game progresses the player character has to try to introduce changes which will potentially respond successfully to problems. For example, a player may decide that closing a certain factory would reduce CO2 emissions. However, such an action would have wide social and economic implications, in which case the NPC can then advise the player of a non-simplistic response to their choice. Further, the teacher has the control to pause the session at any time during play in order, for example, to ask questions of the whole group.

5.3.3 GeoEmission game-play

As the game progresses, the player is able to take on a number of the roles that will be involved in responding to the human activators of climate change, such as the mayor of a town or a scientist responsible for designing renewable energy resources. At the beginning of the game the player can only play as the Greenpeace activist, as the other characters are locked, as shown in Figure 5.2. Each character has different responsibilities and his or her decisions affect other (non-player) characters. Figure 5.3 illustrates islands representing different levels. The game starts by explaining a scenario which represents the 'sorry' state of the island on which they live: the CO2 level in the area is high and the economy is in a poor state. The players are given a list of objectives to be accomplished in order to proceed to the next level. They are required to make decisions by selecting interface elements, and the initial mission is to minimize the CO2 level whilst maintaining energy production and at the same time improving the state of the economy. During the game they will be given

further help – for example Figure 5.4 shows a list of actions that are available for building energy resources for the city, which will encourage the students to consider the consequences of choosing any particular approach.

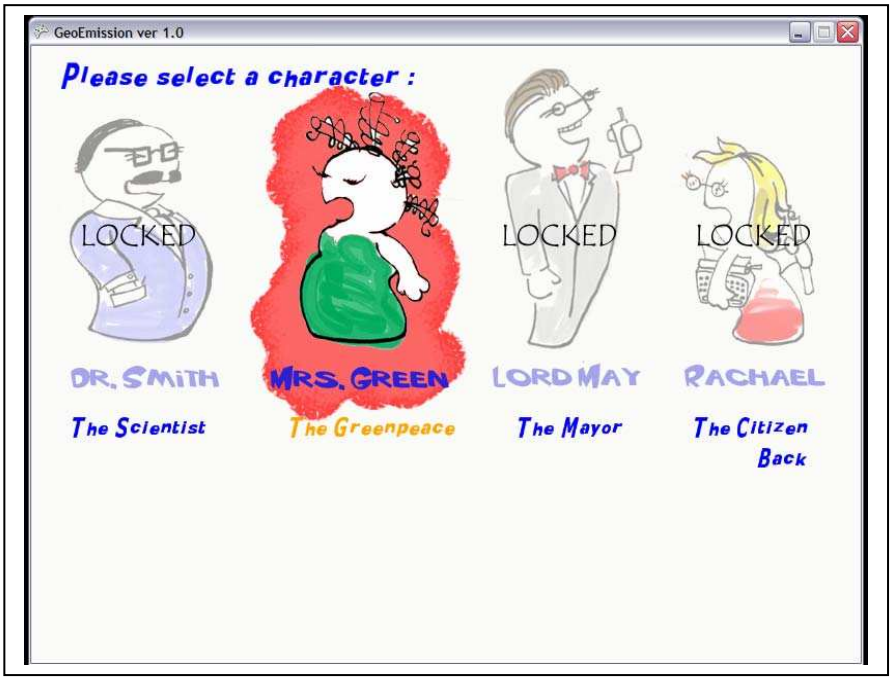


Figure 5.2: Menu screen for choosing a character

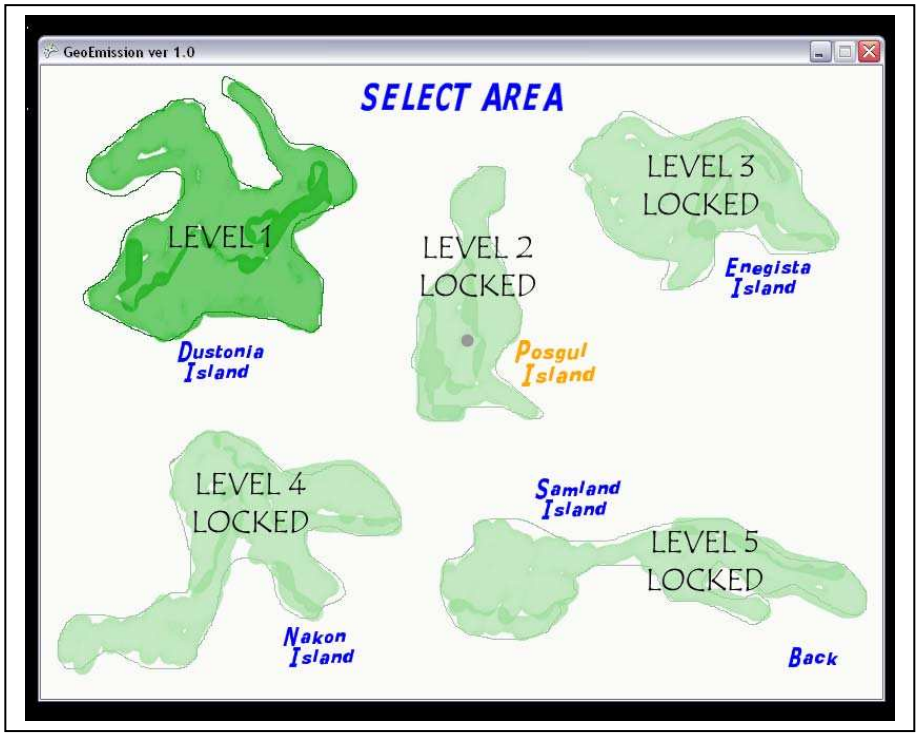


Figure 5.3: Menu screen for choosing an island

Reward cards are one of the main components of GeoEmission, representing the current achievement of goals related to 'Temperature', 'Money', 'Energy' or 'CO2'. To collect these reward cards, the player needs to plant, build or remove elements. In the initial version of the game they also compete in a series of challenges (i.e. mini games) in order to progress through the game. These mini games were introduced to test the hypothesis that they would enhance engagement of the players without detracting from the main educational aim of the game. However, they did not require the players to engage directly with the educational aims of the game. As such they also had the possibility of detracting from the overall educational aims of the game. In the main game the main objective for the players is to collect all four reward cards by minimizing the level of greenhouse gas contamination through negotiation and evaluation of the consequences of each action or decision made. Reward cards can be lost, and the game mechanics deliberately make retaining all four

of them a challenge by the use of realistic interactions between the possible choices. For example, playing as the Greenpeace activist enables the player to shut down heavy industrial activities. Shutting down a heavily polluting industry, however, tends to have knock-on effects such as causing people to lose their jobs. Becoming jobless impacts upon a person's quality of life and therefore on their political response.

Such outcomes can be beneficial because they demonstrate the complexity of relationships. This approach is intended to help the players identify solutions to problems that cannot easily be inferred. They must include other factors before making a decision, and as the storyline unfolds, players are given the opportunity to understand the cause of certain issues and their relationships.

Figure 5.4: Energy menu for selection screen

An example of a mini game is illustrated in Figures 5.5 and 5.6, which show that the player needs to collect at least 100 signatures for a petition before they can hold a demonstration rally.

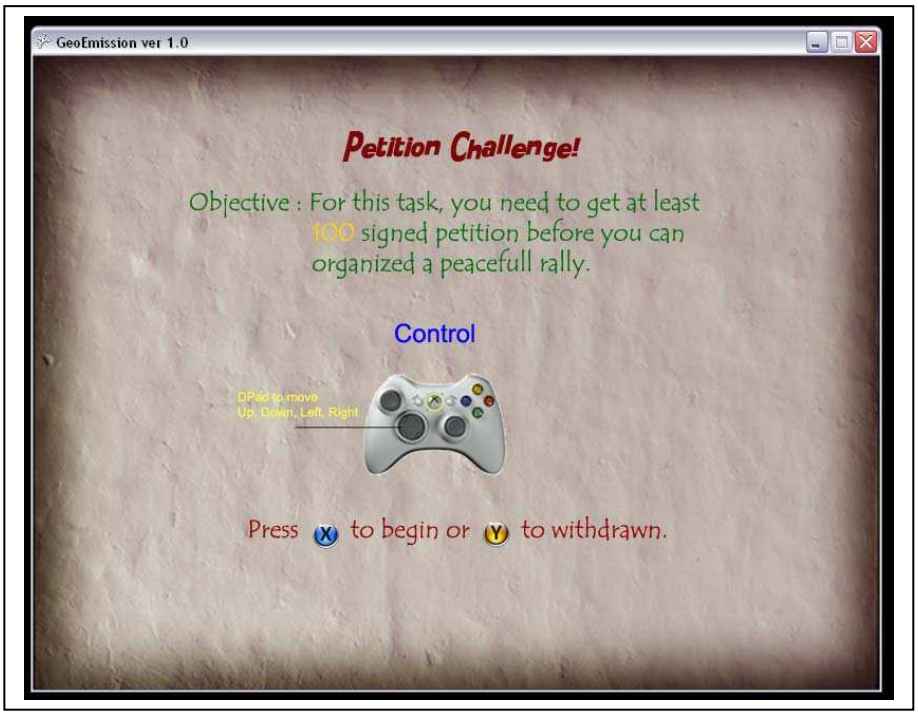


Figure 5.5: Instruction menu for the petition challenge mini game screen

Figure 5.6: Mini game for collecting petition challenge

5.3.4 Teacher's role and influence on the game

The teacher's involvement via an NPC is essential in order to monitor and evaluate the game session, to maintain control of the class and the lesson, and to facilitate the learning process. Examples of how this can work are given in Figures 5.7 and 5.8. The teacher can influence the game play by sending messages and by adding realistic responses to the game in response to decisions made by the students. For example, if they start to build a nuclear power station (which potentially can balance the energy requirement for the city) the reaction of the surrounding population may be to oppose this, even if the actual damage of the nuclear power station to the environment is very low. This reaction might be motivated by the problems associated with the long-term effects of nuclear waste. The teacher can communicate with the students, using the NPC persona, and send them messages that raise issues or give advice as shown in Figures 5.9 and 5.10.

Local environment issues are another example that the teacher might have to deal with. Wind turbines are a form of renewable energy which many environmentalists find attractive, and the general response might be the acceptance of wind energy as a source of clean energy. However, many people object to wind farms being built in their immediate neighbourhood, even though they accept the general principle of the need for clean energy. However, building such a reaction into the game as an automatic response would not be appropriate since the students must feel they are making progress in order to continue to engage in the lesson. This type of human reaction could be simulated deterministically, but the use of the NPC allows the teacher to monitor the progress of an individual player and to improvise unexpected reactions when they judge it appropriate to stimulate the students to consider these issues.

Figure 5.7: Student's screen for GeoEmission game-play

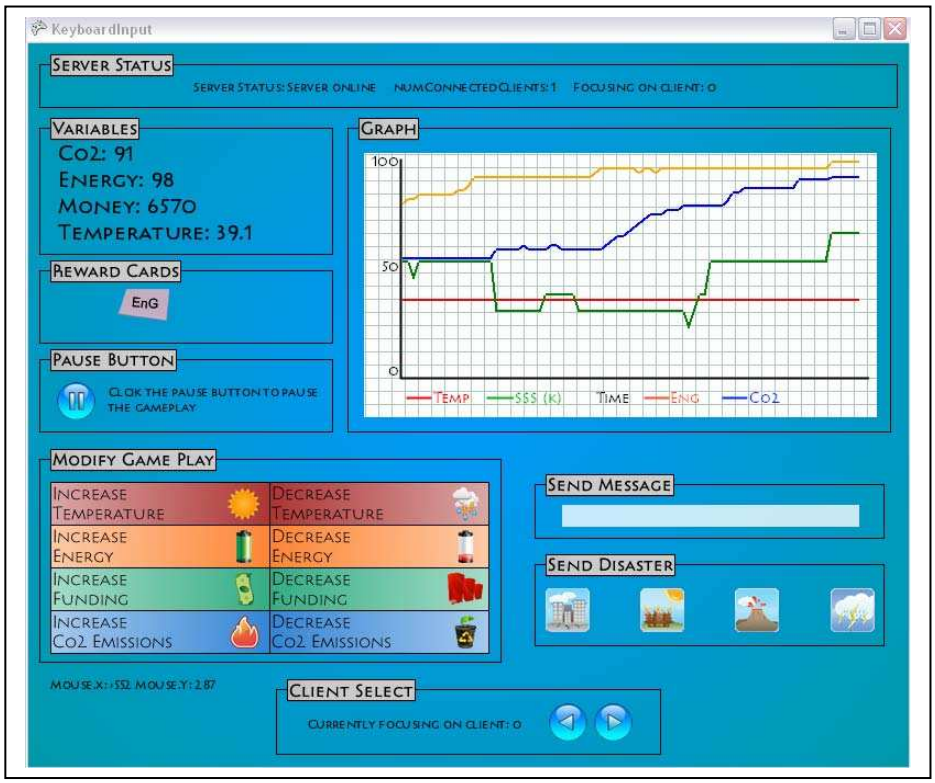


Figure 5.8: Detail of teacher's main screen

Figure 5.9: Teacher's message box

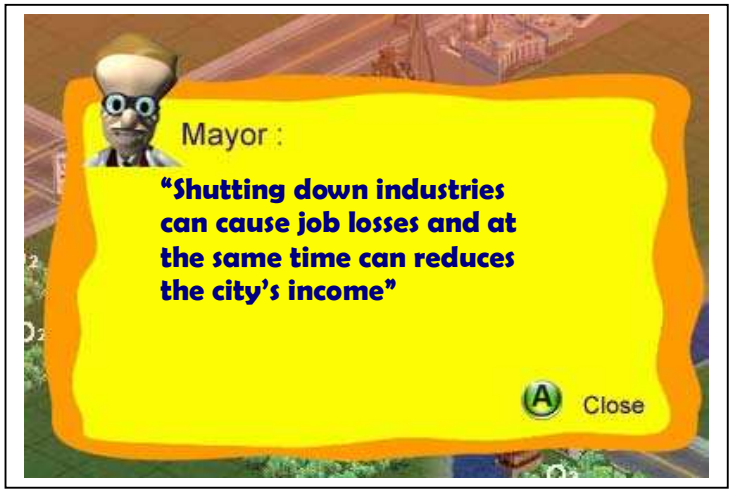


Figure 5.10: The NPC Message Screen

5.4 Interface development

According to Murdock (2005) a game's user interface defines the user's interaction with the game. She also comments that games with a well-designed interface can succeed even if other aspects of the game are poor and games with a high level content can fail if the interface is poorly designed. Colours are another important design element. She emphasises that the colours should match the feel of the game (e.g. light and bright for children's games and dark and subtle for aggressive games). As previously stated in Chapter 2, Omernick (2004) observes that colours play a powerful role in defining mood in a scene and should therefore be chosen carefully to balance the scene; too many powerful colours can be chaotic and over stimulating, whilst too few colours may make the game dull.

5.4.1 GeoEmision interfaces

Initially, there were three options of graphic type in the GeoEmission game implementation: fully three-dimensional (3D), two-dimensional (2D) and a semi-two-dimensional. A fully 3D graphic type would be an impressive environment but in terms of development, it is complex to produce. The machine used for the development must be powerful enough to handle the attributes, components and rendering purposes. Further, the machine running the game at the school would have to be at a high-end capability.

To facilitate development and reduce production time, a decision was made that the game should be in a semi-2D approach, as shown in Figure 5.11. Another advantage for choosing this option is that running the game would not be as heavy as in a 3D environment.

Figure 5.11: GeoEmission semi-2D approach

5.4.2 GeoEmision components

There are four main components in the GeoEmission game: ‘Main Status Indicator’, ‘Climate Indicator’, ‘Reward Cards’ and the ‘Main Menu’. Table 4.1 explains each component and their functions while Figure 5.12 shows the location of each component in the game environment. GeoEmission is played using a game controller, as shown in Figure 5.13.

Components	Functionality	Purpose
Main Status Indicator	Displays the current game Date, Temperature, Funding, Energy and Emission.	Information for the players of the current game main status
Climate Indicator	Displays the current game climate.	Information for the players of the current game climate status
Reward Cards	Display the current game reward cards that the player has collected.	Information for the players of the current game reward cards status
Main Menu	Displays a set of actions that can be taken.	Enables the player to interact with the game

Table 5.1 Main components of GeoEmission game

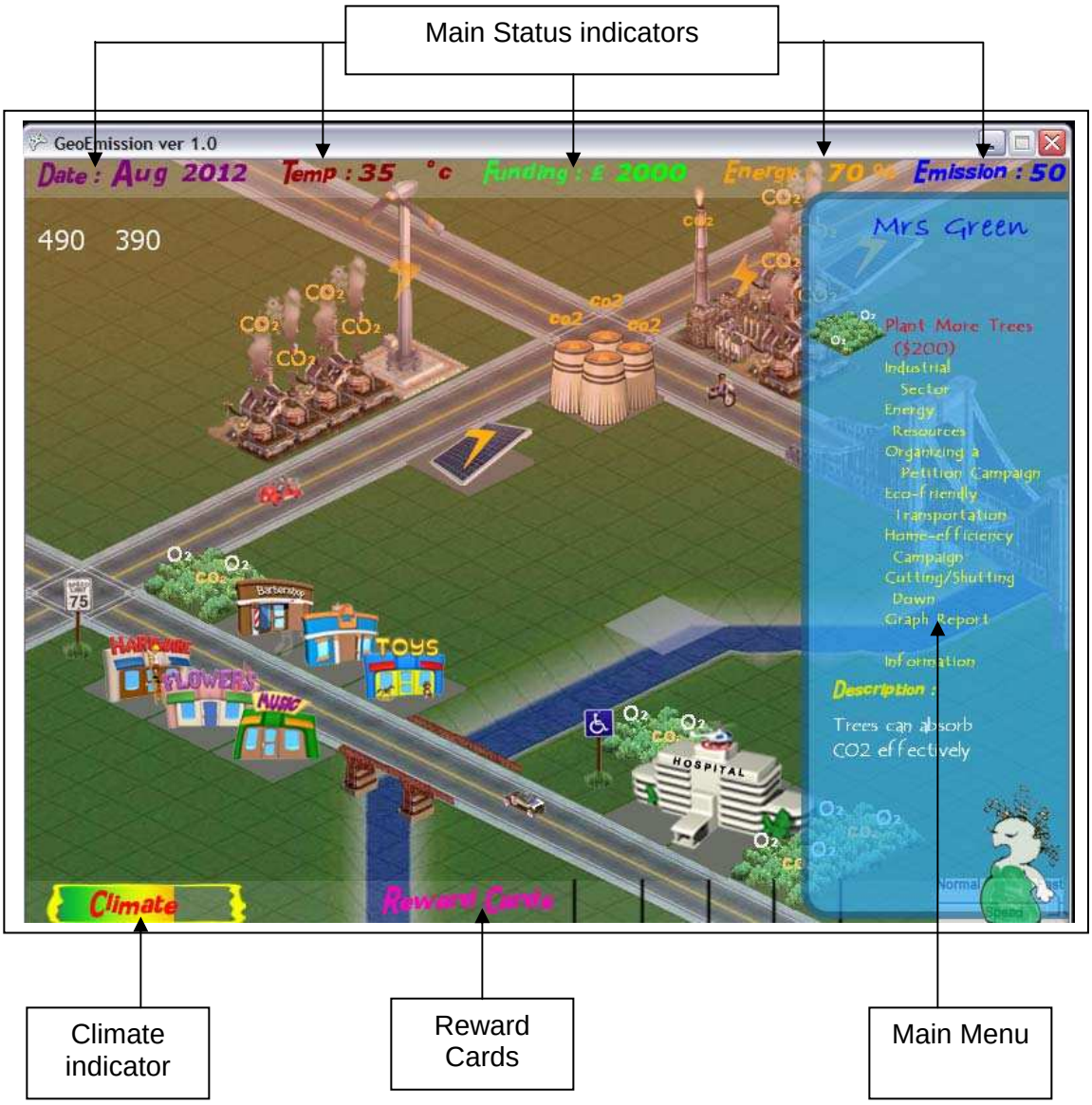


Figure 5.12: Main interface indicators for GeoEmission game

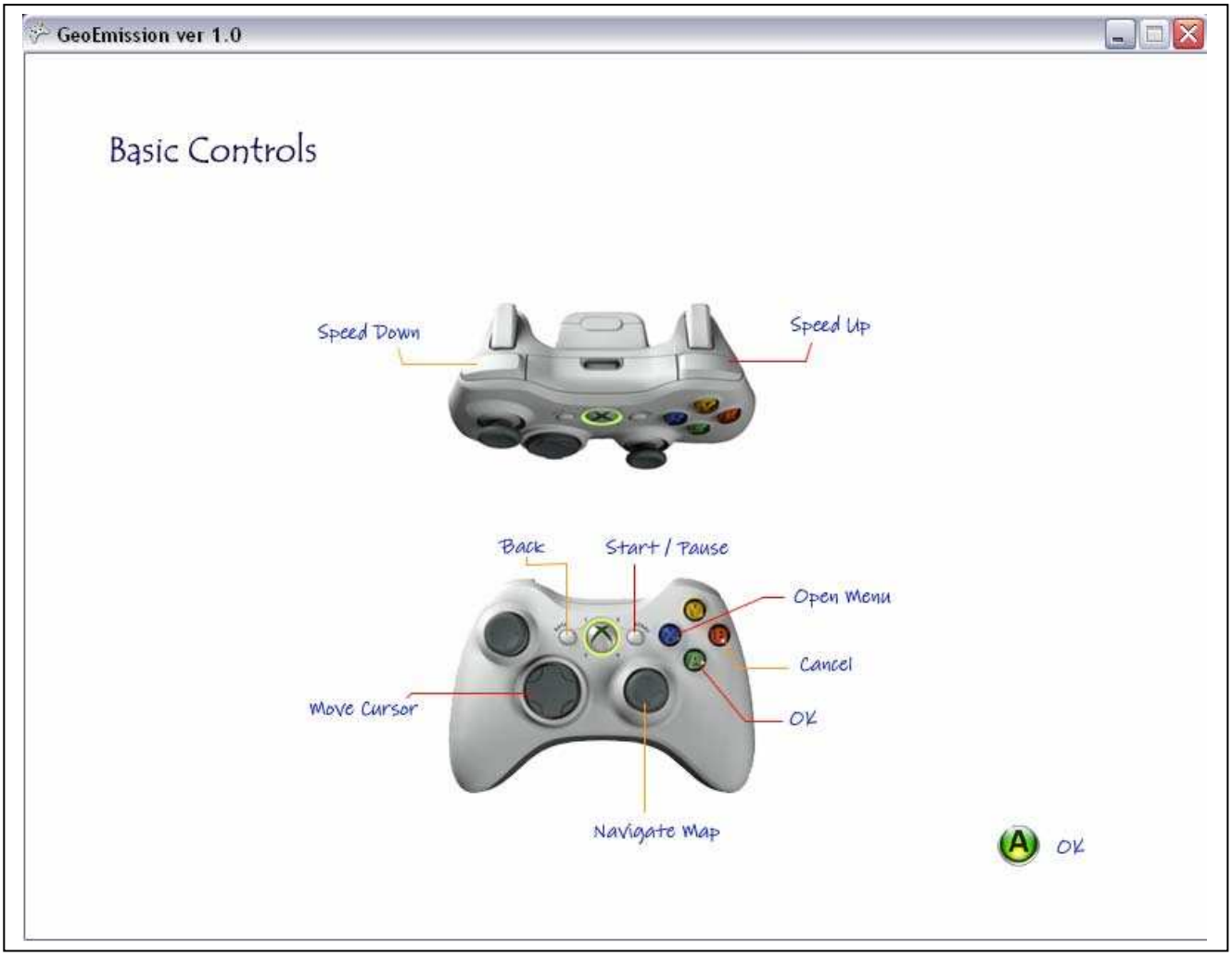


Figure 5.13: GeoEmission game controller

5.4.3 The re-design of the GeoEmission game

The original idea was to have multiple game levels. However during development it was decided to have two styles of play instead; one is where the game is completely linear and the player can win easily just to learn basically how to play the game and in the other version there is more challenge with a

more realistic model and where the teacher can introduce variables that are distinctly none programmed. In the original GeoEmission, the plan was to have four different characters consisting of the Scientist, the Greenpeace activist, the Mayor and the Citizen but in the third study changes were made from the 4 character into 2 characters (which only consist of a male and a female player as shown in figure 5.14) . The big differences between this version compared with the previous version was how much the game mechanic changes into more stochastic one with the input from the NPC (which is the teacher).

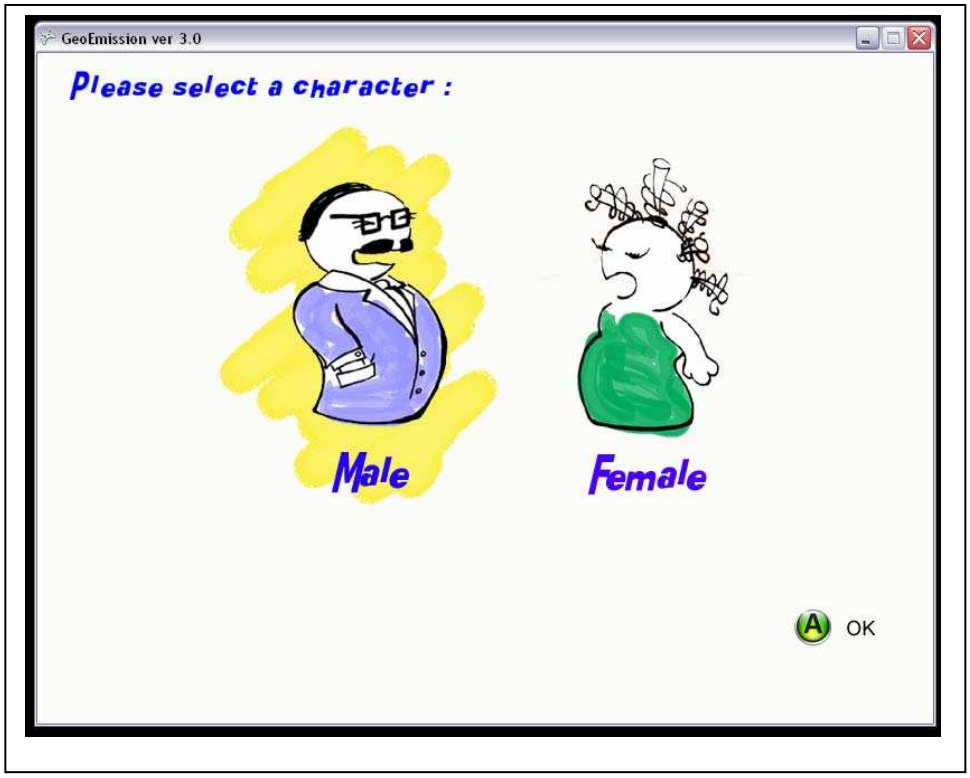


Figure 5.14: GeoEmission male and female character

5.5 Summary

This chapter has described the design, the components and the developmental phase of the GeoEmission game. These features include the choice of game type, game concept and the game-play mechanic. One of the important elements embedded in the game-play mechanic involves the teacher's role during game-play time. It is crucial for the teachers to be involved with the game in order to monitor and evaluate the game session, maintain control of the classroom, and facilitate the learning process. For the Empirical study (1st study), the mini games were embedded in the game but these were later removed in the experimental study (2nd study). The reasons for this are discussed in Chapter 7. Meanwhile, more changes to the GeoEmission were made for the third study (3rd study). The game mechanic in this version allows the NPC to add more inputs to the game making the game more challenging. Also at the second level the game response itself becomes more realistic by using non linear responses containing an element of stochastic change to the model responses. Further detail of the software design are given in the following chapter, including details of the class structure and the way in which the changes in the model have been introduced.

CHAPTER VI

GAME DESIGN

6.1 Introduction

This chapter describes the game structure and the design in depth. There were three versions of the GeoEmission game and each game version was updated in order to refine and improve the game mechanic. The reason for each version and its updates are discussed below.

6.1.1 Why use XNA Game Studio for the development of the game?

As mentioned in the previous chapter, XNA Game studio was used for the development of the GeoEmission game mechanic. XNA provides a very large set of tools specific to game development. One of the main reasons XNA was chosen for the practical side of this development is that these tools are easy to use and very powerful. Not only this but the design of the software makes for easy maintenance of all (images, C# class files, etc), which is essential when undertaking a large task such as this. Another advantage of XNA is that it has generated a large, vocal online community. As a result there are a wide variety of tutorials and guides on various areas of programming using XNA. Not only this but members of the XNA online forum quite polite and quick to respond to any questions asked of them. Finally, XNA makes it quite easy to create graphical user interfaces, something which is required for the game.

Although XNA Game Studio is specifically design to aid the development of computer games, the tools XNA provides can be used to aid the development of almost any piece of software, including human non-player software. The language used to develop software with XNA is C#.

6.1.2 The benefits of utilising a human non-player

Most traditional computer games today are comprised of a “player”, and “non-player’. The player provides input to the system, some process occurs and corresponding output is given. This cycle of events is repeated continually and allows the player to progress through the game. It is perhaps best to think of the non-player as the fundamental game mechanic; the series of functions, algorithms and the artificial intelligence that has been created during the development of the game. The non-player (as shown in Figure 6.1) manages the gaming experience for the player by monitoring their actions and providing appropriate feedback. This project explores the possibility of integrating a human into the non-player element of the game. In fact in the final version of the game the behaviour of the non player character is used to help differentiate between the game levels.

Meanwhile, a human non-player (as shown in figure 6.2) is a user who is able to monitor the actions of some other user(s) who are playing a game. As part of the fundamental game mechanic, the human non-player is able to manipulate the game play for each of the user(s) he/she is monitoring in order to alter the game state so as to provide either an advantage or a disadvantage within the game environment.

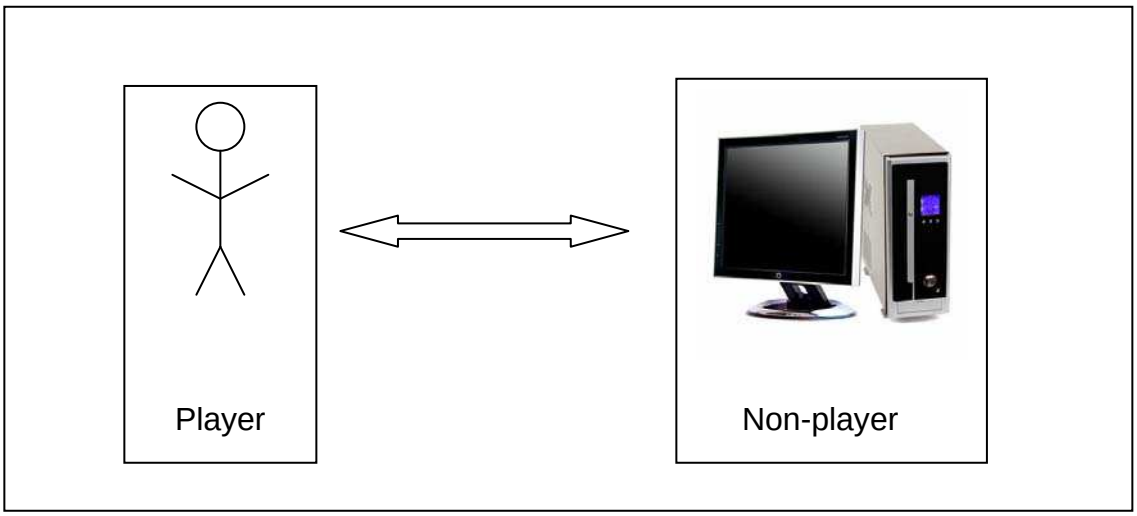


Figure 6.1: A diagram representing a typical computer game arrangement

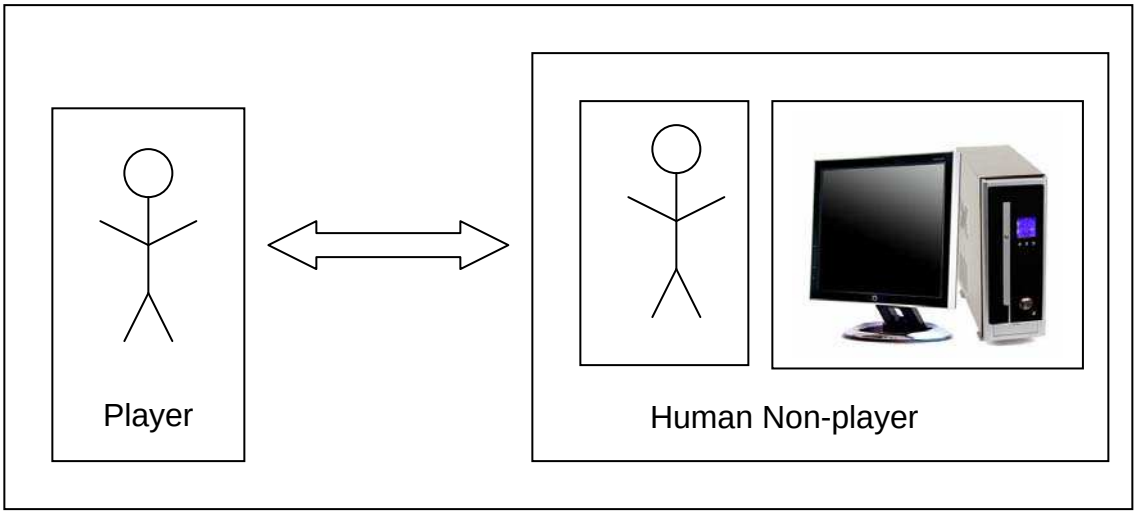


Figure 6.2: A diagram representing a computer game arrangement including a human non-player.

The use of human non-players in games today is limited. A large portion of game-based research is concerned with the development of ever more complex artificial intelligence algorithms. While this research is certainly

important, the potential use of human non-players is being largely overlooked. One of the advantages of using a human non-player for educational gaming presents itself in a classroom environment. Parents are much less likely to be sceptical of the idea of using computer games for education if a teacher figure is a part of the process. A further advantage gained by using a human non-player is that detailed feedback can be provided on how well a player is performing and the ability to accurately adapt the game to the player. This point is used to great advantage in the GeoEmmision game.

6.2 The GeoEmission Game Design Mechanic

6.2.1 The initial design of the GeoEmission game

As mentioned in the previous chapter, the initial design of the GeoEmission game consists of one level which allows the players to choose the Greenpeace person as their character. The reason for this is to give the basic level of understanding in a linear fashion where by the player is able to become familiar with the game environment. The design of the game mechanics in this level is simplistic for example planting trees will decrease the amount of Co2 by -2. The mini games were included in this initial design and the reasons were discussed in the previous chapter.

In this level, the player has several options to choose from in order to minimize the Co2 level at the same time as maintaining the energy required for the city and also improving the city's economy. These options include planting trees, introducing renewable energy technology and campaigning to close down heavily polluted factories.

The teacher acts as the NPC, which acts as the mayor of the city. This initial version of GeoEmission was used in the Empirical Study.

6.2.2 The 2nd version of the GeoEmission game

The main differences of the 2nd version and the initial version in GeoEmission game was the removal of the mini games. In this version, the players engaged with the main game. The reason for removing these mini games from the main game components was discussed in chapter 5. This version of GeoEmission was used in the Experimental Study.

6.2.3 The 3rd version of the GeoEmission game

An alteration has been introduced to the game mechanic for the 3rd version of the GeoEmission game which involved changes to the model for the game mechanic. In the first versions a simple linear model was used where e.g. each set of trees produce a simple linear change in CO_2, power stations produce constant output, power drain is constant. All of these mechanics are linear and unrealistic model that leads to an 'easy solution'. However, the third version, is similar to the previous version in terms of the user interface but the game mechanic now includes a more complex model. For example oxygen output / CO_2 absorption is now variable, changes with the time in the game year links amount of CO_2 absorbed to sunshine. A photovoltaic generator gives varying amounts of output per day and depends on the time of year. Weather conditions control effectiveness of wind power, etc.

In the original design it had been intended that new levels would introduce varying levels of challenge. However, it was also intended that completion of one level would "unlock" new potential player characters. In the original concept the game would start with only the Greenpeace activist available to the player. This character would have a limited set of abilities that they could use. (For example, planting trees or introducing a limited number of "clean energy" resources.) In the second level the "scientists" character would

also be available, with an increased and more complex set of solution tools. In practice it was not evident why this mechanic would be useful. How, for example, would the previous role of the Greenpeace activist continue to be usable? Therefore in the first and second versions of the game as implemented the only player character available was the Greenpeace activist and this player character was given the ability to introduce the full range of potential responses to the climate change problem (those appropriate to the scientist, the industrialist and so on). This allowed players of the game to investigate the full range of possible approaches to solving the problem. However, with hindsight, it would have been better to replace this Greenpeace character's representation with that of a generic "player", with a choice only of that being represented by a male or female character. Thus in the third version of the game this approach has been adopted. In the original concept the idea had been for a number of different levels to exist which introduce a series of different scenarios. However, again with hindsight, it was felt that it would be better to merely have two levels. The first level would allow the player to "solve" the problem by adopting fairly obvious solution approaches. This is achieved by the model of the climate change problem being basically linear. In the third version of the game the second level introduces a more realistic model of the effects of any game play action. This was achieved by introducing the non linear model, described above and outlined further below.

Every month (depending on the months) an amount of sunlight is randomly chosen depending on the time of year (winter = smaller ranger because of shorter days). Average sunlight has an effect on CO_2 absorption and an effect on solar energy generators. Another change that was made in this version is that of no longer having a range of player choices. The player is only able to choose whether a male or a female character is used. The whole concept of the game in this version is that two levels will exist – one with a simple model that allows users to investigate solutions to global warming that will generally work and a second level with the same interface but a more

challenging problem due to the more complex model of global warming. Such variation is limited by only allowing a small range of totally random responses to be used. This is easily implemented in C# as shown below.

```
Random rand = new Random();
sunLight = rand.Next(0,6), rand.Next(3,12);
```

Further developments would allow the ranges for these random variables to be generated algorithmically.

In the third version of the game in addition to the change in model a change in role for the NPC (teacher) is introduced. The teacher now plays the role of making sure the second level is more “realistic”. In the first level in this version of the game the teacher is restricted to monitoring the player performance – allowing the introduction of “loans” to players who have made poor choices and run out of money so that they could investigate further avenues to the solution. In the second level the teacher is able to make more interventions. For example, when a player chooses to introduce a wind farm the teacher NPC can intervene by telling the player that planning permission has been denied and the planned wind farm cannot go ahead! This then requires the player to investigate other options and therefore interact with more of the learning material but also experience a more realistic problem to solve.

This third version of the GeoEmission game was used in the 3rd experiment and the results discussed in chapter 7.

6.2.4 The human non-player software (the teacher)

As introduced in section 5.3.4, figure 6.3 illustrates the human non-player software interface. There are three key areas that need addressing with regards to the human non-player software. These are:

a) How does the software allow the user to monitor other users playing the educational game?
b) How does the software allow the user to manipulate the game play for the other users playing the educational game?
c) How does the software allow for the user to perform the previous two tasks for more than one other user who is playing the educational game?

In order to satisfy these three conditions, the software takes the form of a ‘control panel’. The control panel provides a set of tools that enable the user to easily monitor and manipulate game play for each of the connected clients individually. These tools are detailed next.

One of the most important tools is the Focus tool. As the system was built to handle multiple clients/players, some mechanism was required in order to differentiate between individual clients. The human non-player needed to monitor individual players of the game and to make changes that are specific to them. With this in mind, the focus tool allowed the software to collect data from all the connected clients, but to only display the information about the client who is currently ‘in focus’. Similarly any game play manipulation the user (teacher) wishes to perform will only be applied to the player who is in focus. The user is able to switch focus by either pressing the right/left keys on the keyboard or by clicking the back/forward arrows on the control panel.

The next tool is simply concerned with the state of the server. It allows the user to see how many clients are connected (i.e. how many players the human non-player is currently managing), the maximum number of clients the server can handle and whether or not the server is online. The second tool provides the user with up-to-date values for each of the four key variables (temperature, energy, Co2 emissions and money). This allows the human non-player to easily identify if the player is having trouble with a particular variable. For example if the energy value is equal to zero, clearly the player hasn't built any energy producing buildings. This might suggest to the human non-player that this particular player hasn't grasped the concept that their virtual city needs energy to function. The human non-player can react to this and attempt to help the player by using one of the manipulation tools.

The third tool is a graph. While it is useful to have an up-to-date recording of the four key variables, that information alone could be misleading. The graph used is a line graph which plots the information for the four key variables over time. 4 new points (one for each of the variables) will be plotted onto the graph every 3 seconds. By analysing the player's history, the human non-player can make better judgments as to how the player is performing. The fourth tool is the last of the monitoring tools in the software. It shows the user any reward cards the player has received through playing the game.

The four previously mentioned tools are all used to monitor the players of the game. The following tools each enable the human non-player to manipulate the game play in some way. The most important manipulation tool takes the form of a set of eight buttons. There is an increase and decrease button for each of the four variables, e.g. 'Increase Energy', or 'Decrease Funding' etc. These buttons allow the human non-player to manipulate the game play if, when and where required. The effect of clicking one of the buttons is immediate.

The second tool is a simple pause/play button that allows the human non-player to pause then resume game play for all players who are connected to the server. This feature is particularly useful in a classroom environment, for example when the teacher wishes to make an announcement and wants the full attention of all the students, the pause button is used to ensure students do not continue to play the game when they should be listening. This is the only tool that takes effect across all connected clients, not just the client in focus. The third tool is a messaging tool that enables the human non-player to type a message and to send it to the client on whom the software is currently focused. This enables the user to give more direct feedback to the players. It also adds a dynamic element to the game play, which in turn should help to keep the experience engaging for the players.

A notification system is implemented to alert the user to various client/server events. For example, a notification was display when a new client connected to the server.

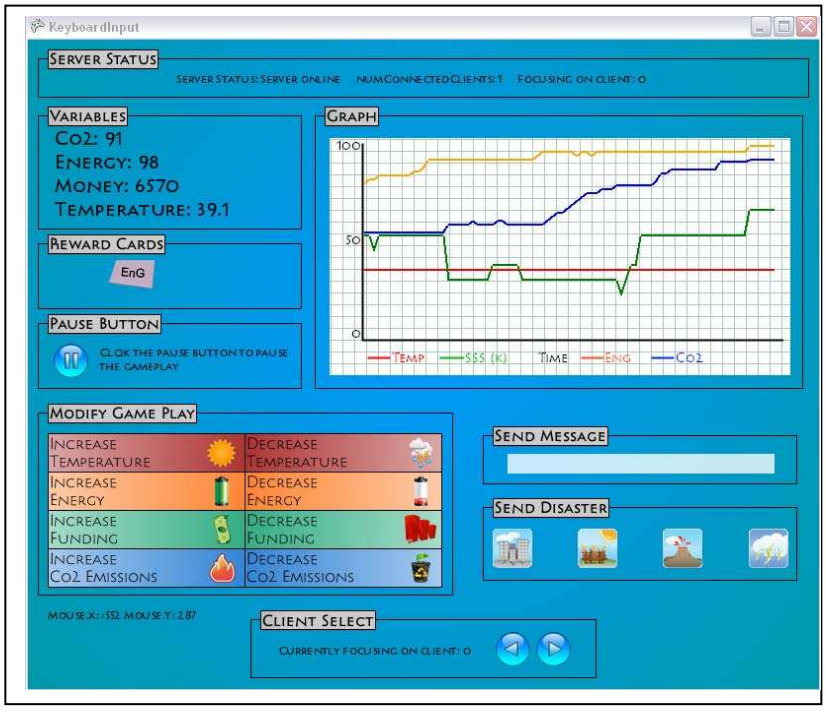


Figure 6.3: Teacher's main screen

6.2.5 Key design features of the human non-player software

All elements of the design have been carefully thought about to ensure maximum efficiency and ease of use. The first thing to note is that all the tools are immediately accessible and visible within the same window. This is an important aspect of the design because the human non-player is responsible for overseeing multiple clients. Therefore the teacher does not want to be wasting time by opening up tools in different windows or changing views in order to get to the tool they want. All required information is up-to-date and immediately available.

The second thing to note is that, aside from the server status tool, no other element of the design is focussed on the server. The software handles all client connections/disconnections automatically and the human non-player should not have to worry about accepting/denying clients.

The third key aspect of the design is the layout of the tools. The windows can be loosely split into thirds with the server status tool at the top of the window, the monitoring tools in the centre and the manipulation tools at the bottom. A conscious decision was made to arrange the tools in this way. The user is likely to spend most of their time monitoring the players and so it makes sense to centre these tools in the middle of the window. The graph is likely to be the most used tool and thus it is given the largest portion of the window in terms of size.

The fourth key design feature is concerned with providing the human non-player with feedback after having used one of the manipulation tools (this feature is not depicted in figure 6.3). Once the human non-player used one of the tools, the mouse pointer is momentarily changed to a green tick and a sound is played. This help to prevent the occurrences of accidental use of the tools.

The fifth key design feature handles the way in which the user is able to act as the human non-player for more than one client at a time. Upon clicking the next/previous client button (N/P), all the tools are immediately updated to display the information for the next/previous client. This transition is instantaneous, as the user will spend a lot of time switching between clients. It would be very inefficient for the user to have to wait for the information to load each time a different client is selected.

The decision was made not to create a server-side renderer as it was felt there was no need for one. Using the design above, the user is still able to keep track of all the key variables and is provided with all the required information to fully understand how difficult/easy the players are finding the game. It was felt that a server-side renderer would slow the system down and clutter the display.

6.3 The GeoEmission Technical Implementation

6.3.1 Technical analysis of the human non-player software.

All programs developed within XNA can be exported to run on a Windows-based operating system. To set the window size of an XNA project, the following two lines of code should be added to the constructor:

```
graphics.PreferredBackBufferWidth = 800;
graphics.PreferredBackBufferHeight = 600;
```

XNA provides MouseState and KeyboardState objects, which will be used to allow interaction with the program via mouse and keyboard. For example to determine if the space bar key is pressed down, the following code should be added to the Update method:

```
KeyboardState keyboard;
If (keyboard.IsKeyDown(Keys.Space)) { /* Do Something*/ }
```

The next requirement ensures the program provides the user with a selection of choices. A simple menu was implemented via a series of if/else statements being used to determine which button the user has clicked. For example the code to determine whether or not the user has clicked the start server button looks like this:

```
MouseState theMouse, prevMouseSate;
if (theMouse.X> 29 && theMouse.X<229 &&
theMouse.Y>399 && theMouse.Y<439)
{
     if (theMouse.LeftButton == ButtonState.Pressed &&
          prevMouseState.LeftButton !=ButtonState.Pressed)
     {
          // User has clicked the start server button
     }
}
```

If the user does click the start server button, a server will be created and will begin to listen for incoming messages from clients. The Lindgren library was used to handle the networking aspect of this project. Lindgren.Library.Network is a pure C# networking library using a single UDP socket which delivers a simple API for connecting a client to a server, reading and sending messages” The server is created as follows :

```
public void createServer()
{
     NetConfiguration config = new
     NetConfiguration(“chatter”);
     config.MaxConnections = 128;
     config.Port = 14242;

     server = new NetServer (config);
     server.SetMessageTypeEnabled(NetMessageType.Connection
     Approval, true);
     server.Start();
     serverRunning = true;
     info = “Server online”;

     buffer = server.CreateBuffer();
```

```
        runNotification(“Server Online\n” +
        numConnectedClients +” /x connected clients”, 1);
}
```

6.4 Use Case Diagram and Case Diagram of the GeoEmission Architecture

This chapter describes the game structure and the design in depth. There are three versions of GeoEmission.

6.4.1 Use case diagram for GeoEmission game

Figure 6.4 illustrate the user interaction for students and the GeoEmission game and also the teacher and GeoEmission game. The student has the ability to start the game, play the game and end the game while the teacher able to monitor the GeoEmission game and also manipulate the variables in the game. For example, the player starts the game by selecting the ‘Start Game’ option from the main GeoEmission screen and then the player then chooses his/her preferred character (whether a male/female character). Once the game enters the main game environment, it automatically connects to the server thus allowing the human non-player (the teacher) to monitor and manipulate the game’s entities. This server/client connection remains connected throughout the game play until the player end the game.

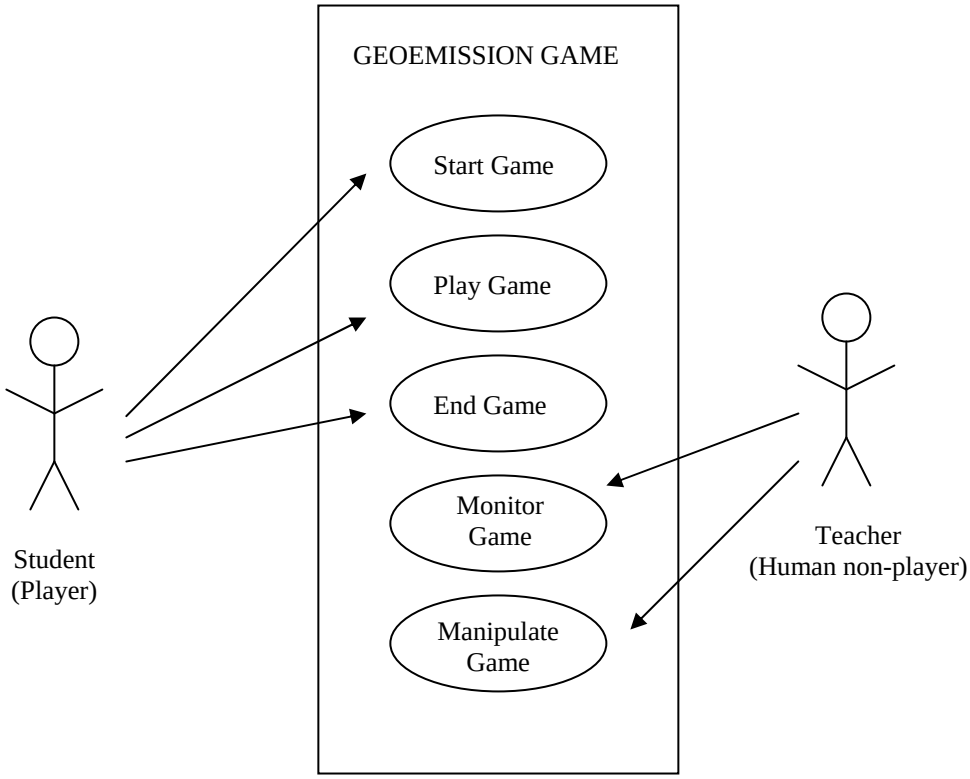


Figure 6.4: Basic overview Use Case diagram for GeoEmission Game

The following use case diagram depicts the various interactions between the human non-player, the player and the two pieces of software. The four key variables referred to within the human non-player boundary and the GeoEmission boundary are the same set of variables.

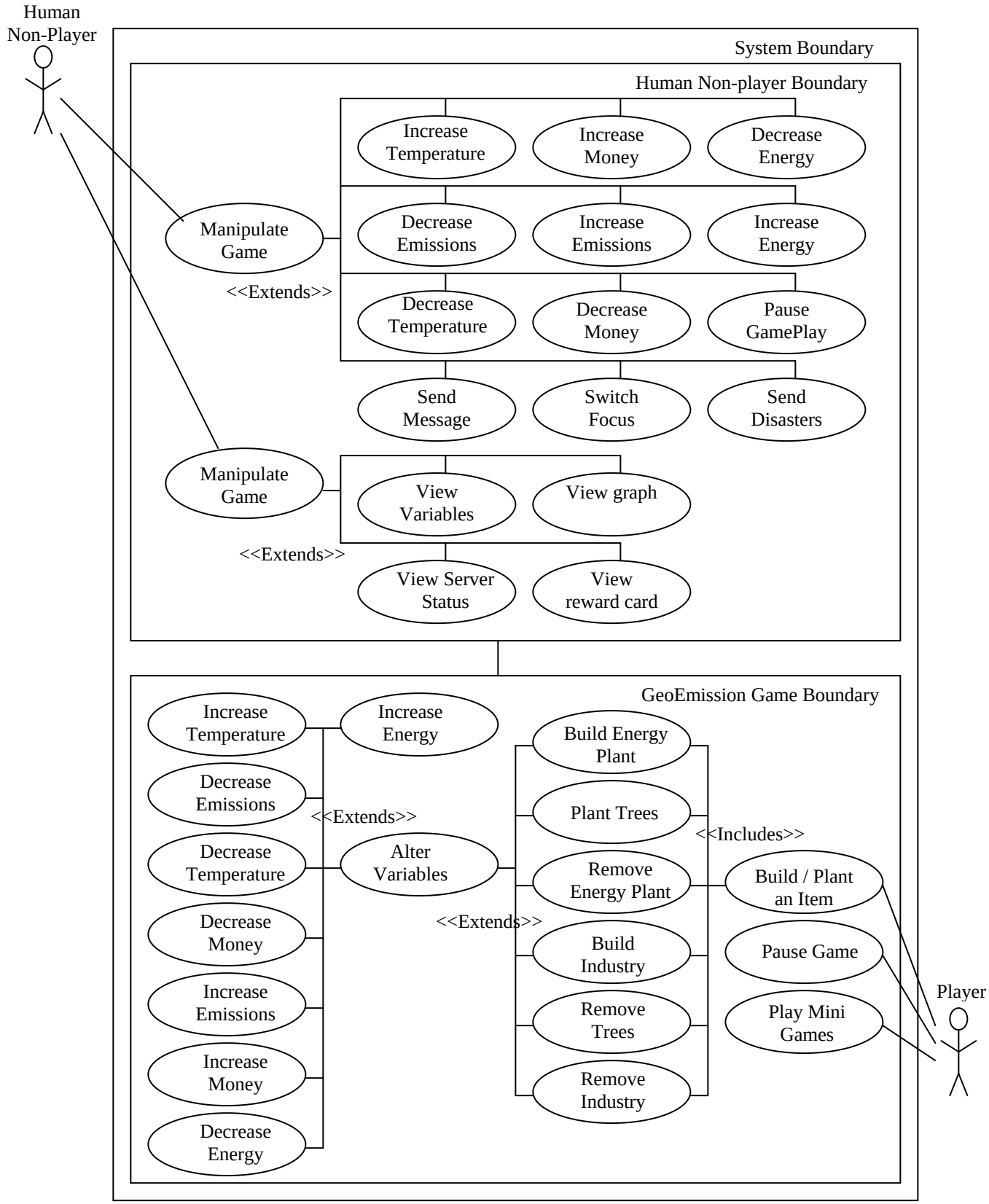


Figure 6.5: Use Case diagram for GeoEmission game and Human non-player interactions

6.4.2 An overview of the human non-player classes and their methods

In order to provide the appropriate functionality, the program will be split into 4 classes as shown in Figure 6.6. There are:

a) `Game1.cs` – This will act as the main class from which the software will run

b) `Client.cs` – This class will be used to provide a Client object that will allow the server to keep track of all the information for all the connected clients

c) `TextBox.cs` – XNA does not provide native support for user input through typing using a keyboard. The TextBox class will handle text input via the keyboard

d) `Program.cs` – Acts as a starting point to load the program. This class is a part of the XNA project template ans will not require any modification.

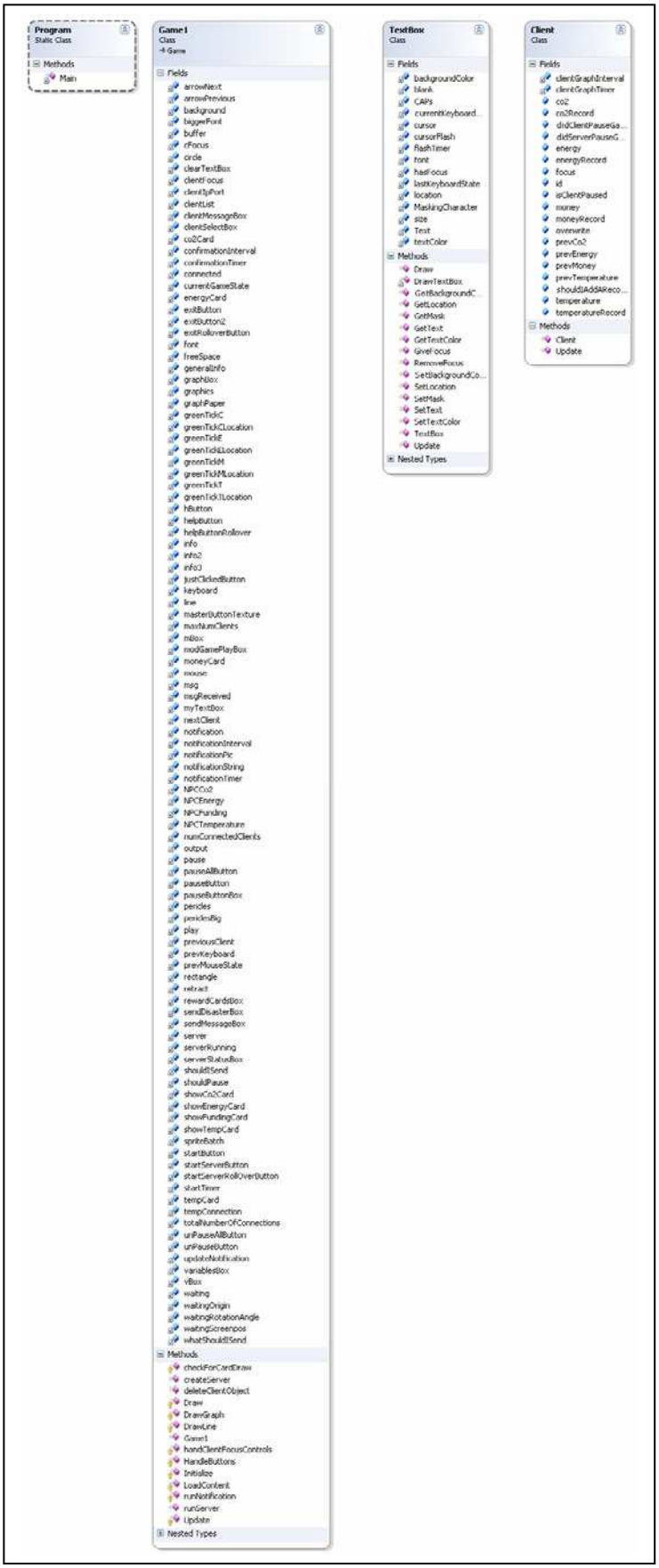


Figure 6.6: Case diagram for human non-player

Each of these classes will now be discussed in more detail and the major methods within the classes will be established.

a) `Game1.cs` methods

The main class will be the Game1.cs class, which is given as a template when creating a new piece of software using the XNA Game Studio. This class provides a number of compulsory methods that are used to organise the code in an efficient manor.

i. `public Game1()` – The Constructor

   This method will be used to initialise various starting variables.

ii. `protected override void LoadContent()`

   This method is simply used to load all of the content(graphics, textures, etc) when the program launches.

iii. `protected override void Update(GameTime gameTime)`

   This is one of the most important methods in the Game1.cs class. It is responsible for handling all the logic behind the program. The gameTime variable will be used to sync the Update method with the Draw method. The Update method will be responsible for:

   1. Handling any input from the user
   2. Determining the *currentGameState*
   3. Starting/stopping timers as required
   4. Running the server.

iv. `protected override void Draw (GameTime gameTime)`

   The Draw method is used to draw all graphics to the screen.

v. `public void createServer()`

This method will be used to create a new instance of a server using the Lidgren networking library. The port on which the server operates (a port number that is not already commonly in use will be used to avoid any clashes) will be defined along with the maximum number of connections the server can handle.

vi. `public void runServer()`

This method will be called from the Update method and will allow the server to check for any new connection requests from clients, check for any disconnection events from clients, check for any new messages sent by the clients and if required, to send any messages to the clients.

b) `Client.cs` method

i. `public Client (string theId, bool inFocus)` – The Constructor

The Constructor will be used to set the Client object's unique id and to initialise all Client-related variables.

ii. `public void Update(GameTime gameTIme)`

This method will contain a timer that will be used to determine whether or not to plot a point onto the client's graph.

c) `Textbox.cs` method

i. `public Textbox (Vector2 Location, int Width, ContentManager content)`

The constructor will be used to set the x and y coordinates of the textbox and the textbox width. A *COntentManager* object will also be passed as a parameter to allow access to various Font's and Textures.

ii. `public void GiveFocus()`

This method simply gives focus to the TextBox and hence, allows the user to type something into it.

iii. `public CycleControl Update (GameTime gameTime)`

This method handles the input from the keyboard by determining which key has been pressed.

iv. `private void DrawTextBox(SpriteBatch SpriteBatch, byteAlpha)`

This method is used to draw the textbox and any text the user has entered.

d) `Program.cs` method

i. `Static void Main(String[] args)`

This is the only method in the Program.cs class and simply used to run an instance of the Game1 class.

6.4.3 An overview of the main GeoEmission classes and their methods

The main GeoEmission game components involves a large number of classes in order to provide the appropriate functionality as shown in figure 6.7 and figure 6.8. Both figures show the complexity of the game mechanics and how the components are held together from a software engineering perspective. Here are the list of some major classes that are involved in the design and the development of the GeoEmission game :

a) Main game component – GameplayScreen.cs
b) Buildings components – Powerstations.cs, Industries.cs, Trees.cs, etc
c) Vehicles components – GreenCars1.cs, Buses.cs, Cars1.cs, etc
d) Game screen management components – GameScreen.cs, ScreenManager.cs, MenuScreen.cs etc.
e) Inputs components – InputState.cs
f) Mini games components – Protesting.cs, Drive.cs.

a) Main game components

`GamplayScreen.cs` methods

This is considering the main class of the GeoEmission game which handles most of the game mechanics interactions and the behaviour of the game mechanic together. Examples of game method used in this class are :

i. `public override void HandleInput (GameStateManagement.InputState input)`

This method is used to let the game respond to player input.

ii. `protected override void LoadContent()/ protected override void UnloadContent()`

This method is simply used to load and unload all of the content (graphics, textures, etc) when it is executes.

iii. `public void AddObject()/ public void RemoveObject()`

This method refers to the core game's mechanics where it handles all adding and removing an object in the game state environment. This includes for examples the calculation method of adding / removing an object and checking the location when adding /removing an object,

iv. `public void DrawAnimatioin(SpriteBatch batch,`
`Texture2D img, Vector2 position)`

This method involves calculating the number of frames in the texture, reset the elapsed counter, and draw the selected animation position onto the game screen.

v. `public void Navigation1(Vector2 input)`

The purpose of this method is to handle the inputs from the player in navigating around the game space environment.

b) Buildings components

`Creatures.cs, Powerstations.cs, Industries.cs, Trees.cs`

methods

The building classes are a unique identifier for a certain building types. Each class contains their own constructors for example:

i. `public Powerstations() / public Industries() /`
`public Trees()` – The Constructor

These methods are used to initialise the unique variables for each different method.

c) Vehicles components

`Vehicles.cs, GreenCars1.cs, Buses.cs, Cars1.cs` methods

The vehicles classes are a unique identifier for a certain vehicle types. Each class contains their own constructors for example:

i. `public GreenCars1(int start) / public Buses(int start) / public Car1(int start)`

This method refers to each vehicles initial starting location to move to another location in main game screen.

ii. `public override void Update (GameTime gameTime)`

This method is used to update the next location of the direction of a certain vehicles movement.

d) Game screen management components

`GameScreen.cs, ScreenManager.cs, MenuScreen.cs` methods

The game screen management classes are a unique identifier for a certain vehicle types. Each class contains their own constructors for example:

i. `public void FadeBackBufferToBlack(int alpha)`

This method gives a nice smooth transition between screens. It is used for fading screens in and out, and for darkening the background behind popups.

ii. `private bool UpdateTransition (Microsoft.Xna.Framework.GameTime gameTime, System.TimeSpan time, int direction)`

This method is used for updating the screen transition position.

iii. `public override void HandleInput(GameStateManagement.InputState input)`

This particular method is used to responds to the user's input, changing the selected entry and accepting or cancelling the menu.

iv. `public virtual void OnSelectEntry(int entryIndex)`

This method is a handler for when the user has chosen a menu entry.

e) Inputs components

`InputState.cs` methods

The inputs component class is an important class that handles all the input received from the player via the gamepad.

i. `public InputState()`

This method construct a new input state.

ii. `public bool IsMenuSelect (Microsoft.Xna.Framework.PlayerIndex playerIndex)`

This method is specifically used to check for a "menu select" input action from the player

iii. `public void Update()`

This method reads the latest state of the gamepad

f) Mini games components

`Protesting.cs, Drive.cs` methods

These two methods belongs to the mini games class which was used in the first version of GeoEmission game.

i. `public override void Update(Microsoft.Xna.Framework.GameTime gameTime,`

```
bool otherScreenHasFocus, bool
covereByOtherScreen)
```

This method allows the game to run logic such as updating the world, checking for collisions, gathering input, and playing audio in the background in the petition challenge mini game.

ii. `private void AddHazard()`

This method is used in the Biofuel challenge mini game. It is responsible to create a random hazard (petrol can) on the road which the player must avoid in order to score higher marks.

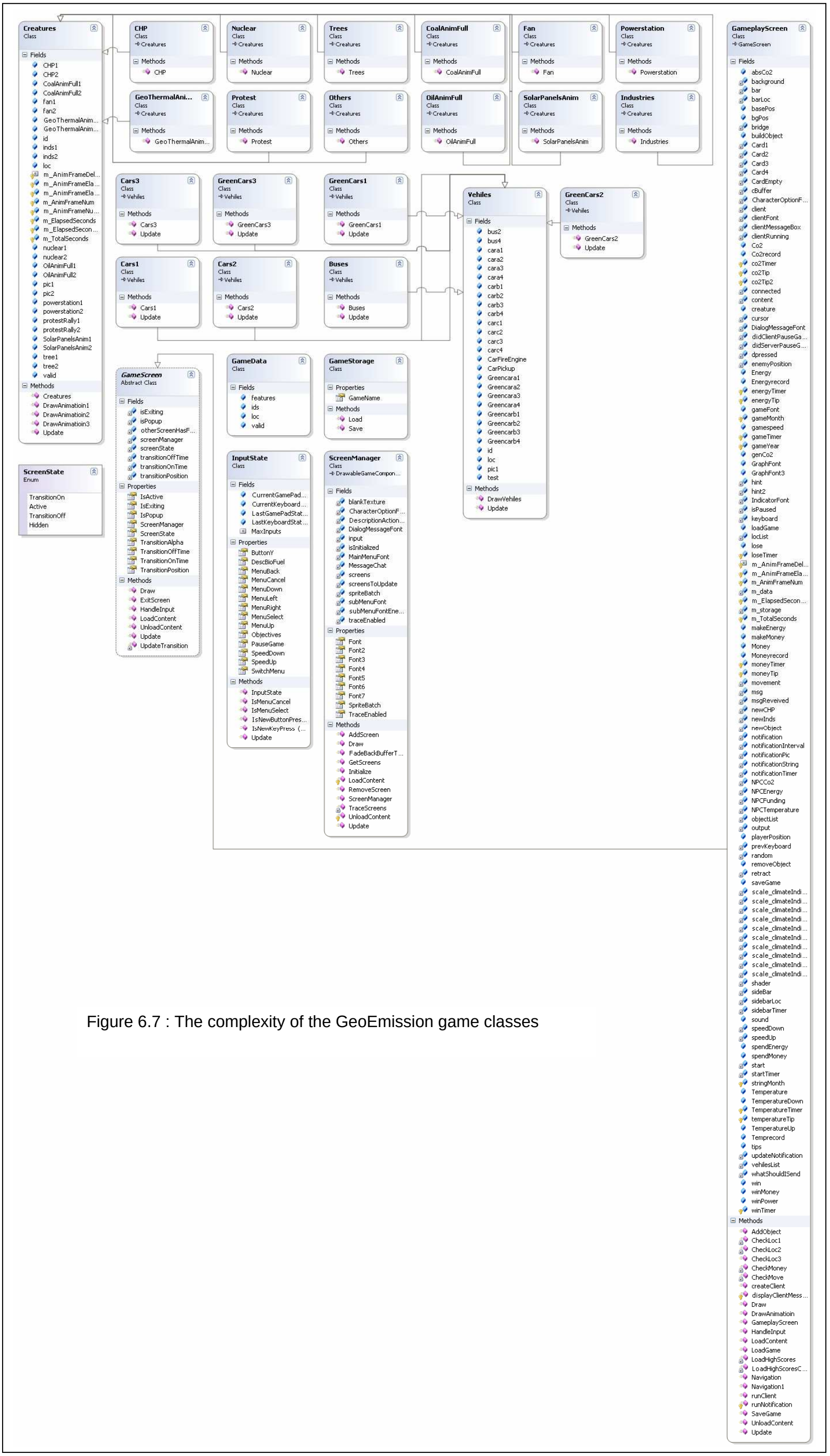


Figure 6.7 : The complexity of the GeoEmission game classes

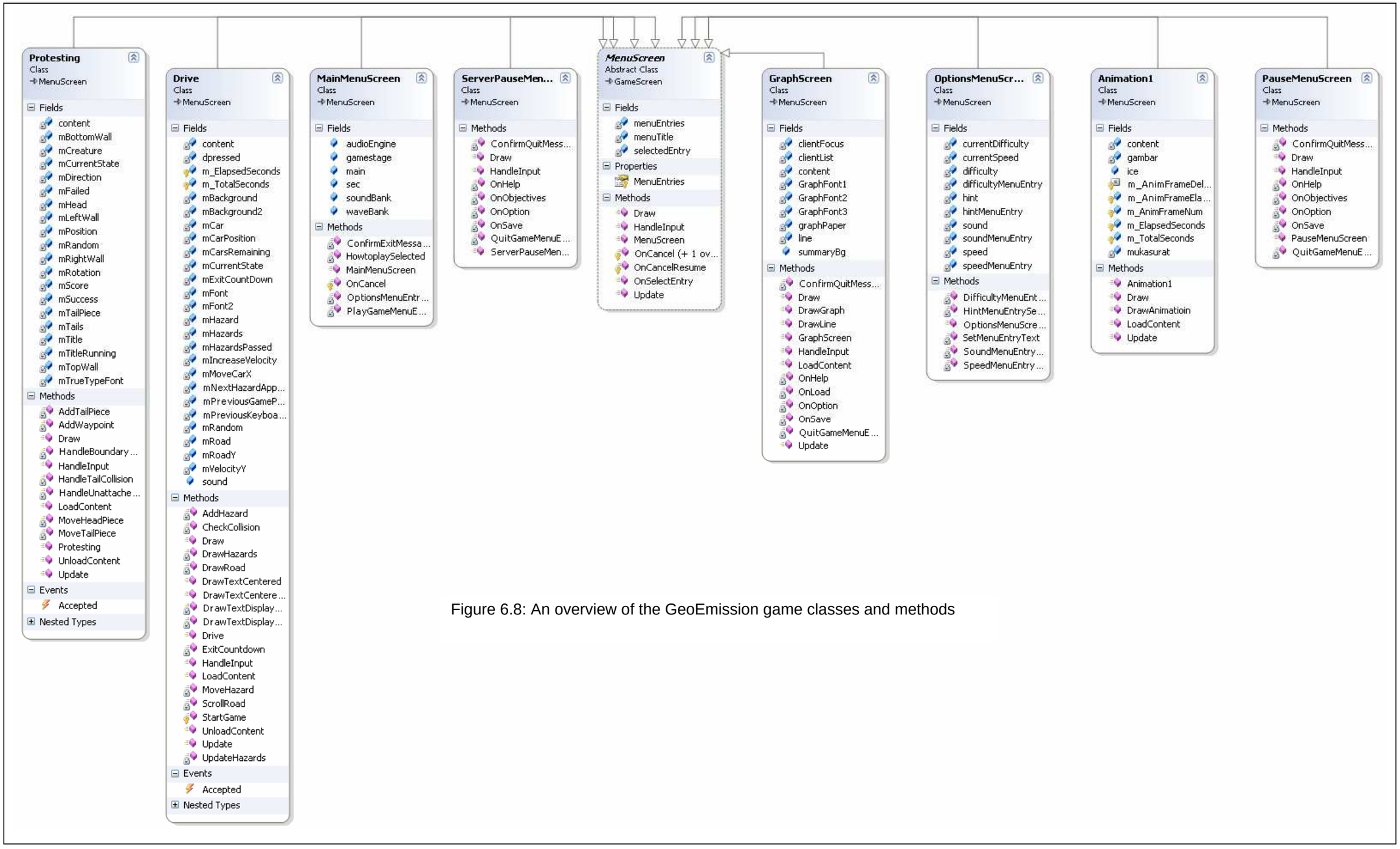


Figure 6.8: An overview of the GeoEmission game classes and methods

6.5 Summary

The GeoEmission game was developed using the XNA Game Studio platform which is an integrated development environment (IDE) that includes tools and code development libraries to create computer games for Microsoft Windows and XBox360. XNA Game studio is based on the C# and object-oriented programming (OOP) languages through Visual Studio 2005 (at the time of development). The main reason for choosing the XNA Game Studio is the ability of many tutorials and starter kits as well as it being a very easy to use and fast to learn programming environment on personal computers (PC). XNA allows you to take your existing Windows code and let it run on a console. It gives you a completely different feeling about consoles, you suddenly feel more in control and interact directly with it as a development system.

The GeoEmission game involves complex mechanics and relationships between each module. The game mechanic was designed and implemented as logically as possible thus giving the correct output and information to the player. Many requirement specifications have been taken into consideration, for example heavily polluting industries produce high CO_2 levels. Another important component of the GeoEmission game was the ability to enable the teacher to influence the game play by adding realistic responses to the game, making it more challenging for the players. Not only that, the GeoEmission game allows the teachers to monitor, maintain control of the class and also facilitate the learning process. This chapter has provided extensive detail of the architecture of the GeoEmission game mechanic as a whole.

CHAPTER VII

EXPERIMENTAL RESULTS AND ANALYSIS

7.1 Introduction

This chapter describes the results and analysis of all three studies. As stated in Chapter 4, the empirical study involved twenty Key Stage 3 students and their Geography teacher from a local secondary school in the UK while the experimental study involved a further twenty students and the same Geography teacher at the same school. The third study was carried out in Malaysia and involved an additional twenty participants with multi-ethnic background consisting of the three main ethnic groups in Malaysia, which are Malays, Chinese and Indians. The final study allowed the software to be tested in a very different academic culture – one in which group discussion in class is particularly difficult to engender. It also allowed a study of whether collaboration would take place across the ethnic groups – something which is equally difficult to produce in a normal Malaysian classroom but something the Malaysian government are eager to stimulate.

7.1.1 Rationalization on the location of the studies and the curriculum plan

All the studies were undertaken during game-play sessions within the same real-life classroom environment the students were used to. Figure 7.1 below illustrates the classroom floor plan for the room in which the first two

studies took place while Figure 7.2 illustrates the floor plan of the computer laboratory where the control group of students used the Internet and figure 7.3 shows the environment settings use of the third study.

It was important that this research was carried out in an actual teaching and learning environment with the intention that feedback could be obtained and evaluated more accurately and effectively. Running all these studies in the normal classroom was likely to prove significant in that both the teacher and the students would experience how game-based learning could be integrated into a routine lesson. It was felt that students would feel more comfortable and motivated, and behave more naturally, if the study was carried out in a familiar environment. Conducting both the empirical, experimental and the third study in an unfamiliar environment and location, such as a special laboratory, might cause discomfort and awkwardness or could cause increased communication because of its novelty alone.

7.1.2 Classroom setting

During the game play session, the teacher sat in his usual position at the front of the class, as shown in Figure 7.1. This enabled him to observe and control the attitudes and behaviour of the students, and to manage the discussion. Figure 7.1 also illustrates the grouping of the students into clusters, sitting close together and facing one another in order to encourage collaboration and promote discussion; which stimulates brainstorming and encourages critical thinking among peers.

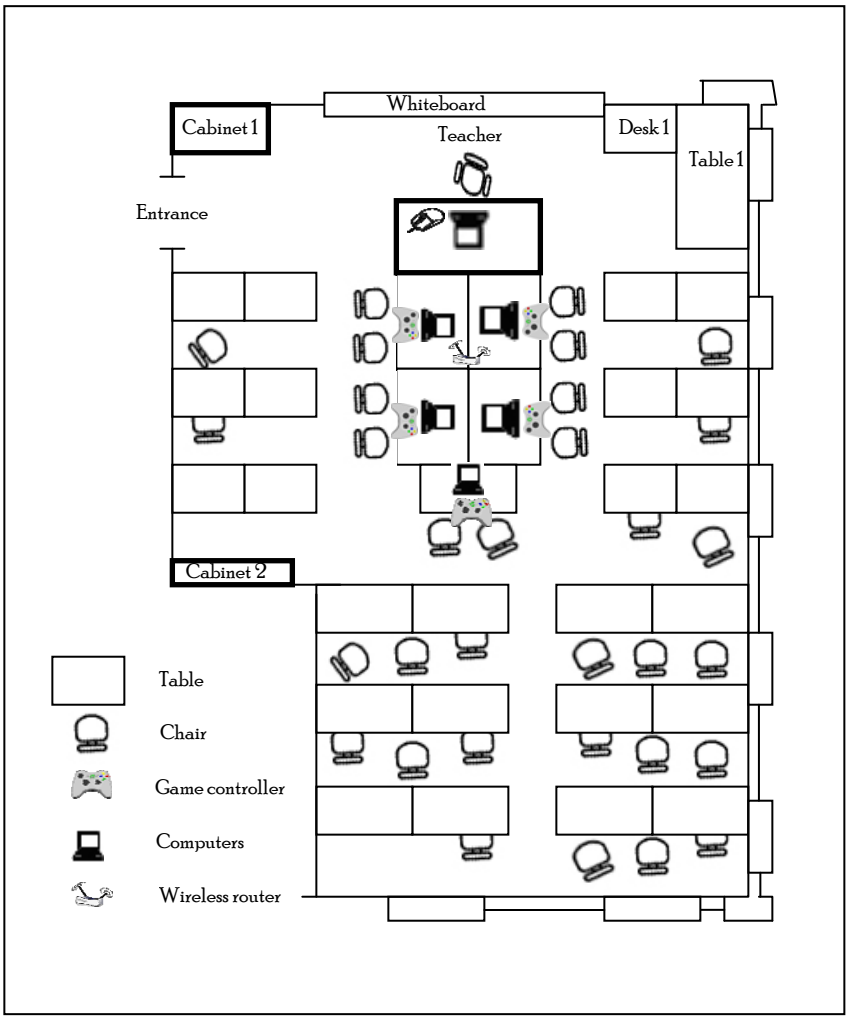


Figure 7.1: Layout of classroom

The internet session took place in the school's computer laboratory, the setting of which is shown in Figure 7.2, indicating that the layout was more conducive to individual work. It can also be suggested that the positioning of chairs and computers may have discouraged collaboration among these students, in contrast with those taking part in the classroom game-play session.

However, the layout of the laboratory was clearly not necessarily inhibiting the students from collaborating because as can be seen the students

are sitting in close proximity so the opportunity to collaborate with each other was still available and yet they chose to work independently.

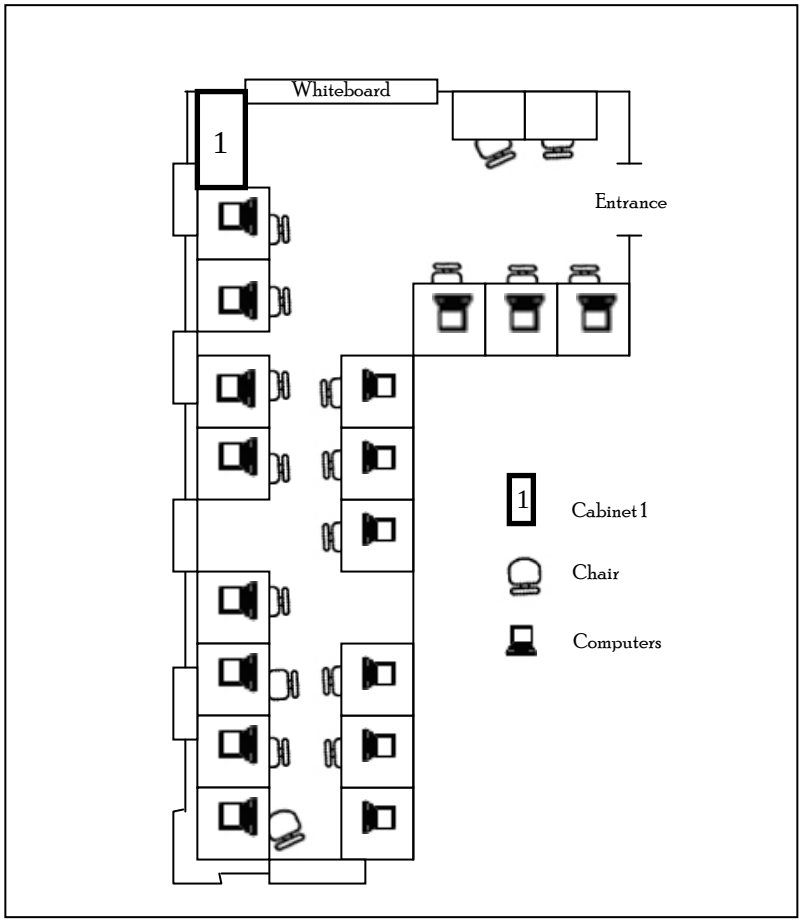


Figure 7.2: Layout of computer laboratory

For the third study, the session was carried out in an Information Technology laboratory as shown as figure 7.3. Again the students sit in close proximity with each other

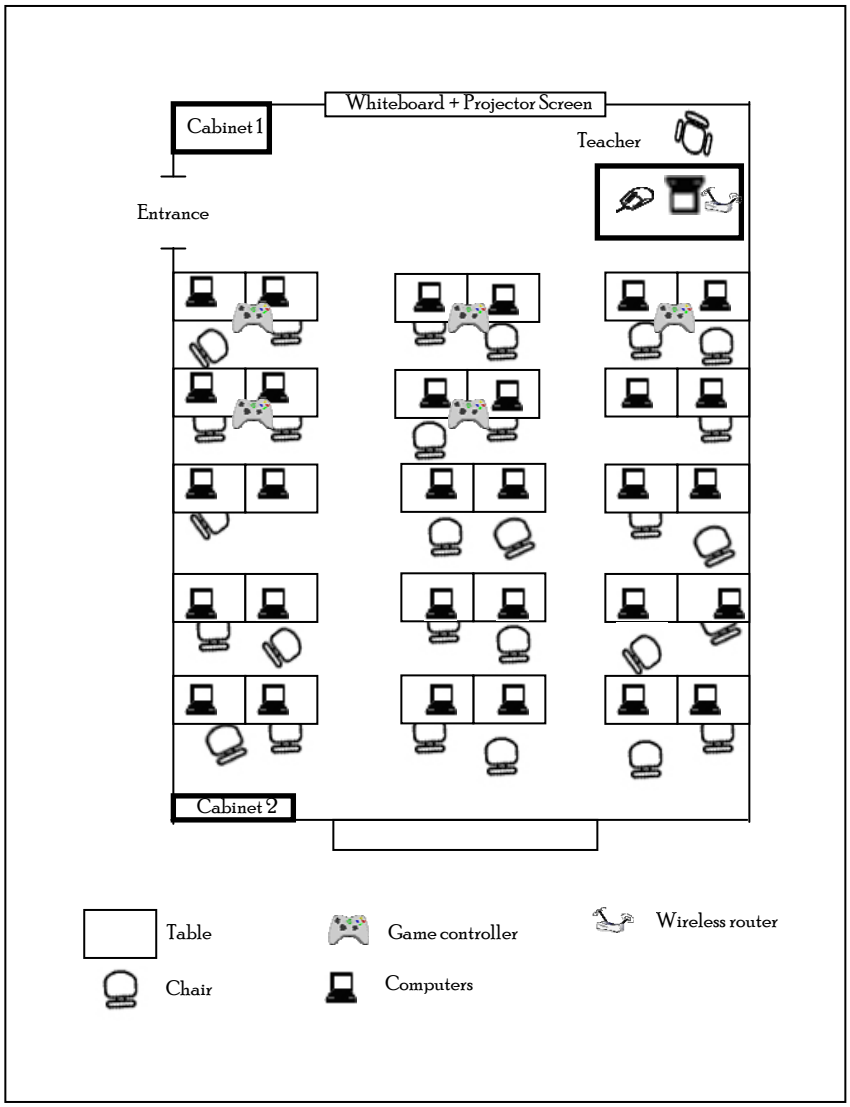


Figure 7.3: Layout of the Information Technology laboratory

7.1.3 Procedure for acceptance of study by the school

All studies were carried out in three phases: early stage, implementation and evaluation. The early stage consisted of identifying the demographic, including relevant school, age group and subjects.

The empirical study was scheduled to integrate into the school's own lesson plan for Geography. In order to be accepted by the proposed school, regulations had to be followed, including the completion of a written statement by the present researcher of how the study was to be undertaken. This statement was made on an ethics form from the School of Computer Science, The University of Nottingham.

The main purpose of this research was to investigate whether or not game-based learning could take place effectively in a classroom environment; it therefore had to be carried out in an actual teaching/learning setting for the students to gain maximum benefit.

7.2 Study 1: Empirical Study

The empirical study was carried out to investigate the effectiveness of introducing GeoEmission as a supplementary teaching tool for Geography, and to examine whether game-based learning can promote collaborative and cooperative behaviour among students in a normal classroom environment. The students were divided into two groups of ten for separate gaming sessions; each group represented either high or less high achievers, based on standardised achievement test scores. The game sessions were integrated into the Geography curriculum in consultation with the Geography teacher.

Each game session lasted sixty minutes, under the supervision of a teacher. Each group of students was divided into separate sub-groups based on gender (one pair of two males, three mixed groups, and one pair of two females). The data was collected through a combination of voice recordings and observations made and noted by a group of four assistants, who also dealt with the few technical problems that occurred, mainly related to the networking of the game. Despite the fact that the presence of the assistants could have changed

the behaviour of the group it was not felt that this was having an effect. Observers were also present with the control group and they did not actively engage in intra group communication. Even when the observers left the room, the control group still did not communicate with their peers. Communication and collaboration did not take place at all in the control group. In the experimental group however, this communication took place freely.

The full session of sixty minutes was split into three phases. First, the teacher held a discussion with the students in order to assess how they would perform in a group; the students in both groups were well known to each other. The discussion revealed interesting differences between the responses of each group: the high achievers all engaged fully in the discussion, although it was noted that most of their responses were directed at the teacher rather than at each other. Before the start of the study, both groups had been involved in the same sessions in which they had been introduced to the basic concepts relating to the human contribution to climate change. The high achieving groups, as expected, had retained more of this material and were generally more able to draw conclusions from it in response to the questions from the teacher. The lower achievers had to be encouraged to respond and were often very unwilling to demonstrate any knowledge they may have previously acquired. Part of the discussion was devoted to asking the students about their game playing habits; the girls in the lower achieving group were generally reluctant to admit to playing games other than casually. Nevertheless, one of the girls from this group showed greater skills in game play than her male partner, clearly showing that she had regularly played games previously. Indeed, she admitted after the session to playing a wide range of games.

Following this initial discussion, which lasted about fifteen minutes, the students played the game for approximately thirty minutes, although a short period at the beginning of that time was taken up with setting up the game and dealing with network connection issues. The players all readily adapted to the

game play interface, demonstrating that the design principles were successful. The character control keys and other command keys were the same as those commonly used for similar features in other games such as SimCity. The game was played using a game-pad rather than a keyboard or mouse, and the students were observed to be quite adept in using this. It became clear that the girls in the second group had greater familiarity with playing computer games than they had admitted in the first part of the session. However, the most important differences took place during the main game-play session, when members of both groups interacted with each other almost continuously. This was true both within sub-groups and between groups. Both groups showed significant collaboration in an attempt to win the game. It was also noted that, in contrast to the second group, the high achievers first investigated the game very thoroughly and became aware that the responses of the NPC varied for different groups, leading them to the conclusion that the teacher was in some way influencing the interactions of the NPC with the players.

The final session was used to evaluate the players' response to the game. Results of this survey suggested that the high achievers had derived new information from the game and were eager to discuss how this had helped their progress. The second group, however, had tended to use the more limited knowledge they had acquired previously rather than information drawn from the game; they had not progressed as well as the first group. Nevertheless, they maintained a greater level of interaction with each other and with their teacher than during the earlier discussion.

7.2.1 Did the mini games fulfil their purpose?

A mini game refers to a short computer game embedded within other computer games. It is usually more simplistic and takes minimal time to complete (Prensky, 2005). Kim and Yoon (2009) explain that mini games consist

of a number of games with a shorter playing time and lower level of difficulty than larger, more complex games. They also suggest that mini games can offer a greater fun factor than that provided by the main game, and can be utilized as a method to encourage greater immersion, with a different playing atmosphere than in a game with a long playing time. Mini games are said to act as a supporting tool to the main game. Many educational mini games have been produced, but it is generally considered that inserting mini games into an edutainment game will increase engagement because the players can be entertained.

However, the results of the empirical study do not bear this out. The group of high achievers, for example, spent little time on these, playing them only when required, as, for example, with the petition mini games, which had first to be completed before giving the option of organizing a peaceful demonstration rally. Furthermore, while the group of low achievers did find the mini games engaging, they were distracted from the main purpose of the game, and as a result the mini game did not reinforce the activity; the group did not focus on the lesson content in the main game and make progress.

The use of the Bio-fuel Challenge mini game, depicted in Figures 7.4 and 7.5, also demonstrated that mini games could divert some students' attention from the main purpose of the lesson. Bio-fuel is a valuable energy resource for transportation because of the low level of carbon monoxide it produces compared with petrol, a regular type of fuel. In order to enforce the use of bio-fuel for transportation in the game city, the students were asked to complete the bio-fuel challenge successfully. Most of the higher achievers treated the mini game as part of the task to progress further in the main game by attempting to solve the wider problem. A few may played it more than once, but subsequently returned to the main game to explore other options in order to engage with the main scenario of global warming. However, the low achievers group played it

repeatedly, despite successfully completing the task it presented, and paid little attention to the main game.

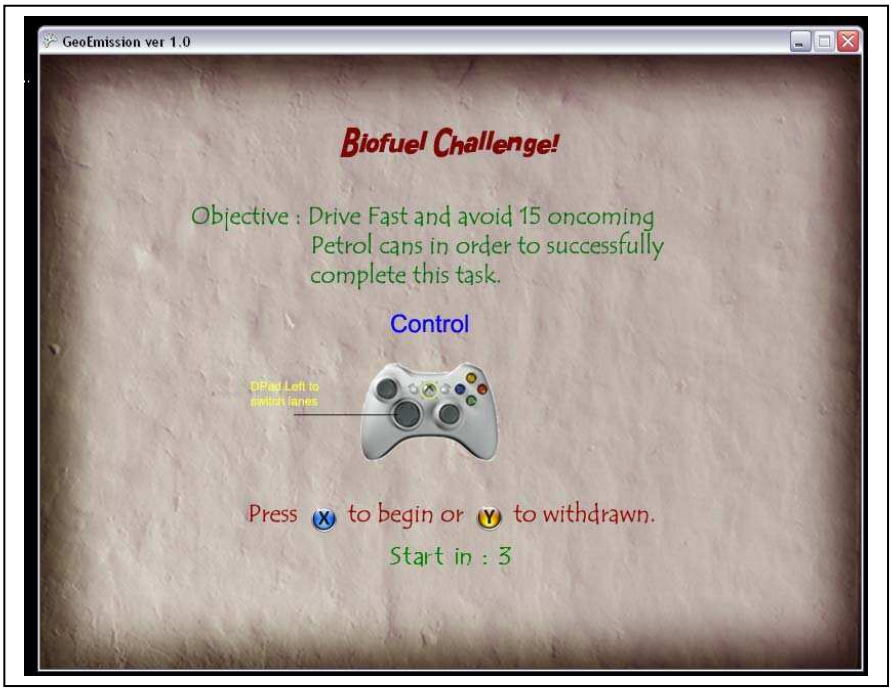


Figure 7.4: Instruction menu for Bio-fuel challenge mini game screen

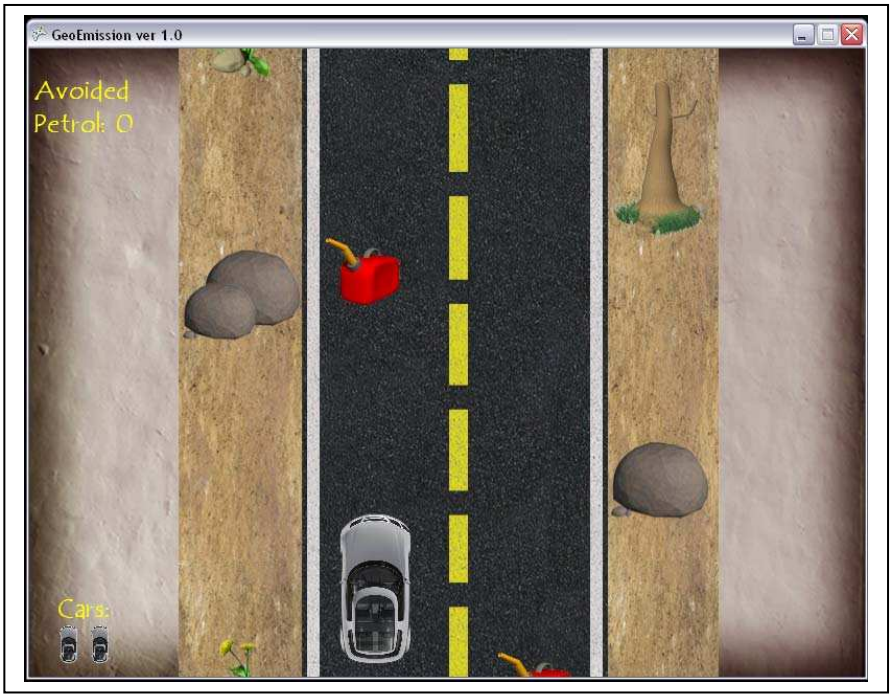


Figure 7.5: Challenge screen for Bio-fuel driving mini game

The researcher had therefore recognised a flaw in the initial phase of developing the design of the components and rules integrating the mini games into the main game. The design should have properly identified how and when the mini games could be implemented. This defect was immediately noted by the researcher after the empirical study had been completed. One solution could have been to limit the period before the player could return to each mini game in succession.

7.3 Study 2: Experimental Study

A second study was undertaken making use of a control-based experiment which involved two groups of students: one group played the GeoEmission game to answer a specific open-ended question, while the other used the Internet:

> *"What is the best way for a country like the UK to maintain the energy production it needs and yet reduce the impact of CO2 emissions?"*

The major aim of the experiment was to test whether inter-student communication was mainly affected by the game environment or merely by the fact that they were not in their normal classroom environment. The experiment was carried out with four sub-groups, each of five students (a total of ten played the game and a further ten engaged in the Internet exercise of the control group). The difference in behaviour between the four sub-groups was very marked. Both the game groups freely engaged in exchanging ideas and comparing strategies and information. One of the sub-groups was more active than the other, but both were observed to adopt the 'game playing' level of cooperation and collaboration.

The two Internet sub-groups demonstrated somewhat different behaviour. The first treated the task as a test and did not communicate at all, while the second group acted under the self-appointed leadership of one student who set each group member separate tasks, although each then worked at their allotted task independently. After the session, when the groups were brought together to discuss their findings, it was observed that both experimental and control groups had nevertheless achieved valid answers to the initial question.

Observation of both groups in the initial empirical study show that use of the computer game in the group session stimulated interaction among the students. The level of interaction within the group of high achievers was not adversely affected by the game and the fact that some group members derived new knowledge ensured that the interaction was animated as other sub-groups tried to compete. The reaction of the second group, comprising less high achieving students, was also very encouraging, as their interaction with each other and with their teacher and their enthusiasm for asking questions increased significantly.

Questioning after the study revealed that both groups had developed their knowledge and had become more willing to share their learning. At that point it was impossible to confirm that the game itself caused this effect.

However, the experimental study involving the control group using the Internet to obtain information indicated very clearly that it was the game itself, and not merely the novelty of a technology based in a less formal classroom setting, that produced a positive effect on inter-student discussion and cooperation.

It was stated earlier that a number of mini games had been added to increase the level of fun in the game. However, the lower ability group spent long periods on the mini games and as a result did not engage with the primary

teaching material as they could have done. While the games may have encouraged these students to stay involved in the interaction between groups, it is doubtful that they contributed to their engagement with the learning material. In the second experiment, the mini games were removed, resulting in greater involvement with the game. The level of enthusiasm for the games was raised rather than reduced as a result of this increased engagement.

Overall, the results of this study are very encouraging. In particular, the comparison study using a control group demonstrated that the use of a game in the teaching of a complex subject encourages interaction and that the normal collaboration observed between players of entertainment games transfers into the playing of educational games.

7.4 Third Study : Malaysian multi ethnic setting

Within the Malaysian context stimulating discussion in a learning environment is very difficult. Rote learning has been a common practice in the Malaysian educational system for most of the subjects (Campbell, 2008). Most teachers and educators are uncertain of the student's ability to acquire knowledge on their own. Teachers will "fill" the students with facts in order to trigger student's cognitive capability thus this will lead to rigidity of the teaching approach which is more teacher-centred than is common in the UK. It also leads to the constant spoon-feeding on the teachers' part and the students' dependency on the teacher in the quest of acquiring knowledge (Campbell, 2008). (Vadivelloo and Vijayarajoo 2004) concur that in the Malaysian educational practice including in schools, teacher-centred methods remain a widely used instructional strategy to pass on knowledge. This method of teacher lectures, presentation of information, discipline of the students and giving instruction is a popular method due to its convenience for the teachers since they can pass on a large amount of information and knowledge to many

students. Scholars believe that the Malaysian schooling system should move beyond the rote learning method which most consider as outdated. (Kaur 2001; Wong 2003; Lee & Tan 2004; Ismail 2005; and Campbell 2006)

The main reason for this study was to investigate whether a game-based activity can be incorporated in a rote learning environment (Malaysia). In this study, an investigation was carried out to see whether the differences in the Malaysian educational cultural background had any effect on student's behaviour compared to the first two studies that were conducted in the UK. There are many cultural based reasons for this. In particular questioning your teachers is not encouraged as is the class discussion.

However, it is recognised that such discussions and responses are necessary to further engage students in a more explorative or constructivist learning. An interesting question thus arises. Will the use of a collaborative game in the Malaysian context encourage the exchange that is so necessary for collaborative learning? Other barriers to this will potentially exist as the population of Malaysia largely consists of three ethnic groups (Malays, Chinese and Indians) who seldom interact in social circumstances. In a mixed teaching group playing a collaborative educational game will the interaction that takes place also be inter ethnic. If it is then the value of future use of games in such circumstances would be very much encouraged.

In this study, before cooperative game-based learning was incorporated in the pre-test, the students were reluctant to put forward ideas or discuss amongst each other even when answering questions from the teacher. However, after the implementation of the game activity, the students began to naturally express themselves in discussion. Also when observing the students in school it was found that students began to work with each other and share information across the class. When seeing their peers actively involved in

discussion, students who were shy started to get involved by giving input and opinions on the matter. The students engage with the game play and this was due to the fact that even though these students have different educational culture their attitude towards game-based materials has not change compared to the empirical and experimental study. Clearly, the game-based activity has an effect on collaborative learning in this context.

7.5 Results: Higher Achievers vs. Low Achievers vs. Mixed Achievers vs. Educational Cultural Background

The empirical and experimental studies involved three groups of students representing different levels of achievement; each group included a mix of gender. Both groups of high achievers and lower achievers participated in the empirical study, while the mixed achievers group was involved with the experimental study.

The empirical study was carried out during the second week of the global warming topic, while the experimental study was conducted at the end of the school term. It was significant that although the high achievers were given fewer lessons on the subject and, it can be suggested, may have acquired less knowledge as a result, they responded more successfully than the mixed group in the experimental study who had previously spent more time on the topic in their normal classroom activities. The group of high achievers appeared more engaged with the game, retaining information and coming to more considered conclusions throughout the session.

The lower achievers, as expected, found it a challenge at the beginning of the session to understand the concept of global warming and its related issues; this may have been that they had only just been introduced to the topic the previous week. They did not engage as well as the high achievers with the

information provided in the game and therefore had initial difficulty in defining and understanding the multi-relational problems of global warming. Nevertheless, with their teacher's help, they managed to gain an overall concept of complex inter-relating problems by the end of the session.

The group of mixed achievers had already completed the topic and therefore had opportunity to apply their knowledge of the human contribution to the causes and effects of global warming to playing the game. As a result, this mixed group performed well, seemingly having little difficulty in absorbing information that was presented. It was clear that they understood the game concept and the actions needed in order to win the game. Their acquired knowledge helped them to explore further and make progress in this area of learning. It has already been observed that the absence of mini games was a factor in the students' success in this experimental study. The issues that arose with the use of mini games will be discussed later in this thesis.

The differences between the two studies and the third study were the difference in educational culture. The third study was carried out in Malaysia where the educational culture is much more lead from the front, engendering a "do as you are told" attitude in students and focuses on memorization. So getting students involved in a discussion is a problem particularly at secondary school level in Malaysia. While in the UK teachers try to stimulate students to be involved in such group discussion and participation but in practice it does not happened in the classroom easily but in contrast the studies showed it occurs naturally when they are playing games. Even with different educational culture ethnic differences in Malaysia the experiment show a positive outcome that game based activity can promote collaborative learning.

7.6 Dialogue from Students' Engagement via Voice Recording

Voice recording was the main form of noting the behaviour, reaction and feedback of the students during the session, since video recording was not allowed to be used in school on ethical grounds of for security and safety reasons. Voice recording tools were used for all the studies in order to capture the students' dialogue and tone of voice – for instance, whether they enjoyed the activity, or were excited, bored or frustrated. For the purpose of this thesis, transcripts of dialogue are presented in Appendices F, G and H in order to illustrate the experiences and feelings of the students who took part in both the empirical and experimental studies, including the control groups.

7.6.1 Empirical study voice record

This empirical study involved students working in pairs while still communicating with other groups. For example, Scenario 1 (Appendix F) illustrates how the students engaged constantly with the GeoEmission game and actively discussed with their peers solutions to deal with the problems presented to them. On a number of occasions some pairs were engaged in a disagreement in deciding the best method to solve an issue; nevertheless it can be observed that this was conducted positively as a brainstorming session. The environment had become one of collaborative learning in which all the students participated.

Scenario 2 (Appendix F) involving the lower achievement students shows that one of the group members spent more time playing the mini games than in concentrating on the main game content about global warming. It was clear that they enjoyed playing the mini games, but that this shifted their attention from how to deal with global warming issues.

At the end of the session the teacher led a discussion to evaluate students' knowledge of global warming issues, which was recorded (Scenario 3, Appendix F). The students answered questions and gave their opinions regarding their experiences playing GeoEmission. It was evident from the tone of their voices that the students not only enjoyed the session but were also actively engaged and working collaboratively.

7.6.2 Experimental study voice record

Scenarios included in Appendix G illustrate the conversations that took place during the game-play session in the experimental study. For example, in Scenario 4 Girl 1 received a game pop-out message informing her that she was making good progress in reducing Co2. When asked to explain this by her teacher, she stated that she had been planting trees and shutting down heavy industries. The girl then questioned why her funding and energy levels were low, indicating that while her actions were successful, at the same time they had caused further problems. At this point she was joined by other students who gave their opinions on the matter. The voice record clearly shows that the atmosphere had become lively and active. The teacher then sent Girl 1 a message through the network, to which she responded. There was an element of "fun" in the atmosphere; further, not only were they collaborating in sharing information across the class but also learning together to deal with the issues presented to them. The students' enjoyment of the session was clear to observe.

Scenario 5 (Appendix G) gives another example of communication between students and teacher during the game-play. The teacher asked the students if anyone had managed to obtain all four reward cards, and in turn students voiced their progress, turning this into a positive communication. The complexity of the game mechanics was revealed when students began to

understand that any single problem could not be solved independently, but had to be considered in relation to others, encouraging them to collaborate in evaluating and thinking critically of the issues involved.

As previously stated, the Internet group behaved somewhat differently. Because each student worked independently, with minimal communication, and no interaction or collaboration between peers, few voice records could be gained from this session. It has already been suggested that this was because the students were in an examination mode; the students appeared to work hard in browsing the Internet and it was observed that they made good progress in finding information, probably because they were familiar with the technology and could easily navigate the World Wide Web.

A discussion session conducted by the teacher at the end of the class is transcribed in Scenario 6 (Appendix G) reflecting the experience of both sessions. Based on the voice data collected, the students clearly understood that it was not easy to deal with the particular problems presented by the global warming topic. The recording also illustrates the significant role of the teacher throughout the whole session in addressing and controlling the class.

7.6.3 Third study voice records

As mentioned before, the third study participants included students from multi-ethnic backgrounds but this produced no barrier in getting the players to engage with the materials. This was illustrated in Scenario 7, 8 and 9 (Appendix H). For example, in Scenario 7 (Appendix H), one Malay girl was asking which energy sources she should use for her city and instantly another Malay girl and a Chinese boy gave inputs thus encouraging a positive discussion. In Scenario 8 (Appendix H), a Chinese girl made a statement that she was able to lower the CO_2 level and sustaining the energy sources but her money was very low. A

Malay girl then explained to her that it is quite difficult to balance it and this illustrates the understanding of the inter-related problems which cannot easily be separated. This was then agreed with by an Indian boy who gave another example of building coal powered energy which is cheaper but will cause the rise of the CO_2 levels to be much quicker. At the end of the session in Scenario 9 (Appendix H), the teacher held a discussion by asking the students their experience and knowledge of the activity. The students responded by acknowledging the importance of judging, assessing and valuing a certain problem thus encouraging them to use more evaluative thinking.

7.7 Increased Knowledge throughout the Studies

The mechanism for evaluating the student's knowledge was through observation and discussion. At the beginning of each session for all three studies, the students were pre-tested by being asked to answer questions on their knowledge of the global warming issues. Upon completing the game session and the internet session students were re-tested through observation and discussion by answering questions related to global warming issues (post - test) as shown in figure 7.6. They all had an increased level of knowledge between the two tests – whatever level of knowledge they had at the start. Clearly, they at least temporarily learnt something. It may be that is it merely in their short term memory but whether this is the case or not it can be said that the intervention did actually affect their short term knowledge. Not only did they answer correctly but there was an enhanced level of abstraction in their thinking and their knowledge that solving one particular problem does not solve the whole problem.

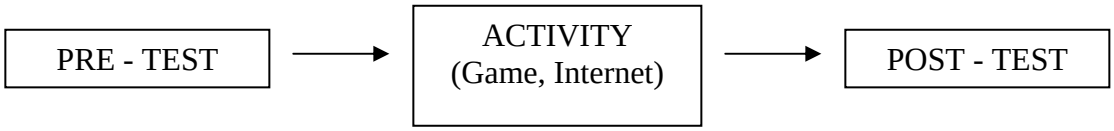


Figure 7.6: The process of the experiments

7.8 Technical Arrangements and Issues

Conducting all the studies was challenging and could be very unpredictable, especially with the use of technical equipment and software. This equipment had to be brought to the location in order to accommodate it into the real-life school environment and deploy it for teaching and learning purposes. The first step for the researcher was, with assistance, to set up the equipment in the classroom before the start of the session, ensuring that laptops, cables, wireless router and power sockets were arranged so that they did not present a risk to students.

Shortly before the students entered the classroom with their teacher, a test run was made of the equipment and the game software for each laptop in order to check that they were in working order. The test run ensured that the game for each laptop was installed and successfully connected through the wireless router, and that the teacher's main game as the server recognized each client. This initial setup ran smoothly and no problems were identified at this point.

However, during the empirical study one of the clients for the high achievers' group crashed and lost connection with the server, although the game-play for that client continued to run as normal. Other clients maintained the connection with the server. This event was immediately noticed by the teacher, and the client experiencing the lost connection had to close and re-start

the game from the beginning. The researcher and his assistants made a note of progress as it was not saved in the previous game-play. This first version of GeoEmission did not include a mechanism in the game engine to allow students' work to be saved if there was a crash or loss of connection with the server. The incident did cause the student pair involved to be frustrated for a short time until they had re-started the game. Nevertheless, apart from this event, the session was successful and there were no other technical issues. The researcher and his assistants did not identify the cause of the lost connection.

The following session involving the low achieving students was largely successful. However, although there was no loss of connection or other disruption with the server, another specific issue arose during this session involving the mini games. As previously stated, this group of students spent more time on the mini games compared with the high achievers' group, and a malfunction occurred in the Bio-fuel Challenge game, experienced by two of the five groups. The game requires the players to achieve three successful attempts at avoiding the petrol can in order to pass this challenge; however, it was observed that once the bio-fuel task was completed, this mini game did not behave in the way it had been programmed: the intention was for the bio-fuel cars to appear to be driving around the city while at the same time helping to reduce the level of CO2, but there was no indication of this occurring. This might be explained by the constant playing of the mini games while the main mechanism of the game is still running in the background; it would seem that the main game mechanism did not manage multitasking efficiently. A note was made of all feedback involving technical issues, including both the networking disruption and the base of the software game.

For the experimental study, the technical equipment and an updated version of the GeoEmission game were brought back into the school. As previously stated, all the mini games were removed from the main game, thus avoiding the previous issue with the Bio-fuel Challenge game.

A major technical issue occurred involving the first group in the experimental study, about three-quarters of the way through the session: the teacher's computer became unresponsive and therefore all the clients involved immediately lost connection with the server. The teacher's computer turned into a standstill state, and the game application was manually 'killed' using the *Ctrl* + *Alt* + *Delete* buttons on the keyboard. Students were observed to become frustrated because they were unable to progress further, although while efforts were made by the researcher and assistants to resolve the problem, the students continued to discuss the topic among themselves and remain involved in collaborative learning.

Once the teacher's computer had responded again, the students had to restart the game from the beginning. At this point the teacher was able to control the situation by creating a new scenario in which students were loaned a large amount of money to address global warming issues.

It was a disadvantage of GeoEmission that the saving mechanism was not included in the game engine due to major constraints of time for the researcher.

At the time, it was not possible to identify exactly why the teacher's computer crashed during that session. There could be several reasons for this event. Firstly, it might be due to the heavy transmission of data between the server and the clients, overloading the server. Secondly, the teacher's computer system might have become unstable because of the high number of network interactions, and ceased to respond. Thirdly, the teacher's computer hardware may have been incapable of handling such high demand, due to insufficient processing power or amount of RAM required, or there may have been a problem with overheating. Finally, the game design for the teacher's application might not have been properly implemented; indeed, any combination of the

above factors may have caused the teacher's computer to become unresponsive and unstable. However, no further technical problems were reported, and the last session involving another set of students progressed well.

7.9 Summary

Having the mini games in the main mechanic can be a distracting factor. It was therefore decided to exclude the mini games from the main game in the experimental study, and as a result these students engaged with the main game more successfully and for a longer period, achieving more understanding of the content and making considerably more progress than expected. The absence of the mini games did not lessen motivation. The activity seemed to run more smoothly as all the students were focused on the activity and worked collaboratively; they also appeared to enjoy the session.

In fact, all the mini games were removed in the experimental study which had sought to investigate the overall game-play with or without the mini games. As a result, the students played far better than expected and paid more attention to the content of the lesson.

The method of teaching games gave the students information, allowed rapid uptake of the information and produced more collaboration than in the normal classroom. There was, in all three studies, a dramatic improvement in collaboration. Nobody in any of the studies did not engage in discussion in the game environment. By contrast there was little or no peer-to-peer engagement in the other environments, for example in the control groups. In the ordinary classroom situation, most of the students did not collaborate and did not speak unless actually individually challenged. The students who did speak, spoke to the teacher only. Students seldom responded to each other in any way.

Whereas in the game session for all three studies, students share information with each other and shared information across groups.

In the experimental study (2nd study), the use of the alternate group was repeated. One of the groups did not talk to each other at all and it was even worse than in the ordinary classroom. In the second group, they collaborated by distributing the task given to them but they did not collaborate by sharing information with each other during the session. All studies showed the students did increase their knowledge during the session because in the pre-test, they were asked specifically for information but they were unable to share that information, while in the post test, they were able to share information indicating that they had obtain the information in the activity.

Apart from the observation method, voice recording was very useful for capturing the environment. Video recording would have been a better medium for capturing and recording the student's behaviour but due to the safety regulations of the school, this was not possible.

CHAPTER VIII

CONCLUSION AND FUTURE RESEARCH

This thesis has set out to address a number of hypotheses. In particular it was believed that a game based approach was a suitable way of teaching a subject where a problem involving optimisation of a multiple set of competing factors needs to be solved. It was believed that the cooperation and collaboration usually found when gamers play a game in close proximity would continue when they were playing an educational game. Thus educational computer games could be used to stimulate such competition. However, the literature survey had also strongly emphasised that the games needed to be good games using similar game based tools to those from entertainment games – challenge, fantasy, competition identification etc. There is a strong belief in the literature that the game can only teach the game mechanic so it would be necessary to build a game with a suitable genre in which to embed the teaching aim. However, some literature had also said that mini games – with little or no actual educational content – would enhance student engagement, thus improving time on task and hopefully encouraging prolonged engagement with the learning material.

To test these hypotheses the area of tackling global warming by controlling human contributions to the emission of greenhouse gases was chosen as the topic for the game. This had been chosen after having a brainstorming session with a group of geography teachers. The issue is a complex one with many interacting factors that make the optimisation of a

solution very difficult. However, the timescales for these changes are quite long so direct practical study is difficult. However, the role-play game genre could clearly embed such an educational aim in its game mechanic. It would also be necessary to have some form of modelling system to produce credible responses to player choices in order for the game to teach the real results of choices the players might make. Doing this in the timescale available for the study would be quite difficult and it was decided that the addition of a human non player character, able to add realism to the responses in real time, would be used to enhance the much simpler model used in the game. An interface that would be familiar to players was chosen – the same look and feel as Sim City was chosen. To include the non player character the game had to be connected via a local area network. The game produced is called GeoEmission.

The game and concept were next tested in two environments with a total of 60 students in three groups. In the initial study groups were selected by ability. The higher ability students had better responses in pre-tests and quickly mastered the game. They readily shared their results and in the post tests had shown a significant increase in relevant and correct knowledge – though no measure of their long term retention of this was attempted. The second group were of lower ability. In the pre test they exhibited little knowledge of the subject and a great reluctance to share in the class. However, they readily engaged in the game and happily exchanged in game (subject relevant) knowledge during play. After the game they were able to answer correctly significantly more questions relating to the topic of the lesson. One problem emphasised by the play of this group was that they spent a lot of time engaged with the mini games and had to be urged to re-engage with the learning material. It was thus decided to remove these mini games in a future version of the game. In the next test a control group was also used. This group did a lab based activity in which they were encouraged to find the answer to a specific thermal emission problem using Internet resources. Though they were encouraged to share they failed to interact at all. The game based groups (this time of mixed ability) once again

shared readily. The absence of the mini games did not reduce their enthusiasm for the game nor their willingness to share. In the post test both the control and experimental groups had gained correct answers to the questions posed. Thus the major effect of the game was the greater collaboration and thus wider contribution of the group to the gaining of the knowledge.

A third experiment was undertaken. This time the group chosen were students in Malaysia. These students come from three major ethnic groups which seldom interact in normal class situations. The nature of education and cultural norms in Malaysia discourages discussion in class and so when it is desired to promote such discussion and the development of non teacher directed learning it is significantly difficult to achieve. The same game was used with this group as before. The behaviour of the students – significant sharing even between ethnic groups – showed that a games based approach could be a significant tool in helping to tackle these problems.

The results gained from all studies are thus very encouraging. They show that the use of computer games in education can support students with their learning, especially in geographical topics such as global warming, which involve multi inter-relating problems and events which develop over a long period. Furthermore, the design and the implementation of the GeoEmission game in the classroom promoted collaborative and cooperative learning among the students and with the teacher. The game sessions conducted by the researcher and his assistants show clearly that students are open-minded in accepting computer games. The findings of the research are thus summarised below:

a) This research has shown the value of having an NPC as the teacher in which the role of the teacher in structuring and framing the activity of the learner remains crucial if learning outcomes are to be achieved. By using the teacher as the NPC in a networked environment, the

teacher can continue to control the game without reducing the engagement of the students in the game and therefore the students can be taught in the game environment without influencing the whole teaching and learning process. The teaching process will take place and flow naturally in the game play. No attempt was made to determine the efficiency of this method compared to other methods.

b) This research has also revealed the value of stimulating collaboration through the medium of game play. Observations which were carried out did show that collaboration amongst peers and their teacher become active and lively. The combination of games software, teacher input and collaborative peers was reported to provide powerful learning experiences not only for the students but also for the teachers. Thus it can be concluded that simulation games can offer learners sophisticated scenarios to support meaningful discussion if the correct game mechanic is selected for the learning objective.

c) This research also has shown that the method used in the game mechanic is suitable for embedding the teaching in the game mechanism. It may not work in other subjects or areas, but nevertheless the design of the game mechanic did work for this research particularly for this subject and especially as a subject involving inter-related problems. Students gained valuable information and understanding of the issues by responding to the teacher during and after the game session.

d) The mini games did not seem to work. Indeed this research found that the mini games can be a distraction factor and thus can disengage the students from the main teaching materials.

e) Of particular interest to this research was the behaviour of the group of Malaysian students of mixed ethnicity. Lively collaboration took place which is unusual and difficult to engender in a normal Malaysian classroom. In addition collaboration took place readily between the ethnic groups, which is again less normal in a Malaysian setting.

8.1 Were the Hypotheses Proved?

8.1.1 Hypothesis 1

Games would prove a good mechanism for constructivist teaching by implementing the lesson in the game mechanic. The motivation engendered by the game would not be inhibited by this integration.

This hypothesis is upheld by the study. For all four groups who took part:

a) Their knowledge of the problems and challenges presented by global warming was increased. This was evidenced by the quality of their responses to questions in a post-test compared to the pre-test.

b) Most students showed no sign of losing focus on the game.

c) However, weaker students were significantly distracted by the mini games (see Hypothesis 3).

8.1.2 Hypothesis 2

The nature of game-play will enhance the sharing of information and discussion within the groups:

This hypothesis was upheld by the study. Evidence for this is that:

a) All groups readily shared information during game-play.

b) The low achievers significantly improved in their willingness to share ideas after the game.

c) However, neither of the control groups took part in any real sharing during the Internet based control activity.

d) The unusual amount and quality of sharing in the mixed ethnicity Malaysian group.

8.1.3 Hypothesis 3

The mini games would improve engagement with the game and therefore not reduce its effectiveness but rather enhance this by increasing motivation and time spent on task:

This hypothesis shows evidence of being denied by the study. Evidence for this includes:

a) Low achievers in particular spent a significant length of time aiming to achieve high scores in the mini games, without any evidence of learning.

b) The low achievers had to be actively encouraged to re-engage with the main game mechanic.

c) The mixed groups in the experiments in which no edutainment components (mini games) were available did not demonstrate any de-motivation with the game.

8.2 Future Research

There is no doubt that this research can be extended to explore further benefits for teaching and learning purposes. If learning material is integrated into the game mechanics, then it can be effective, if only for a temporary period. It can be concluded that learners who are not naturally motivated can still gain from participating in the game, and the process of learning is enhanced when they are able to share their ideas through the game. More content and a higher level of complexity should therefore be included, such as adding more effects and consequences in order to bring students closer to real-life scenarios. Because mini games were found to be distracting for some students, it is suggested that, if mini games are to be incorporated, they should be limited and under greater control - for example, in limiting the amount of time or playing these only after certain objectives have been achieved or better still integrating some learning objective understanding more closely into the games.

It can be further recommended that a 3D-style game can be incorporated into the interface, yet the problem remains that, due to financial constraints, schools have difficulty in upgrading their hardware in response to the rapid growth of technology. This presents a serious disadvantage in that players are likely to become frustrated and abandon a game that is slow to load or run.

Further testing and experimental study can also investigate the extent to which students are actually gaining knowledge. A more formal methodology (such as a quiz or test) can be employed to evaluate the extent of students'

knowledge both before and after playing the GeoEmission game. Some study on long term retention of the knowledge and the extent to which this knowledge has been shared in the group could be made.

As for the mini games, it is suggested that, if the mini games were developed in line with the themes of the learning and if the students have to engage with the learning concept through the mini games then the mini games are not necessarily bad. It would be positive to the students if the mini game's mechanics actually teach the subject. The problem for such mini games might be making them engaging enough. The solution is trying to find a mechanism that is engaging yet exercises the main materials. For example, a timed quiz or test can turn into a game which involves gaining extra points (e.g. receive free loan, reduction of interest rates within the main game).

It should be stated that the game was never intended to replace the role of the teacher. From the outset, it has been proposed that GeoEmission can be used as an additional tool by teachers for teaching and learning purposes, offering them a new experience. Indeed the use of a teacher controlled NPC showed that the teacher themselves can be actively involved in the game and enhance the learning that can take place, thus reinforcing rather than negating the role of good teaching.

8.3 Final Conclusion

That the game-based collaboration in learning worked in the very different cultural setting in Malaysia shows strongly that the game process has the ability to engage students in discussion who would not normally be involved. That learning also occurred in all three studies was observed – though not quantified. In all cases the students were given an oral pre – test and an oral post – test and the only intervention between these tests was the playing of the game. All

the students gave evidence of having new knowledge about the subject from the pre-test to the post-test. A comparison was also made between the students behaviour in a normal class room environment where, despite the best efforts of the teacher, students didn't talk to each other including sharing relevant information with each other. In the game situation this sharing was regularly taking place. In the Malaysian study students who would not normally work with each other, eagerly worked with each other. The environment was compared with the normal classroom environment and the results are that the students actually talk more when playing games and this can be about the learning material. Thus the activity when playing the educational game was the same as that when playing entertainment games. The difference was that with the educational game the information being shared was about the effective use of new technologies to reduce emissions of greenhouse gases – the very topic of the lesson. It was not just being in a novel environment as in the control study where students were in an abnormal environment that was not a game playing environment but did involve computers they did not communicate and collaborate through. Indeed they showed even less than the normal level of collaboration and cooperation in that environment. In cooperative learning, the teacher needs to provide a conducive environment and appropriate tasks with equal opportunities for all class members. The element of team competition should also be incorporated once in a while in cooperative learning between well-matched competitors and without grading them for the norm-referenced grading system. This is because team competition can spur students to achieve the group's goal. Even though cooperative learning is learner-centred, the teacher has a paramount role to play in structuring and planning the lessons

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APPENDICES

APPENDIX A

GAME SESSION OBSERVATION SHEET

Secondary Lesson Plan (Key Stage 3)
Discussion/Observation Session

Tools to be used:
- GeoEmission game
- Audio recording
- Click streams

Indicator: Y = YES
NR = NOT REALLY
NA = NOT AT ALL

Key Questions	Method	Category	Y	NR	NA	Notes
1. Did the students want to complete the game session?	Discussion / Observation	Motivation				
2. Did the students want to explore all the options that were available to them?	Discussion / Observation	Motivation				
3. Were the students having fun during the game-play session?	Observation	Motivation				
4. Did the students know what to do in order to complete the game session?	Discussion / Observation	Clarity				
5. Were the goals of the game clear?	Observation	Clarity				
6. Were the instructions of the game clear?	Observation	Clarity				
7. Did the students feel that they could achieve the goal of the game session?	Discussion / Observation	Achievability				

Key Questions	Method	Category	Y	NR	NA	Notes
8. Did the students feel the game session was frustrating?	Observation	Achievability				
9. Did the students feel the game session was challenging?	Discussion / Observation	Achievability				
10. Did the students feel the game session was too complex?	Discussion / Observation	Control				
11. Did the students find the pace of the game too fast/slow?	Discussion	Control				
12. Did the students find it difficult to identify the effect of their actions?	Discussion	Control				
13. Did the students find the game session absorbing?	Discussion / Observation	Immersion				
14. Did the students find the time passed quickly?	Observation	Immersion				
15. Did the students find the game session exciting?	Discussion	Immersion				

Key Questions	Method	Category	Y	NR	NA	Notes
16. Did the students have to concentrate during the game session?	Observation	Interest				
17. Were the students interested in exploring the entire game environment?	Discussion / Observation	Interest				
18. Was the game interface aesthetically pleasing?	Discussion	Interest				
19. Was it clear what the students could learn?	Discussion	Purpose				
20. The feedback given in game-play was useful / not useful.	Discussion	Purpose				
21. Was the activity worthwhile?	Discussion	Purpose				
22. The level of interaction between other players (teamwork, communicating)	Observation	Communi-cation				

APPENDIX B

INTERNET SESSION OBSERVATION SHEET

Secondary Lesson Plan (Key Stage 3)
Discussion/Observation Session

Tools to be used:
- Internet
- Audio recording

Indicator: Y = YES
NR = NOT REALLY
NA = NOT AT ALL

Key Questions	Method	Category	Y	NR	NA	Notes
1. Did the students want to complete the Internet session?	Discussion / Observation	Motivation				
2. Did the students want to explore all the information that were available to them?	Discussion / Observation	Motivation				
3. Were the students having fun during the Internet session?	Observation	Motivation				
4. Did the students know what to do during the Internet session?	Discussion / Observation	Clarity				
5. Did the students feel the Internet session was frustrating?	Observation	Achievability				
6. Did the students feel the Internet session was challenging?	Discussion / Observation	Achievability				
7. Were the students absorbed in the Internet session?	Discussion / Observation	Immersion				

Key Questions	Method	Category	Y	NR	NA	Notes
8. Did the students find the time passed quickly?	Observation	Immersion				
9. Did the students find the Internet session exciting?	Discussion	Immersion				
10. Did the students have to concentrate during the Internet session?	Observation	Interest				
11. Was the information in the Internet interface aesthetically pleasing?	Discussion	Interest				
12. Was it clear what the students could learn?	Discussion	Purpose				
13. Was the internet activity worthwhile?	Discussion	Purpose				
14. The level of interactions between other players (teamwork, communicating)	Observation	Communi-cation				

APPENDIX C

LESSON PLAN A

Secondary Lesson Plan (Key Stage 3)
Lesson A: Playing GeoEmission Game

Lesson I – Playing GeoEmission Game	**Time Required:** 60 minutes (Total) ▪ 15 minutes (setting up) ▪ 45 minutes (lesson session)
Intended Level: KS3 (11-14 years old)	**Curriculum Areas:** Geography, Science
Resources: ▪ GeoEmission Game	**Key:** ▪ Interacting complex issues ▪ Open-ended problems ▪ Reasoning / critical thinking skills

About this Lesson:

This lesson introduces the GeoEmission game to the students as part of their Geography or Science lesson. It encourages them to play and explore the game by building industries, choosing energy resources and competing challenges. It is a very similar game-play approach to the SimCity™ games. Each action will have an impact on the problem. The game introduces the students to the idea that one solution sometimes does not solve a problem, nor can it be easily prescribed due to the complexity of inter-relating problems. GeoEmission is a network game.

At the end of the session, a brief discussion will be held to capture and reflect the students' thoughts on the game and crucially to assess their understanding of the problems.

The aim of introducing the GeoEmission game is to facilitate the student in a new learning environment. By introducing a game-based learning in a classroom, they will be offered the opportunity to experience a game-based learning style.

Learning Objectives:

- To explore the effects and solutions of global warming by playing the game
- To use a game-based learning style as a supplemental learning tool
- To recognize, reflect and understand complex relationships of an issue through game-play

Prior Knowledge - Students need to have some understanding that:

- Climate change is a contemporary, global concern
- It is influenced by humans

Timing	Starter Activity	Key Questions
(15 mins)	**Before Session Start / Preparation** Setting up the computers: ▪ Make sure computers are in working order. ▪ Install GeoEmission into computer. ▪ Conduct quick test runs on GeoEmission. ▪ Prepare key points for discussion.	*Are there any technical problems with the computers? *Are the key points for discussion ready?
(45 mins) 10 mins	**Begin Session** Introduce global warming issues. Discuss potential problems caused by global warming. *Data collection 1 (pre-game-play)* ▪ *Discussion 1*	How does the issue of global warming make you feel? What is your attitude towards: - environmentalists - politicians - industrialists?
5 mins 20 mins	**Main Activities** Arrange students into pairs. Give brief introduction of game. Launch GeoEmission game. *Data collection 2 (game-play)* ▪ *Observation 1*	*Observe game-play. *Did the session go well? (e.g. technical issues)

10 mins	**Reflection** Quickly recap / discuss: ▪ *GeoEmission game and its game-play.* ▪ *Some problems cannot easily be separated into independent variables because the variables intrinsically interact with each other.* *Data collection 3 (post-game-play)* ▪ *Discussion 2*	What are the key issues and why are they important? What do you think are the solutions to the causes and effects of global warming? Are there any facts that surprise you? Which ones and why? How do you feel about the game being integrated in the lesson? Are there any questions that came out of today's lesson? *Did the discussion go well? (Tools : Audio recoding)
Notes / Comments :		

APPENDIX D

LESSON PLAN B

Secondary Lesson Plan (Key Stage 3)
Lesson B: Playing GeoEmission Game

Lesson 2 – Playing GeoEmission Game	**Time Required:** 60 minutes (Total) ▪ 10 minutes (setting up) ▪ 50 minutes (lesson session)
Intended Level: KS3 (11-14 years old)	**Curriculum Areas:** Geography, Science
Resources: ▪ GeoEmission Game	**Key:** ▪ Interacting complex issues ▪ Open-ended problems ▪ Reasoning / critical thinking skills ▪ Collaboration and cooperation

About this Lesson:

In this session, students are divided into two main groups (one group using game-based learning and another using the Internet). The students will be working in pairs within each group. The aim is to observe and compare student interaction, interest and behaviour, especially their ability to collaborate and cooperate, within the two groups.

The teacher and the students are given the opportunity to engage either with the game or with the Internet as an additional teaching tool. The lesson will help the students to recognize that the solutions to certain problems (e.g.global warming) cannot easily be solved in a prescriptive way. This is due to the fact that each problem is linked together and quite difficult to separate.

At the end of the session, a brief discussion will be held to capture students' thoughts on the game and the use of the Internet to understand the problems presented. Comparisons of the two groups will be made in order to see if there are any differences between the two methods.

The aim of introducing the GeoEmission game is to facilitate the student in a new learning environment. By introducing game-based learning in a classroom, they will be offered the opportunity to experience a new game-based learning style; this will be compared with learning in the other medium.

Learning Objectives:

- To explore the effects and solutions of global warming by playing the game and comparing it with the use of the Internet.
- To recognize, reflect and understand complex relationships of an issue through game-play and with use of the Internet.

Prior Knowledge - Students need to have some understanding that:

- Global warming is a complex problem because of its conflicting aspects.
- Climate change is a contemporary global concern.

Timing	Starter Activity	Key Questions
(10 mins)	**Before Session Start / Preparation** Setting up the computers: ▪ Make sure computers are in working order. ▪ Conduct quick test runs of GeoEmission. ▪ Prepare key points for discussion. ▪ Check the school's Internet connections are working	*Are there any technical problems with the computers / Internet? *Are the key points for discussion ready?
(50 mins) 10 mins	**Begin Session** Recap last session on global warming and student experiences of GeoEmission game-play Briefly introduce today's activities (Game group and Internet group) *Data collection 1* *(pre-game-play & Internet use)* ▪ *Discussion 1* ▪ *Observation 1*	What are your opinions on the previous game-play? Why does it make you feel this way? Tools: Audio recording
10 mins 20 mins	**Main Activities** Divide into 2 groups (GeoEmssion and Internet) Arrange students into pairs within each group. Launch group activities simultaneously. *Data collection 2* *(game-play & Internet use)* ▪ *Observation 2*	*Observe game-play and Internet session. *Does the observation session go well? Tools: Audio recording

10 mins	**Reflection** Quickly recap / discuss: ▪ *Student's opinions on both sessions* ▪ *Some problems cannot easily be separated into independent variables because the variables intrinsically interact with each other.* *Data collection 3* *(post-game-play & Internet use)* ▪ *Discussion 2* ▪ *Observation 3*	What are the key issues? and why are they important? What do you think are the solutions to the causes and effects of global warming? Are there any facts that surprise you? Which ones and why? Are there any questions that came out of today's lesson? *Did the discussion go well? Tools: Audio recoding
Notes / Comments:		

APPENDIX E

LESSON PLAN C

Secondary Lesson Plan (Key Stage 3)
Lesson C : Playing GeoEmission Game

Lesson 3 – Playing GeoEmission Game	**Time Required :** 60 minutes (Total) ▪ 10 minutes (setting up) ▪ 50 minutes (lesson session) **Curriculum Areas :** Geography, Science
Resources : ▪ GeoEmission Game	**Key :** ▪ Interacting complex issues ▪ Open-ended problems ▪ Reasoning / critical thinking skills ▪ Collaboration and cooperation

About this Lesson :

In this session, students are requires to work in pairs. This lesson is to observe on student's interaction, interest and behaviour especially on collaboration and cooperation during gameplay.

The teacher and the students are given the opportunity to engage with the game as an additional teaching tool. It tends to help the students to recognize and help them to think that the solution of certain problem (e.g global warming) cannot easily be solved in a prescriptive way. This is due to the fact that each problem is linked together and it is quite difficult to separate them individually.

At the end of the session, a brief discussion will be held to capture and reflect the student's thoughts on the game in understanding of the problems

The aim of introducing the GeoEmission game is to facilitate the student in a new learning environment. By introducing a game-based learning in a classroom, this would give them the opportunity to be exposed in a new game-based learning style compare to others medium form of learning.

Learning Objectives :

- To explore the effects and solutions of global warming by playing the game.
- To recognized, think and understand complex relationships of an issue through gameplay

Prior Knowledge - Students need to have some understand that :

- Global warming is a complex problem because of it's the conflicting nature of the different aspects of the problem.
- Climate change is a contemporary, global concern.

Timing	Starter Activity	Key Questions
(10 mins)	**Before Session Start / Preparation** Setting up the computers : ▪ Make sure computers are in working order. ▪ A quick test runs GeoEmission. ▪ Getting the key point ready for discussion.	*Are there any technical problems with the computers *Are the key point for discussion ready?
(50 mins) 10 mins	**Begin Session** Pre-test about global warming issues Brief introduction on today's activities (Playing GeoEmission game) *Data collection 1 (pre-gameplay)* ▪ *Discussion 1.* ▪ *Observation 1.*	What opinions the students have on global warming issues? Why does it make you feel this way? Tools : Audio recoding.
10 mins 20 mins	**Main Activities** Students get into pairs and start playing the GeoEmission game. The students begin the sessions *Data collection 2 (gameplay)* ▪ *Observation 2.*	*Observe the gameplay *Does the observation session go well? Tools : Audio recoding.

10 mins	**Reflection** Quickly recap / discuss that : ▪ *Discussion – Student's opinions on both sessions* ▪ *Discussion – Some sort of understanding that problems cannot easily be separated into independent variables because the variables intrinsically interact with each other.* *Data collection 3 (post-gameplay)* ▪ *Discussion 2.* ▪ *Observation 3.*	What are the key issues? and why are they important? What do you think the solutions to the causes and effects of global warming? Are there any facts that surprise you? Which ones and why? Are there any questions that came out of today's lesson? *Does the discussion go well? Tools : Audio recoding.
Notes / Comments :		

APPENDIX F

EMPIRICAL STUDY
(Dialogue)

Scenario 1

Game-play Session

Group 1 (male and male):
Boy 1:
“Hang on. Do we need to build more factories?”

Boy 2:
“Yeah! That’s how we get the money.”

Another group join the conversation

Group 2 (male and female):
Girl 1:
“You guys can try building the geothermal energy like we did.”

Boy 3:
“Yeah. It gives us money and energy but it is quite expensive. We’ve got high-tech industries as well. They are good. How much money you guys have?”

Group 1 (male and male):
Boy 1:
“Not a lot. We still need to build more energy. Our energy supply is running low.”

Group 3 (female and female):
Girl 2:
“We think wind power is the best energy. It’s cheap but we have to build lots of them to cope with the city’s energy needs. What’s your energy like?” (asking Group 4)

Group 4 (male and male):

Boy 5:

“92 %.”

Group 1 (male and male):

Boy 1:

“How did you get that much? What stuff have you built?”

Boy 2:

“We got a nuclear energy, some solar panels and few geothermal.”

Continuous discussion among the pair and groups in the class.

Scenario 2

Mini Games

Group 4 (male and male):

Boy 1:

“Okay, let me try this.”

Boy 2:

“You need to get at least 100 petition.”

Boy 1:

“Yes, I know.”

Boy 1 plays the mini games and only manages to score 55 points.

Boy 2:

“My turn. Let me have a go.”

Boy 1:

“Try and beat my score.”

They then play the game 4/5 times in succession.

Scenario 3

End Session

Teacher:
“Okay, who did really well?”

Students respond answering question at the same time.
Students:
“We did.”

Teacher:
“*Okay, this group first. What did you do?”*

Group 2 (male and female):
Girl 1:
“Built factories and trees. Factories are good financially and trees absorb Co2.”

Teacher:
“What sort of energy resources did you guys use?” (pointing to another group)

Group 3 (female and female):
Girl 2:
“We use geothermal and solar panels.”

Group 4 (male and male):
Boy 1:
“Yeah, we use nuclear power and then we spend all our money on trees.”

Teacher:

“Right! That’s a good strategy. Do you know what that’s called, that kind of strategy? …….. It’s called mitigation. You do something which causes a problem and then you do something else and try to offset that problem. Have you heard of carbon offsetting?.....”

***Continuous discussion among the students in the class.**

APPENDIX G

EXPERIMENTAL STUDY
(Dialogue)

Scenario 4

Game-play Session

Girl 1:
"I've just got a message saying Good Job! Your Co2 is low, try to keep it that way."

Teacher:
"That's good. So, what have you been doing to get that?"

Girl 1:
"I've been planting trees and I'm shutting down the heavy industries, but my money is low and my energy is low as well."

***Others joining the conversation**

Boy 1:
"What's the point of having lots of trees and you shutting down industries? People can't work. No industries, no income."

Boy 2:
"We need income to build other things".

***Teacher sending message to Girl 1.**

Girl 1:
"Wait!…. The mayor is talking to me again and said that we are in trouble, bankrupt. ……. Now the mayor said people are going on strike! Oh no!"

*** Others laugh**

Scenario 5

Game-play session

Teacher:
“Has anybody got all 4 cards?”

Boy 1:
“I’ve got 2 cards. My energy is 90%, my temperature is 25c, my funding is 2000 pound and my Co2 is 89. I need a loan.”

Girl 2:
“My energy is 50%, my Co2 is 75, my funding is 12600 and my temperature is 34c. Just the one reward card.”

Boy 3:
“Well, I’ve got 3 cards. My Co2 is 16, my energy is 91%, my temperature is 22c, but my funding is 250 pound.”

Boy 1 & Girl 2:
“Let me see.” / “Let’s see.”

Boy 1:
“What did you do?”

Boy 3:
“I shut down coal energy and replace it with solars and wind power. I plant trees. But my money is not going up.”

Scenario 6

End Session

Teacher:
"You had a different resource but have you all come up with the same answers? What would you say we should be doing and what is the best way of, for example, maintaining the energy production while reducing the Co2 emission?"

Anonymous student 1:
"Get rid of the factories but not all of them because they give us the money and ….errrr build trees to absorb the Co2."

Teacher:
"*What happened if you shut down all the industries? What happened to the people who work there?"*

Anonymous student 2:
"They are just out of work. Fired."

Teacher:
"What will happen to them? What do they do?"

Anonymous student 3:
"Get a new job or find a new job."

Teacher:
"How do they get a new job?"

Anonymous student 4:

“Put in new factories with less Co2.”

Teacher:

“Right… good! We need to improve the energy efficiency of the factories. We do not need to just shut them down We need more clean energy factories.”

APPENDIX H

THIRD STUDY

(Dialogue)

Scenario 7

Game-play Session

Malay Girl 1:
“Energy mana yang patut saya guna” ?
Translation : ‘Which energy should I use?”

Malay girl 2:
“Geothermal are quite good tapi agak mahal. Guna wind turbine lah”.
Translation : Geothermal are quite good but expensive. Build wind turbine instead.

Chinese boy 1:
“Saya setuju kalau kekurangan duit, better bina wind turbine dulu selepas itu baru bina Geothermal.”
Translation : I agree if your money are low, better build wind turbine first and then you can build Geothermal later.

Indian boy 1:
“Yes, but you have to build plenty of wind turbine because they give us very little energy resources.

Scenario 8

Game-play session

Chinese Girl 2:
Here look at mine. I manage to make the co2 low and my energy is sufficient but my money is very low.

Malay Girl 1:
Itu yang agak susah tu, kalau nak dapat income besar kene build factories, tapi nanti co2 naik pula. Benda nie somehow related antara satu sama lain.Kita kena balance
Translation : This is quite difficult. If we want to gain income, we have to build factories but it will raise the co2 level. These are somehow related between one another. We have to balance it out.

Indian Boy 1:
“True”. Same as well if you build a coal plant which is much cheaper but it produces a lot of Co2

Scenario 9

Discussion session (after game-play)

Teacher :
Okay students, what can you say about today's lesson?

Malay girl 1:
It is quite difficult to solve global warming issues because the problems are linked together.

Indian Boy 1:
"Yes, you cannot simply solve one problem and hoping that it will solve the whole problem.

Teacher :
Good, but what does this mean?

Chinese girl 1:
You have to carefully analyse, consider and think thoroughly the effects and causes before making a decision.

Teacher :
Well done!

Continuous discussion among the students in the class.

APPENDIX I

RESEARCH ETHICS FORM

Research Ethics Form

SECTION I: Project Details

1. Project Title	**COMPUTER GAMES USE IN AN EDUCATIONAL SYSTEM**
2. Description of Project and methods to be used	**About the project:** This research project focuses on how computer games can be used as an additional tool in the educational sector, specifically in the school curriculum. More importantly, this research investigates how computer games can help students to construct critical thinking and knowledge about the complex relationships of an issue and at the same time promote and motivate students to learn. **Target sample group:** The intended research group is Key Stage 3 (11-14 years old) students. **Method:** The proposed method for carrying out this research is via discussion and observation. There will be two sessions for collecting the data. The details of the sessions are attached to the end of this form. **Tools to be used:** ▪ GeoEmission Game ▪ Internet ▪ Audio recording

SECTION II: Applicant Details

2. Name	NAIM CHE PEE
3. Status	**Undergraduate Student / Postgraduate Student / Staff** (circle as appropriate)
4. Email address	anc@cs.nott.ac.uk

SECTION III: For Students Only

5. Module name and number, or MA/MSc/MPhil course and department	PhD IN COMPUTER SCIENCE
6. Supervisor /Module Leader's name	DR. PETER BLANCHFIELD
7. Email address	pxb@cs.nott.ac.uk

For completion by the Supervisor (please tick the appropriate boxes)

This study should not begin until all boxes are ticked or appropriate provision for training made:

The researcher has read the University's Code of Practice	✓
The topic merits further research	✓
The student has the skills to carry out the research	✓
The participant information sheet or leaflet is appropriate	✓
The procedures for recruiting and obtaining informed consent are appropriate	✓

SECTION IV: Research Checklist (Part 1) – for completion by researcher/student

Please answer each question by ticking the appropriate box:		**Yes**	**No**
1.	Does the study involve participants who are particularly vulnerable or unable to give informed consent (i.e. children, people with learning disabilities, prisoners, your own students)?	✓	
2.	Will the study require the co-operation of a gatekeeper for the initial access to the groups of individuals to be recruited (i.e. students at school, members of a self-help group or residents of a nursing home)?	✓	
3.	Will it be necessary for participants to take part in the study without their knowledge and consent at the time (i.e. covert observation of people in non-public places)?		✓
4.	Will the study involve the discussion of sensitive topics (i.e. sexual activity, drug use)?		✓
5.	Will participants be asked to discuss anything or partake in any activity that they may find embarrassing or traumatic?		✓

6.	Is it likely that the study will cause offence to participants for reasons of ethnicity, religion, gender, sexual orientation or culture?		✓
7.	Are drugs, placebos or other substances (i.e. food substances, vitamins) to be administered to the study participants or will the study involve invasive, intrusive or potentially harmful procedures of any kind?		✓
8.	Will blood or tissue samples be obtained from participants?		✓
9.	Is pain or more than mild discomfort likely to result from the study?		✓
10.	Could the study induce psychological stress or anxiety or cause harm or negative consequences beyond the risks encountered in normal life?		✓
11.	Will the study involve prolonged or repetitive testing for each participant?		✓
12.	Will financial inducement (other than reasonable expenses and compensation for time) be offered to participants?		✓
13.	Will the study involve the recruitment of patients, staff, tissue sample, records or other data through the NHS or involve NHS sites and other property? If yes, NHS REC and R&D approvals from the relevant Trusts must be sought prior to the research being undertaken.		✓
14.	Will data be recorded? If so, how? ▪ Audio Recording ▪ Click Streams	✓	

Research Checklist (Part 2)

Please answer each question by ticking the appropriate box:		Yes	No
15.	For research conducted in public, non-governmental and private organisations and institutions (such as schools, charities, companies and offices), will approval be gained in advance from the appropriate authorities?	✓	
16.	Will written consent be gained?	✓	
17.	Will participants be informed of their right to withdraw from the study at any time, without giving explanation?	✓	
18.	Will data be anonymised?	✓	
19.	Will participants be assured of the confidentiality of the data?	✓	
20.	Will the data be stored in accordance with the Data Protection Act 1998	✓	
21.	Will participants be asked permission for quotations (from data) to be used?	✓	
22.	Will participants be asked permission for photographs (from trials) to be used?	N/A	

If you have answered 'no' to all questions in Part 1 and 'yes' to all questions in Part 2, please send the completed and signed form, together with proposed information sheets and consent forms, to your departmental manager for their records. You should also keep a copy of this form for your records, as you may be asked to include it within your dissertation or research report.

If you have answered 'yes' to any of the questions in Part 1 or 'no' to any of the questions in Part 2, please describe in Section V why this is necessary and how you plan to deal with the ethical issues raised. **This does not mean that you cannot do the research, only that your proposal will need to be approved by the department head, and in certain circumstances will need approval by the School Ethics Committee.**

Please note that it is your responsibility to follow the University of Nottingham's Code of Practice on Ethical Standards and any relevant academic or professional guidelines in the conduct of your study. **This includes providing appropriate information sheets and consent forms, and ensuring confidentiality in the storage and use of data (sample consent forms attached).**

Any significant change in the question, design or conduct over the course of the research should be notified to your department head and may require a new application for ethics approval.

SECTION V: Further Information as required for paragraph 2 above

In this session, students are divided into two main groups (one group using game-based learning and another using the Internet). The students will be working in pairs for each group. The aim of the lesson is to observe and compare students' interaction, interest and behaviour, especially their ability to collaborate and cooperate, within the two groups.

The teacher and the students are given the opportunity to engage either with the game or with the Internet as an additional teaching tool. The lesson will help the students to recognize that solutions to certain problems (e.g. global warming) cannot easily be solved in a prescriptive way. This is due to the fact that each problem is linked together and quite difficult to separate.

At the end of the session, a brief discussion will be held to capture the students' thoughts on the game and the use of the Internet to understand the problems presented. Comparisons of the two groups will be made in order to see if there are any differences between the two methods.

The aim of introducing the GeoEmission game is to facilitate the student in a new learning environment. By introducing game-based learning in a classroom, they will be offered the opportunity to experience a new game-based learning style; this will be compared with learning in the other medium.

SECTION VI: Agreement

Principal Investigator [Name]	NAIM CHE PEE
Signature	
Date	11 June 2010
Supervisor/Module Leader (where appropriate) [Name]	DR. PETER BLANCHFIELD
Signature	
Date	

SECTION VII: Departmental Head / Ethics Officer to complete

Date form received	
Comments or suggestions	
Decision (circle as appropriate)	**Approve** **Revise** **Reject**
Signature	
Date	

On completion, a copy of this form should be sent back to the applicant and his/her supervisor if applicable.

This form will be kept by the departmental manager.

APPENDIX J

PARENT / GUARDIAN CONSENT LETTER

Parent / Guardian Consent Letter

Dear Parent or Guardian,

I am Naim Che Pee, a doctoral student of Dr. Peter Blanchfield from the School of Computer Science at The University of Nottingham. I request permission for your child to participate in a research study on the use of computer games in education, to be used for my doctoral dissertation. .

Your child will play a computer game designed to teach them part of their normal geography syllabus. The specific lesson is about human contributions to climate change and is part of the National Curriculum for their age group.

As well as playing the game, the children may be involved in answering questions about what they have learned in the session and how they feel during the session.

The activities will be audiotaped. The audiotape is mainly to record their responses based on their experience in the session. This recording will not be retained after the session has been analysed.

The project will be explained in terms that your child can understand, and your child will participate only if he or she is willing to do so.

This is an activity which reinforces the lesson that normally takes place in the school.

If your child agrees to participate, he or she is free to end participation at any time. At the conclusion of the study, children's responses will be reported as group results only. No information which could identify your child will be kept.

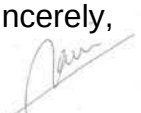
Should you have any questions or desire further information, please feel free to contact:

Naim Che Pee
Researcher
School of Computer Science
The University of Nottingham
Jubilee Campus
Nottingham
NG8 1BB
anc@cs.nott.ac.uk

Dr. Peter Blanchfield
Associate Professor
School of Computer Science
The University of Nottingham
Jubilee Campus
Nottingham
NG8 1BB
pxb@cs.nott.ac.uk

Please retain this letter after completing and returning the signature page.

Sincerely,



Naim Che Pee
School of Computer Science

Please indicate whether or not you wish to allow your child to participate in this study by ticking the box next to one of the statements below, signing your name and returning this part to the school.

☐ I give permission for my child to participate in the study of the use of computer games in education.

☐ I do not give permission for my child to participate in the study of the use of computer games in education.

_____	_____
Signature of Parent/Guardian	Printed Parent/Guardian Name
_____	_____
Printed Name of Child	Date