

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
CO ₂	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.

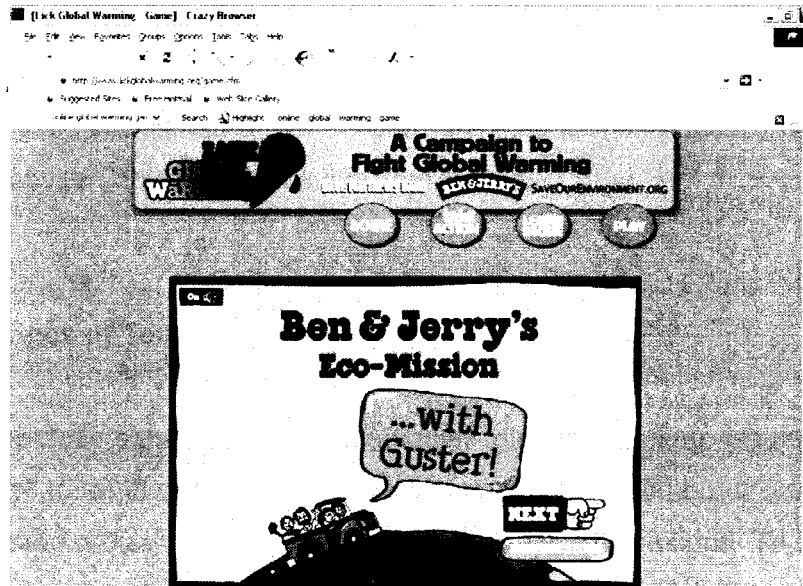


Figure 1.1: The main menu from Ben & Jerry Eco-Mission game (Lick Global Warming)

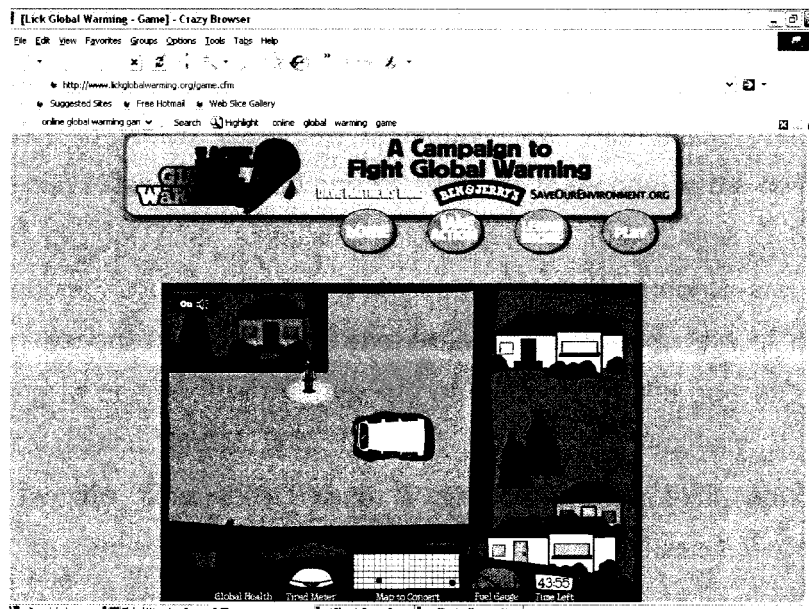


Figure 1.2: Ben and Jerry Eco-Mission game-play screen

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