Computer Games as a Learning Resource

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Abstract: Playing games is an important part of our social and mental development. The computer games industry has grown swiftly, notably on the Windows95 platform, over the past few years. The aims of this project were to: determine the types of games enjoyed by undergraduate Biology students; evaluate student opinions regarding computer games; develop a game (based on criteria identified by students); and assess the role that such a game could play in teaching students. Students evaluated four commercial games (Sim Isle, Red Alert, Zork Nemesis and Duke Nukem). Results suggest that they prefer 3D-adventure (Zork Nemesis, top-scorer) and strategy (Red Alert) games to other game-types ("shoot-em-up" or simulation). A 3D-adventure game on human evolution was designed, developed and used as part of a first-year Biology practical session. While student learnt equally from the game and the traditional practical material, they found playing the game more enjoyable. Games appear to motivate students intrinsically and represent one of the best uses of multimedia in education.

1. Introduction

Play, especially during early childhood, performs important roles in psychological, social and intellectual development, and could be defined as a voluntary activity that is intrinsically motivating, involves some level of activity (often physical) and may possess make-believe qualities [Rieber 1996a]. These attributes closely match those of modern educational theories where learning should be a self-motivated and rewarding activity.

The advent of advanced personal computer graphic systems has precipitated an explosion in game software. This million-dollar market produces many different kinds of games ranging from simulations through to first-person adventures. Here players are immersed into virtual worlds filled with stunning graphics, compelling, if not additive, story-lines, sound and video. However, many question the social consequences of this new form of entertainment.

Some authors [McKee 1992; Billen 1993] argue that games affect cognitive functions, motivation and remove the player from the "real world". But, games appear inherently to motivate users intrinsically by stimulating due curiosity [Thomas & Macredia 1994]. This may be due to the challenges and elements of fantasy [Malone 1980; 1981a,b]. Carroll [1982], Malone [1984] and Malone & Lepper [1987] argue that intrinsic motivation is also a result of the novelty and complexity of games.

Simulations games, in preference to other game-types, are often used in educational environments as students can focussed on single goals, there is decreased competition between students and allows them to explore or experiment at their own pace [Roberts 1976]. However, such simulation games are based on the concept that students need to engage in real-world activities and fail to acknowledge that play is part of our everyday lives, it is not the opposite of work as is leisure [Blanchard & Cheska 1985], and appears to be a universally accepted mode of learning.

Games represent one way in which learners can be emersed into constructivist microworlds. Here, users do not study a particular domain but become part of the scenario, thus stimulating interest and motivation. Microworlds differ from simulations in that they present the user with a simple domain that can be reshaped by the user to explore complex ideas [Rieber 1996b]. Also, self-regulation is an important aspect of microworlds. Such learners appear to be intrinsically motivated [Malone & Lepper 1987], metacognitively active, behaviourally active and self-evaluating [Rieber 1996b]. Rieber believes games, rather than simulations, may provide a meaningful way to present microworlds to learners.

The aim of this project was to evaluate the role that games could play in education. The research was broken down into three phases: (1) Identification of attributes, or game characteristics, enjoyed by students; (2) Development of a game containing aspects of human evolution; and (3) Evaluation of this game in a teaching environment. This paper reports on the evaluation of four commercial games by biology students. Here, student opinions with regard to game attributes, including racism and sexism, were obtained using a questionnaire.
Students also ranked the games according to the enjoyment and were asked how such games could be used in education. A Myst-like game was developed that includes exploration of human evolution in a virtual setting. Students played the game prior to a practical session where they were presented with problems related to human evolution. Each phase of the project will be discussed separately.

2. Evaluation of Commercial Games by Biology Students

2.1. Introduction

The objective of this part of the study were to: (1) Determine the type of game enjoyed by the majority of our students; (2) Identify game elements, or attributes, appropriate for South African students; (3) Create awareness of the racist or sexist elements, if present, of games; and (4) Evaluate student opinion relating to the use of games in education.

2.2. Research Methodology

Outline: Four games, representing different types, were played by a small group (n=20) of first and second year Biology students. Each game was played for about one hour and for each game the student completed a questionnaire. In addition, students provided some demographic data.

Student Selection: All first and second year Biology students were invited to participate in the project. From these applications we selected a group of 20 students made up of an equal proportion of the different race groups and an equal number of male and female students.

Game Selection: Four games were selected and included Command and Conquer: Red Alert (strategy) by 3D Realms; Duke Nukem 3D ('shoot-em-up') by Westwood Studios; Sim Isle (simulation) by Maxis; and Zork Nemesis (adventure) by Activision. All games were played under the Windows95 platform.

Questionnaire: The students answered question regarding to their computer experience and a series for each game. Computer literacy was assessed from questions on experience, how often students used computers and for what they used computers. In this section we also asked them to rate the four games. Questions on each game attempted to ascertain whether the game was captivating or addictive, presented challenges and/or contained racist or sexist elements. Also students identified attractive game properties and suggested how such a game could be used in education, what strategies they used to solve problems and if they acquired new knowledge and or skills. Two types of questions were used: ranking (1 to 4) and open-ended. The time spent on each game and the level, or stage reached, were also noted by each student.

Analysis: Ranking questions were calculated as the mean score out of four (maximum). To determine differences in responses by gender, or by race, the Kruskal-Wallis one-way Anova [SPSS] was used by grouping all the questions relating to each game (n=60).

![Figure 1. Rating of game aspects by students.](#)

![Figure 2. Assessment of skill required to play the games by students.](#)
2.3. Results and Discussion

Of the 20 students who participated in this part of the project, half were female, with an equal distribution among White, Black and Asian. The average age was 19 with most of them having very little computer experience and little exposure to playing computer games. Most students used computers for doing class assignments or for obtaining information. A few students did appear to spend some time playing games.

To determine the type of game elements most appreciated by the students we asked them to rate the games according to the fun aspect, sounds and graphics, type of game, game story and use of technology. Zork Nemesis scored the highest in all aspects, closely followed by Red Alert, Sim Isle, on the other hand, was rated poorly by the students [Fig.1].

As a number of different skills are required to play games, students were asked to assess the importance of some skills (logic, memory, visualization, and mathematics, reflexes and problem solving). The game that required the widest variety of skills was Zork Nemesis followed by Red Alert [Fig. 2]. Few of the games required mathematical skills, while reflexes were necessary in Duke Nukem and problem solving was rated highest for Zork Nemesis and Red Alert [Fig. 2].

Students were also asked whether the game was easy to play, addictive, too long, challenging, confusing, too difficult, illogical, difficult to play or maneuver and if their performance increased with continuous play. Except for Sim Isle, students were able to play the games successfully (see too easy and too difficult); found them addictive, challenging and not boring; were not totally confused; and found that practice makes perfect [Fig. 3].

![Figure 3. Evaluation of game play by students.](image)

Generally students appeared to enjoy Zork Nemesis and Red Alert the most, and did not enjoy playing the simulation game Sim Isle. The student ranking of the different games supports this conclusion (from best to worst: Zork Nemesis ⇒ Red Alert ⇒ Duke Nukem ⇒ Sim Isle).

Statistical analyses of student opinions according to gender, or to race, showed no differences. It appeared that males played the games longer than did the females and therefore completed more of each game.

Students were also asked two open-ended questions dealing with sexism and racism in the games. Only 15% of the total sample indicated that there was evidence of sexism in the games. For Zork Nemesis comments that there was "no character stereotyping" and that "the main character could have been female" was made by one student. Duke Nukem elicited the greatest response with four students making comments. The most evident response was that of degrading, pornographic portrayal of women (expressed by both male and female students). This game was also seen as being "male dominated with rough, violent behaviour". The theme of Red Alert was seen as some what male-orientated but did have both a male and a female in the leading role. No sexism was found in Sim Isle.

Few students commented on racism in the games. However, those that did, showed insight into the underlying cultures that are represented by these games. Duke Nukem was seem as the most racist ("all the
characters were white”; "villains always seem to be dark skinned than the main player or 'hero'”; "hero that wasn't white would be a welcome change”). In Sim Isle "agents were white .. making decisions about island" and "three out of 25 agents were non-white”. Characterisation in Zork Nemesis was seem as appropriate "seeing someone of different colour would have made the game difficult to believe" as the game is based on "white's beliefs" and "wizards". Only one comment was made with respect to red Alert: do "not see any blacks or non-whites in the game".

Generally students enjoyed Zork Nemesis and Red Alert the most. The game requiring the greatest skill was Zork Nemesis. The game least liked was Sim Isle. There appears to be little different between how male and female students viewed the games and the responses according to race groups were similar. These result also suggest that simulation-type games are not appreciated by our students. Therefore, based on these results, we used the 3D-adventure genre to develop a game to solve particular educational needs.

3. Game Development

**Outline:** In consultation with departmental subject experts, a story line was developed based on the adventure-type game. The pilot game was authored to run on the student LAN (Windows 3.11), but is designed in such away that 3D-virtual worlds can be created for the Windows95 platform.

**Technology:** Graphics were created in 3D-Studio Max (Kinetics) and the game-engine in Delphi (Borland). When necessary, graphics were edited in Photoshop (Adobe). The game was created using tools that added navigation and other elements to each game page and created the game files. The game player was programmed to read and display these game files.

**Basic Story:** The player is sent to an island that has been evacuated because of a viral infection. Here, within a single museum-like building the player, wearing a biohazard suit, explores the different levels to discover clues and objects that will be used to create an anti-viral protein in the final episode of the game. In the pilot program only one such level has been built. In the helmet of the biohazard suit the ambient temperature and oxygen levels are also displayed. During game play the temperature changes, depending on the location of the player and the oxygen level decreases with time. Also, e-mail messages are sent to the player. The control panel, at the bottom allows the player access to e-mail messages and the collected objects. The basic design of the game interface is shown in Fig. 4.

![Figure 4](image1.png)

**Figure 4.** Interface of the game showing a view through the helmet of the biohazard suit.

![Figure 5](image2.png)

**Figure 5.** Percentage difference between pre-(□) and post-(■) test.

4. Use of Games in Education

4.1. Introduction

To evaluate the role that games can play in the teaching of Biology, a first year student practical session was redesign to include two elements: (1) Playing of the game; and (2) Practical work on problems relating to human evolution. To determine student knowledge a pre- and post-game test was used. Student attitudes with respect to this activity were obtained using a questionnaire.
4.2. Research Methodology

Outline: Before the start of the two practical sessions, Environmental Biology 1 students (n=58) were asked to complete a number of multiple-choice questions on the evolution of man. During the first practical session students played the game, developed by the research group, for a minimum of 2 hours. In the second session students were presented with a number of practical problems that they had to solve. Thereafter, the students answered the same multiple-choice questions.

Pre- and Post-game Tests: Here knowledge obtained from the game, practical handout and practical session was assessed. Individual students were scored on their success in answering the questions.

Questionnaire: Opinion relating to the use of a game to help in the teaching of human evolution was obtained from the students by means of a short questionnaire.

4.3. Results and Discussion

To assess the use of the game as a viable teaching method, students answered a number of multiple choice questions testing knowledge provided either by the game or during the practical. The mean and standard deviation for the pre-test was 44.13±12.27 and for the post-test 60.07±12.48. While not significantly different, student did perform better in the post-test. Test questions related to knowledge learnt from the practical material or game were separated and plotted as the difference in mean percent for each question (Fig 5). Students appeared to learn information equally from both forms of material (no significant difference between groups, t-statistic: 0.24).

Table 1. Student answers to the question: "What was your motivation to play the game?".

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Number of similar answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curiosity and Interest in topic</td>
<td>26</td>
</tr>
<tr>
<td>Game Completion</td>
<td>12</td>
</tr>
<tr>
<td>Course requirement</td>
<td>10</td>
</tr>
<tr>
<td>Fun</td>
<td>8</td>
</tr>
<tr>
<td>Puzzles and clues</td>
<td>7</td>
</tr>
<tr>
<td>New study technique</td>
<td>4</td>
</tr>
<tr>
<td>Graphics</td>
<td>4</td>
</tr>
<tr>
<td>Informative</td>
<td>3</td>
</tr>
<tr>
<td>Interest in computers</td>
<td>2</td>
</tr>
<tr>
<td>Assisting in practical course</td>
<td>1</td>
</tr>
<tr>
<td>Exploration</td>
<td>1</td>
</tr>
</tbody>
</table>

In addition, we asked them if the game improved their understanding of the course material, if it is a good
idea to include games in courses (3.2), if games made learning more fun, if they would prefer written material and if the game allowed them to explore and learn at their own pace. The scores, out of a maximum of 4 were 3.0, 3.2, 3.2, 2.4 and 3.1 respectively.

Two open ended questions were asked. The first: "What do you think you learnt about human evolution while playing the game?" elicited a variety of answers with "Phylogenetic grouping and origination" and "Facilitated understanding" being the most popular. When asked what their motivation was in playing the game a number of answers were given [Tab. 1]. The majority of the student appear to be intrinsically motivated to play the game, except 20% who stated that they played the game as a course requirement.

These results suggest that students enjoyed playing an educationally based game, appeared to be motivated by the "fun" aspects of computer technology and gained knowledge.

5. Conclusions

First and second year biology students appear to favour 3D-adventure (Zork Nemesis) and strategy games (Red Alert), were critical of the racism and pornographic elements in the first-person "shoot-em-up" Duke Nuken and found the simulation game Sim Isle unsatisfactory. The development of an adventure game by the research group was used to test the applicability of such technology in education. The pilot project on integrating information into an adventure type game was enjoyed by most students and they also learnt knowledge while playing.

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