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ABSTRACT

This introduction to computer simulations as an integrated learning experience reports on their use with students in grades 5 through 10 using commercial software packages such as SimCity, SimAnt, SimEarth, and Civilization. Students spent an average of 60 hours with the simulation games and reported their experiences each week in a personal log. Students became actively involved in problem solution through accessing online helps, reading manuals, doing independent research, and discussing innovative techniques with each other. Simulation games were able to keep students of various abilities challenged and interested and also changed passive learners into active learners. Principles of these rule-based simulations are briefly explained as are learning strategies fostered by these games. Five simulation packages are briefly described. (DB)

Computer Simulations: An Integrating Tool

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Computers have played a significant role in public education for at least the last decade. Many schools in Alberta purchased significant numbers of Apple II computers at the beginning of the 1980's through provincial subsidy programs. These computers were able to perform computer assisted instruction, if the content being addressed was knowledge based, and presented in a drill and practice format. Rapid changes in personal computers technology at the beginning of the decade, promises made by software creators, and a lack of imagination on the part of school system administrators and provincial legislators, left many educators with the impression than an education revolution had begun.

Personal computers provided the teacher with another instruction tool. Given the limitations of the hardware and software, teachers had difficulty using the tool as more than just a drill and practice device. The computers were too slow, and the software resembled the electronic equivalent of a book. Many promises were made, and few were realised. This has left many educators disappointed and many administrators hesitant to commit new funds to a rapidly evolving technology.

During the first two years of this decade, the power to price ratio of computer technology enables us to now buy five computers for the same price of one in 1983, plus processing speed has increased one hundred fold. We now have affordable computers that are capable of creating interactive virtual realities. Many of the computer based instructional desires of the early 1980's can now be realised. The personal computer is now capable of receiving, modifying and delivering text, audio and video on one platform. It is capable of integrating multimodal methods of delivery and of acting as an interactive exploratory medium. This is primarily the result of the change in philosophy by designers of computer systems in the mid 1980s.

In 1984 the MacIntosh computer was introduced. It set the standard for graphical user interfaces, (desktop icons, pull down menus, scroll bars, and no command line) that are now familiar to user of the Mac, and to Windows users.

The MacIntosh has changed the way we write and edit documents, and create drawings. It has had a direct impact on teaching the writing process. In this world the writer is given the 'what you see on the screen is what you get in print' ability. This applies to the formatting of text and to adding visuals to the body of the text. Word processing programs now lend themselves to teaching methodologies that focus on revision, collaboration, and publication. Following in this innovative tradition, the MacIntosh has now given the writing community a new type of document called the *dynamic document*. This document, still created by a word processor, is enabled, so that it can incorporate and play back time-based information, such as sound and video sequences. This will create a new way of writing, and should place many more MacIntoshes in our schools. Recently, similar technical advancements and reduction in costs also placed large numbers of DOS-based machines into schools. While these machines are less expensive when initially purchased, enabling them to produce sound and video on screen requires a greater investment in hardware and software. In the long term, this makes MacIntosh computers less expensive.

Increases in computer processing speed have enabled us to create dynamic documents, which are multidimensional. Instructional software, and role playing or gaming software , has also changed as the result of having greater procesessing power available. Gaming software is becoming more difficult to distinguish from instructional software because software producers have realised that modelling natural phenomena is just as engaging for users, as artificially created worlds. In the last two years, new software has used themes from our history and scientific models as the basis for interactive adventures. Simulation software, where the user has the ability to manipulate many variables and receive immediate feedback in a screen environment that reflects these changes, has become immensely popular. Simulation software is able to model natural, or man made events, with a high degree of sophistication and complexity.

Educational technologists and psychologists promote the role that computers play in presenting information and enhancing the student's recollection of facts. At the same time, they are critical of software producers, in that much of the software available for both educational and entertainment purposes does not address the need to develop observational, measurement and analysis skills. This may be true, but part of the problem was that the personal computer hardware necessary to present interactive and reasonably complex problems was unable to handle the number of calculations required per second to present and change screen based information in real time. This is no longer the case. Personal are now fast enough to handle the calculations required to change screen based information in real time. Software is now being created that presents the learner with realistic situations that are very good at imitating events, processes, and activities that happen in the 'real world'. This class of software is known as*Simulation software.*

Few classroom teachers have the time, interest, or resources necessary to create software of this sophistication. There are commercial programs that can be used effectively in the classroom to address higher order thinking skills. These programs have evolved to the stage where they challenge and engage the learner over time by becoming more challenging themselves.

Myself, Michele Jacobsen, and Jaggit Singh, all of us teachers, have spent the last year exploring the possibilities of using simulation software as an integrating tool in the classroom. I have been pleasantly surprised to find that this type of software is able to keep students of various abilities challenged and interested. I have also found that students who were passive learners became active learners inside and outside of the classroom.

Students from three school systems in and around Calgary volunteered to come to the university one night per week for four hours, (for six months) to "play" with simulation software. These students were in grades 5 to 10. The group was not homogeneous. There was an equal distribution of both males and females, which included students labelled by the school system as being gifted, educationally disadvantaged, and inner city high-needs students. They came from all walks of life. A typical classroom of students.

The curriculum in our program consisted of fo. · simulation softwa.e packages, *SimCity*, *SimAnt*, *SimEarth* (Maxis), and *Civilization* (Microprose). These packages were produced in the last two years for commercial purposes and the authors of the software consider them to be gaming software. The students were introduced to the sof*ware in the order indicated above. After observing how the students iteracted with *SimCity*, it was decided that*SimEarth* was probably too complex for this group.

Each week the students recorded their experiences in a personal log. New challenges and problems were introduced, and possible solutions were discussed each week. Students then spent the balance of the four hours engaged with a simulation.

Initially we found that the students used the tools that were available in the software to cause the rapid destruction of the cities, civilisations, colonies, or life forms. But they quickly became bored with these scenarios, and actively became engaged in seeking solutions to the simulation problems posed. Students spent considerable time accessing the online helps that were available in the software, reading the user manuals, and doing independent research. These simulations assumed a significant level of general knowledge in the areas of population and resource management, economic models and general scientific knowledge.

We found that the students actively sought out their peers to discuss problems during class time and to discover what innovative techniques each was applying to the simulation situations they encountered.

In discussing learning strategies with them, we found that their personal research generally addressed gaps in their own knowledge, information they perceived to be important to the successful completion of the simulation. No one advanced to the stage where they were in a position to finish the game. On the other hand, none of the students became discouraged by the fact that the end 'didn't appear in sight'. In total, each student spent approximately 60 hours at the university pursuing simulation goals, and for some, an undetermined number of hours at home or in their own schools pursuing solutions on computer.

All of the simulations operate from a rule base. For example *SimcCity* uses approximately 100 rules to assess new input, make changes and provide feedback. These simulations were chosen for a number of reasons. They were sufficiently complex so as to not lose the users interest, while at the same time they could be adjusted to the users experience and knowledge level. They addressed mathematical, scientific and social issues in a realistic manner. They were also content accurate.

All the simulations operated in real time. This means that when a change was made to one of the many variables, the results or the feedback was immediate. In most instances, the feedback occurred visually. The programs were not visually static. For example, in*Civilization* , cities appeared to grow overtime; caravans, diplomats, etc. could actually be seen travelling across the country. In*SimCity*, cars and light rapid transit trains followed a 24 hour cycle; city neighbourhoods changed density according to the time of day. Real time feedback and animation helped to maintain user interest. All of the simulations also presented feedback in numerical, graphical, or textual formats, and in many instances, the user could choose the form of feedback desired. The students were required to use concepts learned in social studies, science and mathematics, while they reported to the group and to each other using communication skills learned in language arts.

The problems presented by these simulations are multidimensional. The problems require factual knowledge to solve, but the application of this knowledge, the reactions both organic and procedural, of the 'bio-organisms' (ie: Sims that lived in the cities) and the larger simulation model, (ie: the city) have to be considered. Some understanding of social engineering also has to be applied.

Initially we thought that students and teachers would have difficulty with the"open endedness" of this type of software (participating teachers did, the students did not). Therefore, the fundamental concepts and user techniques of each program was presented in class. This was followed by the completion of one "game" by the group as a whole. After this introduction, the students were given the freedom to address the simulations in whatever manner they found to be successful. They learned very quickly how to decide which input variables to use and to what degree to make changes. We found that they all used a mixture of the available output forms, graphs, numbers, and text based information, to assess the effectiveness of their decisions.

Teacher concerns in using this type of software in the classroom are many. The most important revolve around issues of control. In this type of learning environment, teachers are not in control of the learning, nor are they in control of the content or curriculum. It is difficult to address learning objectives and measure outcomes when each student is learning at a different rate, addressing different problems, and arriving at different solutions. This type of environment does not limit the tools available to the student. We thought that the students might have difficulty with the open-endedness of the software. It was impossible to limit the tools the students had access to. The programs were not designed with that utility in place. The students had no difficulty with the scope of the tools and manipulated variables according to their personal levels of knowledge, experience, and understanding. More important, is that they used tools and manipulated variables in an experimental manner, without having or knowing that there were a predetermined set of outcomes. Each student worked in a uniquely individual world. The rules were not known in advance. They were there to be discovered, based on personal practical knowledge and to be experimented with in real time.

In a traditional classroom experimental setting, students generally repeat and reproduce one the 'classic' set of experiments particular to the subject being studied. They know the outcomes in advance and they are graded according to how well they present the experiment in written form and how close they come to the predetermined results. This type of learning/teaching situation lends itself to empirical assessment methods with which today's teachers are comfortable with.

We know that this type of setting only occurs in the classroom and lessons learned there do not really apply to the real wor:d. Simulations attempt to model the real world, therefore addressing problems found there. Simulations approach reality with a greater degree of clarity and practically then 'content' found in the current curriculum and classroom. Therefore, they have the potential to introduce a greater degree of realism, individuality, and personal responsibility to the learning process.

Our methods represented to the students a new way of addressing learning. Learning is a personal and individual process, done by each of us in a uniquely different way. These students came to us as directed learners. They expected us to direct their learning experience in this new situation because that this the way their own personal schooling experience had been. We struggled with this during their introduction to the first simulation. Initially, they required a lot of direction and reinforcement in tackling the challenges presented by the software. Over the course of our first four meetings,this changed for them. They developed independent problem solving skills, and gained the confidence and the independence to address new problems on their own. They stopped seeing us as 'teacher directors', and started to regard us more as facilitators, and though difficult to document, they probably learned more 'content' in their time with us, than in their previous school experiences.

The following applications represent a guide for assessing the quality and features that should be found in simulation software that can be used across the curriculum. The grades are suggested as a guide.

Flight Simulator 4: (High School)

A real-time simulator, this program is the current version of one of the most popular computer simulations. In this version, the developers have added a design pallet that allows the player to create aircraft of their own design by modifying 30 different design parameters. While it is not possible to provide details here, this feature makes it possible for teachers to use the program to have students study the effects of design variations in terms of Newtonian laws of motion. Principles of momentum, acceleration, lift and force are just a few of the possibilities for dynamic lessons in physics derived from creative manipulation of the program design parameters.

Moonbase: (Junior High School)

Students would use this program to design a moonbase for the exploration and mining of the moon. Variables under the student's control determine the health of the explorers, climate control and power output, mining of, and manufacturing with , oxygen, helium3, and water, and employee relations.

SimEarth: (High School)

The player constructs a planet, choosing from one of the four available geological time periods as a starting point. The curricular possibilities are evident in the broad categories of variables controlled by the player: chemical, geological, biological, and human factors. Among other topics, this program lends itself to creative exploration of concepts in evolution, atmospherics, continental drift, and astronomy.

SimCity: (Grade 5)

The player is the city mayor, city planner, and city manager, having the responsibility of building a city infrastructure that supports a healthy populace with an active, productive economy. Such variables as pollution control and energy systems provide ample room for science-oriented lessons. The whole task lends itself to a marvellous exploration of human factors in ecology.

Civilization: (Grade 6)

The goal of this program is to compete against other emerging civilizations, evolve on Earth so as to lead all others in the scientific and social science departments, and to lead your people to another galaxy. The player can pick the number of other groups to compete against and the planetary conditions from which to start. The goal is to create a growing and happy populous by maintaining a healthy economy, making war and peace when necessary, dispatching diplomats, caravans etc.

All of the above also afford the possibility of interesting mathematics assignments, since underlying the simulations are sets of equations that govern the machine's response to player's input. Other simulations to consider. "Where In the World is Carmen San Diego?", "Shuttle". "Populous", "Railroad Tycoon", "A-Train", and "Glider".

In conclusion, I believe that this calibre of simulation can serve as an effective integrating tool, and can, if effectively implemented, serve as the focal teaching tool for many subjects currently taught in our schools. The emerging state of the technology will only enhance our abilities to create interactive computer based learning environments, freeing both the teacher and student from the restraints placed on them by curriculum and the schooling process.

For more information please contact me at 220-6617 or bilan@acs3.acs.ucalgary.ca.

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