INTEGRATING INFORMATION TECHNOLOGY INTO THE TEACHING AND LEARNING OF HIGH SCHOOL SCIENCE

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ABSTRACT
This presentation will describe innovative applications of Information and Communication Technology in a large Canadian senior high school. In particular the presentation will focus on the instructional use of videoconferencing in the physics classroom. The presentation will also briefly describe, from the teachers' perspectives, two initiatives that integrate the use of the Internet into the classroom notably, the teaching of physics onli*ne* and student development of web pages in physics.

KEYWORDS
Videoconferencing, web-based learning, physics, high school, instructional technology

INTRODUCTION

Two major goals relating to the use of Information and Communication Technology (ICT) in education are the achievement of technological literacy of students and the use of IT in the practice of teaching (i.e., the integration of technology into the teaching and learning processes). In September 2000 a mandatory program of studies was introduced to all schools in the Province of Alberta to ensure the achievement of student technology literacy. This program (which involves all grade levels and focuses on integration) is commonly referred to as the Learner Outcomes in Information and Communication Technology. All schools in the Province are currently working to implement the learner outcomes within a three-year timeline. Although the learner outcomes are reflected in all subject areas there is a strong emphasis on the use of ICT in the later grades, particularly in mathematics and the sciences. This presentation will provide teachers' perspectives on innovative applications of ICT in the physics classrooms of a large Canadian senior high school through which both of the goals referred to previously are being addressed. The three classroom-based initiatives relate to; the use of videoconferencing, student development of web pages in physics, and the teaching of physics online.

VIDEOCONFERENCING IN THE PHYSICS CLASSROOM

Preamble

Thousands of years ago students were learning directly, "live" from the masters. Communication in those times was mainly oral and visual. As time progressed students obtained their knowledge from textbooks, which were written by the masters in the various fields. With the evolution of technology, knowledge and information has more recently been transmitted to the general population by telephone, records, film, audiotapes, television, videotapes, and computer-based magnetic and optical media such as floppy disks and CD ROMs. In using a combination of computer and videoconferencing technologies, today's students can now overcome what were once prohibitive geographical barriers to once again learn directly "live" from the masters.

Videoconferencing is an interactive tool that uses video, computing and communication technologies to allow people in different locations to meet face-to-face and perform most of the same meeting activities they would perform as if all participants were in the same room. Therefore students, no matter where they are located in the world, can have access to the masters at any prearranged time. As Marshall McLuan predicted approximately thirty years ago, we are rapidly becoming a global village (http://www.chipcenter.com/columns/COL20000616F.html).

While videoconferencing has been around for several years it has typically been too expensive for schools to consider. Recently, however, the cost of this technology has decreased to such an extent that it is now feasible to introduce it to the classroom.

The technological environment

At the very start, it was decided that the videoconferencing facility should be mobile rather than being located in a dedicated (videoconferencing) room. It was felt that this approach would maximize the number of students that could simultaneously participate in videoconferencing. Three ISDN lines were installed in seven locations throughout the school (two in regular classrooms, one in a conference room, one in the learning resource center, one in a large humanities room, one in a Career Technology Studies lab, and one in a large gymnasium).

This arrangement provided the school with maximum flexibility for matching the approach to videoconferencing with the needs of the occasion. For example, the needs might vary from the delivery (by an expert from afar) of a special topic in physics in a classroom to an interactive address by the Prime Minister to the whole school in the large gymnasium. In between this range of possibilities is the prospect of using the large humanities room to conduct a town-hall-meeting with a political figure.

The following is a list of the equipment that is presently used by the school for videoconferencing:

Computer CPU - Pentium II, 350 MHz including:
- 100 MHz bus
- 128 MB RAM
- 1.44" Floppy drive
- 4 MB ATI video card
- 4.3 GB internal hard disk drive
- 17" Monitor
- 32 X CD ROM
- Creative labs sound card
- 3 COM network
- Removable hard drive - 4.3 GB

Gated audio mixer (this device, turns microphones on and off to eliminate feedback)
One wired, PZM (pressure zone microphone - this is a the small black microphone which sits on a table and transmits audio to the other side)
Video mixer (allows document camera and multiple cameras to be switched and shown to the other site)
Basic codec (device which translates audio and video into telecommunication signals)
Network terminators (which attach to the ISDN lines)

The above equipment is mounted in an industrial rack in a large black case with casters. A document camera and a NEC MT820 SVGA graphics/video projector are located on top of the large black case as shown in Figure 1. Also an important part of the setup is a wireless microphone which allows the teacher to move unencumbered throughout the room. Recently a Sony Digital Camcorder DCR-TRV320 with a tripod was added so that the students can be seen from angles other that defined by the document camera.

Fig.1 Videoconferencing equipment

The equipment described above allows for connections at the following rates: 56, 64, 112, 128, 168, 192, 224, 256, 280, 320, 336, 384 Kbps. The multiples of 56 K (1 - 6 lines) are CENTREX speeds and the 64 K multiples (1 - 6 lines) are ISDN speeds. All the lines are "dial-up" - this means they are not on an internal network and this allows direct in and out dialing without a bridge or intermediary point. The system is T.120 compatible to allow document sharing, interactive whiteboarding and document mark-up.

Audio compressions supported include the low G.711, the medium G.728 and the high G.722 for crisp audio. The codec works with an IMUX (inverse multiplexor) to "bond" all six lines together. This means that “the other end” only needs to dial one number to connect - the codec automatically connects the other lines.

The software used is OnWan by Zydacron. It is user friendly so that the teacher doesn’t have a steep curve to learn the program. All the teacher has to do is click on the number that s/he previously installed and the software makes the connection automatically. Also, an incoming call is automatically answered and all the teacher has to do is respond accordingly.

The cost of the equipment (which was initially assembled and tested by the local vendor) was approximately $30,000 Canadian.

Experiences with videoconferencing

Videoconferencing has been in use at the school for two years. Recently, with the strong support of the principal, it was decided to introduce this relatively new method of communication to the classroom.

For those considering using videoconferencing in the classroom, one of the first things to do is to sign up with a listserver that specializes in videoconferencing. In this way, it is possible to keep up-to-date on what is happening in the area and to establish contacts and network with other teachers who are interested in the same topics. An excellent listserver is listserver@pacbell.com. According to http://www.kn.pacbell.com/wired/vidconf/ideas.html there are five general practical uses of videoconferencing, notably:

- Courses, lessons, and tutoring
- Remote guest speakers and experts
- Multi-school projects

- Professional activities
- Community events

In the past two years, our school has been involved in the first three of these.

Courses, lessons, and tutoring
Last year the school linked up with the Liberty Science Center in New Jersey which normally provides electronic field trips for a fee (the cost of an electronic field trip was $300.00 Canadian). Two topics in science were experienced with them. One was on Earthquakes and the other was on the Behavior of Waves. The first step in videoconferencing is always to confirm that the connection is good. When it is a point to point connection it is easy but in the US, one sometimes has to go through many telecommunications providers. In this case, it was necessary for the field trip provider to call the school instead of vice versa. With the session on "Earthquakes" the connection was good but another time, after 10 minutes into the "Behavior of Waves" it was necessary to terminate the session because of a bad connection. The school needed to prepare in advance for the earthquake session, by filling out a sheet on the type of building, soil, and size of earthquake we wanted to witness. At the beginning of the session two people at the Liberty Science Center explained the types of earthquakes that existed and what caused them. Afterwards they asked for our predetermined input so that they could simulate the event with the use of a program in order that we could witness the action. The students were allowed to change the variables and observe the results. The experience was good because the students could visualize the effects of their inputs. Using a five point Likert type scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree), the grade eleven (Science 20) students who participated in the earthquake field trip were asked to evaluate the experience. Table 1 shows the results that he obtained.

Questionnaire Item	Mean (N=17)
I learned a lot	2.76
The experience was fun	3.79
The technology made the experience worthwhile	3.85
Talking to the instructor was more valuable than talking to a class	2.35
Videoconferencing is a valuable use of time and school resources	4.16

Table 1 Student attitude towards the earthquake session

While some teething pains were experienced with implementing the virtual field trip, the concept is considered to be worthwhile and more such activities will be pursued at the school.

Remote guest speakers and experts
Two separate initiatives were pursued in this area. The first one connected the school with a student in Skopje, Macedonia during the Kosovo crisis. The second connected the school with three marine biologists from California during the school's career day.

Initiative 1 In April of 1999 Professor Frank J. Gaik at Cerritos College in California organized the Balkan Bridges Videoconference series. Schools from different parts of North America dialed in to Cerritos College and were subsequently connected to a student in Skopje, Macedonia. The College acted as a bridge to the student. While our school only had an audio connection with the student there were sometimes as many as eight schools connected. Our school could always see four of the schools on the screen. Whenever a school spoke they would automatically appear on the screen. The questioning was mainly about the effects of the social upheaval that was taking place in the area at the time. The connection was always at the same time on a Monday morning during April and May. Our school connected four times during the crisis. One time the audio connection was intercepted by someone in Belgrade and during that particular connection they fed us false information about the events in Kosovo. This event was reported in one of our local newspapers (the Sun).

Initiative 2 On November 15, 2000, the school held a career day at. For the occasion a one-hour videoconference session with three prominent marine biologists from the Ocean Institute in Dana Point, California was organized (see Figure 2).

Fig. 2 Marine biologists at the Ocean Institute

This videoconference was held in a classroom but as can be seen in Figure 3, the session was so popular that it was overcrowded.

Fig. 3 Students watching the three marine biologists

The experience began with a virtual tour of the Ocean Institute's videoconferencing facility – a camera located outside showed what the area outside the Institute looked like (see Figure 4). The biologists proceeded to show some videos of the type of work they do and discussed how they chose their profession. Throughout the session, the students asked many varied questions.

Fig. 4 View outside the Ocean Institute

As a result of the overall success of this session, the school is planning to have other professionals/experts interviewed via videoconferencing.

Multi-school projects
Under this type of practical use of videoconferencing our school collaborated with three different schools from around the world (Cleveland, Ohio; San Isidro, Buenos Aires; and Michigan, USA).

The first collaboration involved the sharing of experiences pertaining to Amusement Park Physics with the Cleveland school. In this initiative, students from the collaborating classes went to the nearest amusement to complete an assignment on the physics of various rides. The physics of dynamics, kinematics and the conservation of energy could be easily reviewed and recorded using worksheets. The students experienced the different rides and afterwards, calculated the forces and energies involved.

Two of three, planned videoconferencing sessions were completed. The first session served to introduce the two schools and their respective students to each other. The second session was used to discuss the type of rides that were going to be studied. It was intended that the collaborating schools would use the proposed third session to summarize and discuss their experiences and results but an occupational hazard (a scheduling conflict) prevented this from happening.

The second collaboration was with a physics class (and two teachers) in Buenos Aires, Argentina. With the help of one of the teachers (in Buenos Aires) who spoke English our students were able to communicate with the students and the other physics teacher at the Argentinian school. Several conferences were conducted during two semesters (one school year). During one semester, both schools performed the same experiment on gravity offline and then connected to discuss the observations. On another occasion, the schools connected to perform demonstrations in electrostatics and then discussed the observed results.

The third and most recent collaboration occurred with a physics class at the Michigan school. The physics teachers at the respective schools agreed to exchange three problems on projectiles. Both classes had to solve and explain the problems during a videoconference (see Figure 5).

Fig. 5 Students working on problems in both sites

The large screen shows students from the Michigan School. The small screen shows students from the local school.

For all three collaborations the connection was excellent even though our school was unable to connect at 384 Kbps with Argentina.

Comments

Several benefits of the use of instructional videoconferencing were observed during the past two years. One of these was heightened student motivation in the subject of interest. The students looked forward to collaborating with other classes and therefore would to prepare ahead of time. This improved their communication and presentation skills. Another benefit of videoconferencing was that it increased the students' connection with the outside world. The first contact was always spent on getting to know the other class.

On the sheer practical side, the following observations are offered to teachers who may be thinking of venturing into the world of videoconferencing.

- As a rule of thumb, make sure that the time difference between the communicating schools is not more than two hours (it is hard to schedule during a regular school day).
- Choose a program that is easy to learn.
- Establish the connection in advance without the students (excessive delays can lead to idle and frustrated students).
- Always organize the agenda of the meetings prior to connecting.
- If possible, connect with people close to you. This will keep the phone bill low.

The initial cost of involvement with videoconferencing is high (currently, approximately $25 000 Canadian).

Overall, it is felt that this new technology opens up many possibilities for bringing resources into the school from all over the world. One of the school's immediate goals is to employ this technology to connect one of its classrooms with the space station and to discuss physics in space with one or more of its astronauts.

INTEGRATING THE INTERNET INTO THE CLASSROOM

Teaching online

Becoming involved

In the fall of 1999, the school decided to explore the feasibility of offering online courses to its students. Initially, this challenge was assumed by two teachers at the school. One of these teachers (having previously established a web page for his Physics 20 and 30 classes - http://go.to/studyphysics) was chosen because of his prior knowledge and experience with the Internet and authoring for the World Wide Web (www or the Web). As a result of this early initiative, the experienced teacher was already aware that, in the absence of budgetary support and/or release time, the interactivity of any web pages developed would be severely limited.

In an attempt to find a more efficient approach to development, the teachers decided to explore a product called WebCT (an abbreviation for **Web C**ourse **T**ools). This program had been flagged as promising by one of the other teachers on staff based on its widespread use, including at the University of Alberta. WebCT is essentially a shell with built in Java scripts, templates, intranet email, and other features that make building and offering online courses more straightforward. It removes the necessity for the developer to have a strong background in HTML, while accentuating the development of course materials. Initially, the two teachers set aside a day to learn about the intricacies WebCT by themselves. As the day wore on, however, they became increasingly frustrated with this experience and came to the realization that a much greater investment of time would be needed to acquire any meaningful level of competency, let alone the proficiency to develop curriculum. It became abundantly clear that significant release time would be required to develop the required skills - it was also clear that such resources were not within the scope of one school's shrinking school budget. In the end the general consensus was that it was necessary to rethink the model that was being proposed.

Upon learning of the school's initiative the School Board expressed an interest in fostering a partnership among a number of schools with a view to pursuing the development of online learning opportunities for students. The hope was that, by spreading out the cost and the workload among a number of schools, a greater variety of online materials could be developed. It was as a result of this thinking that the district's online school "Revelation Online" emerged.

During the spring and summer of 2000, a number of meetings, and inservices took place. As well, negotiations were conducted to determine how the costs and potential benefits of the project would be distributed. Approximately ten teachers (from four high schools) were selected to pilot test the program with a limited number of course offerings. Three factors were paramount in the selection of pilot teachers (and their schools) notably: a strong desire to experiment with online learning; the capacity of participating schools to provide pilot teachers with release time (for course development); and the prospect for producing a diverse set of courses. In the first instance, it was felt that the quality of materials produced would be maximized if the participating teachers were allowed to choose the courses that they developed according to their preference and their area of expertise. To date three courses have been developed and are being piloted (Math, Art, and Career and Technology Studies) and two more are close to completion (Physics and Social Studies).

Each participating teacher was provided with a Digital Subscriber Line (DSL) connection at home - their schools were encouraged to provide them with a laptop computer for use as a "virtual classroom". During the pilot phase the courses are being offered only to those schools that are directly involved with the project. The courses are administered by the district's Continuing Education department. Income generated as a result of student enrollment is shared between the school and Continuing Education.

Observations
As indicated previously, the physics course is still under construction (but close to completion). In general, converting a traditional course an online delivery has proved to be more challenging and time consuming than at first imagined. As well, the learning curve for WebCT was more time consuming than anticipated. Despite the fact that the course will be online, the textbook will still be a key resource for the students. However, in recognizing, that there is not the same opportunity for discussing topics online as there is in a conventional class, the web site features a special notes" section for each topic. A conscious effort has been made to ensure that these notes are not merely a rehash of the textbook's treatment of a particular topic. As well, the notes section features hyperlinks to other web-based resources and a limited number of streaming videos. The streaming videos feature the teacher delivering presentations on some of the more challenging topics in much the same manner as they would be presented in a live delivery mode in a conventional classroom. Some difficulties were encountered in integrating the streaming videos with WebCT but these were overcome by streaming over the Internet.

Connection speeds were a constant issue while developing the web pages. In the final analysis it was agreed that web page design should be driven by the needs of students with slower, dial up connections. For this reason, it was decided that all pages should be created in basic HTML with limited (or fast loading) graphics. It is anticipated that the courses will me optimized for the faster Internet connections (such as cable modems and dedicated Asynchronous DSL lines) as these become more commonplace.

In the conventional classroom the introduction of a new topic typically begins with a very dynamic discussion. In the virtual classroom this activity will take place through the use of a bulletin board where students will be required to express their thoughts. Students will be evaluated on the extent of their participation, the originality of their contribution, and on their interpretation and application of physics concepts. Although not as spontaneous as in-class discussions it is expected that the bulletin board will effectively still foster the exchange of ideas.

In the development (and first implementation) phase of the course it is anticipated that conventional lab work will be reduced very substantially in favour of the use of lab simulation activities that are already available on the Internet. In the future it is anticipated that laboratory simulations tailored specifically to the course will be developed in-house. In order to accomplish this it will be necessary to become proficient in the development of Java scripts.

Awarding marks for online work is a concern, since it's difficult for us to be sure who is actually doing the assignments and tests. Because of this only 30% of the course final mark will be based on the online work. The remaining 70% will be divided between two proctored, in-school examinations (a midterm and a final).

Prior research into online schooling showed that the successful schools always emphasized a good relationship between teachers and students, even if it was virtual. In light of this, it was decided that regular contact with the online students would be a key characteristic of the program. A policy has been established that all online students will be contacted by email a minimum of two times a week to ensure that they are motivated and to remind them that their progress is being monitored - just as it would in a conventional classroom. Close contact will also be maintained with the parents as appropriate.

The above description speaks more to becoming involved with online learning at the high school level than it does to its effectiveness. The approach will undoubtedly differ from that which might be workable at the post-secondary level. Course development and refinement will continue and indicators of success will need to be identified. Several implementations will be necessary before any conclusions can be drawn about the viability and effectiveness of online learning in the school setting.

Student development of web pages in the physics class

The previous section describes an initiative in which the intent was to deliver whole courses via online learning. This initiative differs substantially in that its main objectives do not relate to the delivery of a course that was developed by the teacher but rather, the development of an informational web-based resource by the students. Student involvement in this project (which began about a year ago) is voluntary and although the project is integrated into the physics class, most if not all work done on it by the students is done on their own time. While the project takes place in the physics classroom the students receive official credit in a different course called Career and Technology Studies. It is for this reason that the work for this project is pursued largely on the students' own time. It is also the reason why the objectives strongly reflect the use of Information and Communication Technology. The three main ICT objectives are that the students will:

- learn how to develop a simple web page using HTML
- learn how to use the Internet to access information and to enhance their learning
- develop a positive attitude towards the use of ICT and the Internet in particular

The two main objectives from the physics perspective are that that the students will enhance their knowledge of physics and that they will contribute to an evolving, web-based information resource for use by other students.

The project began with the development of the basic web site by the teacher. Students who participated were then given a very diverse list of suggested topics and asked to choose one that was of interest to them (students were also free to submit their own topic for approval). The students were then required to develop a multimedia web page, including hyperlinks, which explored an aspect of physics that related to their topic. The intent was not only for the students to expand their knowledge of physics but to contribute to what might become an online encyclopedia. Under the guidance of the teacher, the students were given one and a half months to complete their web pages according to established criteria – they were not permitted to use commercially available web page development tools. Students submitted their pages to the teacher who then posted them to a host site.

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