Integration of Computer Technology Into Science Instruction

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1. **AGE AND CHARACTERISTICS**

This project is implemented with a wide variety of student age groups. The primary groups are two grade 8 science classes (55 students), two semester groups of physics 30 (42 grade 12 students), one semester group of physics 20 (30 grade 11 students) and one group of science 10 (28 grade 10 students). This exposes to the project, on a regular day-to-day educational basis, approximately 26% of the student body of 600 students. Those encompassed by the project could be described as average ability, teenaged students.

The entire project is implemented at Onoway High School, but the idea of integrating computers into science instruction is also being promoted through the internet site “ScienceMan” - thereby helping other teachers accomplish the same goals. The whole idea has now evolved into helping science teachers integrate technology effectively and as painlessly as possible, by providing a forum (ScienceMan) where teachers can collaborate. It is hoped that students around the province (and farther?) will benefit from the experiences of the teacher and students of Onoway High School.

2. **PURPOSE OF THE PROJECT**

The purpose of the project is to, as completely as possible, integrate computer technology into science instruction into a classroom at OHS. It must be made clear that this project is not the simple addition of so computers into a science lab. The intent is to completely integrate computer technology into a school science laboratory so as to be a part of all facets of instruction. Many objectives and goals are proposed, and ultimately achieved during this technology integration project;

A) **Enhance Student Achievement**

The technology integration has made possible the offering of a greater number of scientific experiments to students. Students have gained access to experimentation that would not have been possible in a conventional laboratory.

Implementation also included more thoroughly meeting the curriculum goals... this was accomplished both through greater efficiency and careful matching of experimentation outcomes with the Alberta curriculum.

The matches between the experimental outcomes that this equipment makes possible and the Alberta curriculum goals can be found in Appendix A at the end of this proposal.

B) **Increase Safety and Experience**
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The need for dealing with antiquated and suspect equipment has been eliminated. Dangerous experiments that previously could not be performed can now be computer simulated or performed safely with the available advanced technology.

The nature of this equipment allows students to perform many experiments that they simply could not before; it also allows them to easily adjust experiment parameters, studying aspects of labs that would have been prohibited in the past due to the expenditure of time.

The end result is that “hands on” experimentation for students is significantly increased. With more opportunity to work with lab equipment such as this that actually functions like it is supposed to, students become much more efficient in their laboratory conduct and end up doing much more than with the laboratory equipment of old.

C) Reduce expenses

Although the initial investment in input and computer technology is high, it is cost-effective in the long run compared to the acquisition of comparable lab equipment, replacement costs for worn out items and maintenance costs. One of this project’s long term goals is to prove that technological integration can be financially prudent.

D) Foster Upgrade Ability

While new developments in science can render expensive lab equipment obsolete, this can be addressed in the computer-based lab with software upgrades; a much less expensive prospect. Technological integration must serve the needs of the student now, and in the future. Another long-term goal of this project is to prove that a technology based-lab will be much more flexible in meeting the needs of tomorrows curriculum. Changes in instruction will be much easier to implement with the wide array of instructional opportunities and techniques that the technology provides.

E) Increase Enrollment in High School Sciences

We wanted to attract more students to high school sciences, especially those courses suffering from chronic low enrollment, such as physics and chemistry.

Even in the first year of the project we experienced significant gains in physics enrollment as students learned of the availability of “cool” computer technology. Feedback from students has been exceptional - students would much rather learn science in a technologically advanced laboratory.
F) Improve Reliability of Experimentation

Using old, antiquated equipment in science labs makes it difficult to produce reliable data for students to use. It is also difficult to train students on different pieces of equipment for every different lab. Student using outdated, unreliable and inefficient lab materials makes for less than adequate instruction.

The real benefit of technological integration is that once software and hardware systems are in place, all that is necessary is a constant power supply! No need for intensive maintenance of many items to ensure proper function. Systems such as the ones requested in this proposal have been reliably used for many years in other institutions. After the difficulty of the first couple of months of integration, consistent and reliable experimentation becomes a fixture in the lab. This has the extra benefit of increasing the confidence of students as they learn that experimentation can actually work in the absence of frequent technical glitches and limitations of old, inappropriate equipment.

G) Enhance Flexibility for Science Instruction

Manipulation of data can be done in many ways with complimenting software - we wanted students to not only be able to do many different types of experiments but also be able to easily shift the nature of the experiment in order to foster creativity and exploration. Experiment parameters can be changed in seconds and experiments performed again without time-consuming adjustments to equipment.

One of the best advantages of today’s technologically integrated lab is that the equipment is capable of just about any type of experiment - almost any type of data can be collected with the simple change of a sensor. In a typical lab if a student wants to approach data collection in a different way, they must endure a significant preparation period as new equipment is painstakingly put together, tested and calibrated.

H) Deliver Programs with Greater Speed

More experiments and more complex experiments could be performed without the huge investments of class time that are necessary when complex lab set-ups, manipulation and clean up are involved.

The goal of this project was to increase the speed at which lab work could be prepared, delivered and performed. All of these speed increases would not be at the expense of good scientific method. I simply wanted to prove that old methods were slow and inefficient, while new methods could perform the same tasks better and in less time. More time means more opportunity for improving instruction.

I found that the time gained with computer data collection often resulted in more time for students to explore different parameters they were interested in. As an educator who has “bent over backwards” in the past trying to get students interested in what they were doing, it was particularly satisfying to see students repeatedly request to continue working and exploring with a lab, even when the data they had set out to collect was already collected. Students are eager to explore with this equipment and the equipment affords the time necessary for students to follow their curiosity.

I) Increase Convenience for Teacher and Student
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Teaching effectiveness would be greatly increased with a laboratory scheme that allows rapid set-up and processing of data.

In preparing for the technologically integrated lab, great care was taken to choose computer systems and interface equipment that would be able to perform all the necessary experimentation. Due to great advances in recent years, equipment has become available that is both easy to use and is extremely powerful. For any educator using this equipment, this means that a myriad of experiments can be set up with the same equipment, simply by swapping a few sensors. This has greatly increased the convenience of laboratory instruction.

J) Enhance Connectivity to the School and to the World

We wanted students who had their own personal computers to be able to use data at home. Since students can save experimental data to storage media, this data can be taken to home computers and processed further (the available software and files produced by the software are usable on both Macintosh and IBM machines). Data can also be processed at other computer terminals in the school. Depending on internet connections, data can be downloaded from other experimental sites in the world, such as Universities and commercial laboratories, and used in the classroom.

The lab where technology integration took place was also networked with other computers in the school and to a central server. The goal was to create access to the internet for every computer in the classroom, as well as providing a central storage facility for student work.

Networking the computers also allowed us to meet the goals of having all computers access printing facilities in the classroom. The final goal that was reached was enabling the teacher to control all of the computers over the network while also being able to observe student work remotely. These were huge advantages in effectively administrating a classroom full of computers and students.

K) Develop New Methods of Instruction

I wanted to use as many new and innovative pieces of software as I could in order to enhance the learning experience for students. Many of these computer applications did an incredible job of delivering concepts to the students.

This proposal will describe the many ways that computer software have allowed students to express their creativity and experience phenomena that they may never have experienced in a traditional school laboratory.

3. METHODS AND PROCEDURES
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Due to the wide scope of this project, it is easier to understand the enormity of the task of implementation if is broken down into sections. I have chosen to divide it into the following four categories;

A) Experimenting with Computer Interfaces
B) Internet Access and Networking
C) Software and Simulations
D) Unexpected Benefits of Technology Integration

A) Experimenting with Computer Interfaces

The core of this technology integration project is the use of computers to collect scientific data. In short, students do experiments as they have always done, with the exception that the data collected goes into a computer via an interface.

Prior to this project being undertaken, many different brands of interfaces were tested. The Science Workshop® brand distributed by Merlan Scientific in Canada was chosen for its ease of use, dedicated software, portability, capacity and price.

Interfaces are small boxes that connect to the computer. The interface (see figure A) has digital and analog ports for plugging in sensors.

![Figure A](image)

A wide variety of sensors were purchased in order to collect scientific data. The sensors are equipped with digital or analog plugs (Figure B); after they are plugged into the interface, the experiment is performed and the data is viewed on the computer screen.
The sensors that were purchased (see page 17 for a complete list) allow students, no matter what the type of data, to see the information being collected in real time. This means that numbers and graphs show up on the computer screen during the experiment - students appreciate the data and can understand it much easier when it is displayed as it is collected.

In order to appreciate how a computer based lab works, I’ll describe one. For example, with Science Workshop, students can do an Electrocardiogram (EKG). Using the EKG sensor (Figure C), students plug in the sensor and attach it to whoever is the “patient” (Figure D).

The whole experiment is easily configured using the science workshop software. Students mimic their real-life actions by dragging and “plugging in” sensors on the computer screen (Figure D) and then is then operated by pressing “record” and “stop”. It is possible for students to change experiment parameters and do multiple runs - it is also possible for students to perform many types of mathematical analysis on the data (Figure E) with the software, and print out their results.
The most advantageous aspect to using the computer interfaces is that it allows students to perform many more experiments than they would be able to in a conventional laboratory. As students became familiar with the equipment and available sensors, lab work is much more efficient. Students also appreciate the fact that they are using “real” scientific equipment that is dedicated to collecting real data - as opposed to using makeshift apparatus in simulation.
**B) Internet Access and Networking**

All computers in the classroom were networked with computers in the rest of the school. This provided access to the school internet server which was connected to the internet via a satellite dish.

All computers in the classroom were loaded with Netscape Communicator internet software for browsing the internet. Internet sites were previewed by the teacher for their educational use and then “bookmarked” into the internet browser for easy access. This proved to be adequate until it became obvious that the frequent use of the internet as a reference tool outgrew the bookmarking method. I estimate that we now use the internet as a supplementary tool for instruction for an average of about 5 to 10 minutes per 80 minute class.

It was then that I began to develop the internet site “ScienceMan” ([http://www.compusmart.ab.ca/dryrot](http://www.compusmart.ab.ca/dryrot)) with the input of students and other educators for ideas. The internet site was meant to serve as a “home page” for the classroom but ended up growing into much more. The internet site is maintained on a daily basis by the teacher and meets several needs;

- The site has a compilation of many high school science links - these are internet sites that have been previewed, reviewed and matched to the Alberta curriculum. This allows students to meet very specific educational goals with absolutely no time wasted searching.
- The site has a student section with links to help students in their general studies. Also provided are fun contests to encourage interest in solving science problems.
- Reviews of the latest technology that is useful for the science classroom is also included in the site.
- Reviews, price and download information for the latest educational software for science is included in the site.

The original scope of the internet site was to provide an internet base for the classroom, however, as other educators discovered the site and they added their suggestions, the site naturally evolved into a centre for teaching science with technology. Many teachers expressed the need for assistance in the task for integrating technology into their classrooms - “ScienceMan” aims to help in this respect. Over the months, I have continued to add to the site; it has been recognized by several other educational sites and search engines. The site has now won several awards and has received thousands of visits by other educators and students.

I thoroughly enjoy sharing the trials and tribulations of technology integration with other educators; it is my hope that “ScienceMan” will continue to be a free source of high school science technology information for a long time to come.

Networking the computers also allowed students to have continual access to a laser printer that is located in the classroom. This easy access provided a means for students to print out all sorts of assignments, data, graphs and drawings.
The classroom was supplied with eight computers (seven for the students and one for the teacher), which in itself introduces difficulties. The two major problems are the time needed for software maintenance and distribution, and the need to be able to supervise students easily and effectively.

These problems were solved with the software local area network (LAN) software that allowed me to control remote computers. The name of the software is Timbuktu, and it allows the teacher to install software, do upgrades, and make changes to student computers without having to leave the teacher computer. Another key feature of this software is that it allows the teacher to observe the screens of student computers and even take over control of their computers when they need assistance. They teacher can also send evaluative comments to a student and have them appear on the student’s screen.

C) Software and Simulations

Many different software programs were and are still used on a regular basis in our technologically integrated science classroom. With the exceptions of the basic Macintosh system software that ran the computers and the aforementioned Science Workshop interface software and Timbuktu LAN software, I will describe the contributions of the following pieces of software to the integration project.

Interactive Physics (IP)

IP is a powerful program that allows students to create physics simulations. By drawing objects and then changing parameters such as gravity, friction, elasticity and applied forces, students can simulate all sorts of physics events.

For example, one assignment called for Physics 20 students to design a simulation that illustrates differing levels of friction. One student designed a simulation that had a car going down a slope, encountering two different levels of friction when it reached the bottom (as illustrated below);

![Simulation Diagram]

When the simulation is set into motion, the car careens down the slope and slides across the variable friction levels at the base.
Complex simulations are also possible, such as the dynamics of moving devices, as in the motorcycle simulation below. Students can see the motorcycle shocks flex and see the force applied to both rider and the bike as the simulation progresses;

![Motorcycle Simulation](image)

**MacMolecule**

With this program, students viewed and constructed 3D molecular structures.

![Molecular Structure](image)

After students used actual models in class, they could use this software to produce more complicated structures with ease, studying bonds and connections. This was facilitated by the software’s ability to rotate molecules in 3D, allowing students to view molecules from all different angles.
Convert

This was an application that allowed students to easily make complex unit conversions.

![Convert](image)

Students used this application to supplement their mathematical conversions in class.

Atom in a Box

This program was used in order to view atomic orbitals. Atomic parameters can be changed, and if students wear special glasses they can view the simulation in 3D.

Calcworks
Calcworks

This program is used to place a full function scientific calculator on screen for the convenience of the student.

Electronics Workbench

This program worked as an excellent electronic circuit simulator for students. It was used to bridge the gap when students could not build a circuit due to concerns of expense, safety and lack of materials.

The software provided every imaginable electronic device for students circuitry. Students simply dragged the items they wanted onto the work area and connected them. The circuitry then could be turned on in order to read meters and check the viability of the circuit.

Gravitation
Gravitation

This program was used as a universal motion simulator. Students could add and place celestial objects in their simulations and adjust their orbital paths and speeds. This works as an fantastic visualization of Kepler’s laws.

Starry Night

Starry Night is used in class whenever any planets, stars or other celestial objects need to be explored.

With a very easy to use and intuitive interface, students can maneuver through space, zooming in and out, taking close up views of planets or very wide views of constellations.

WaveWindow

This program was used to examine sound wave forms. By simply making noises into the computer microphone, wave forms could be seen for the sound. Analysis of amplitude, wavelength, period, etc, is possible with the waveforms that WaveWindow provides.

YP Physics Applications

YP are are series of standalone applications that allow students to examine various physics phenomenon in an interactive sense. Separate applications for circular motion, reflection, refraction, gear motion, projectiles, image formation and slider cranks.

All of these applications served to reinforce principles learned in class and aide in visualization of concepts.

Pearls

Pearls are another set of over 50 standalone physics simulation applications that were used to illustrate and reinforce concepts in class.

Hyperstudio
Hyperstudio

Hyperstudio is one of the most heavily used applications in this classroom. Hyperstudio gives students and teacher the ability to work with multimedia in a very easy way.

Students of all ages find it very simple to produce creative projects, assignments and study aides by combining text, graphics, sounds, free drawings, movies and any other digital media. Producing these presentations is easy because the whole application works on the basis of an index card format… students can add any multimedia they want to successive “cards” in order to put together a coherent project.

I have used Hyperstudio to produce many tutorials; I especially like to focus on those drab subjects such as vectors in physics and try to add some excitement to them with some multimedia flair.

ClarisWorks Suite

Clarisworks is the wordprocessing, database, drawing, painting and spreadsheet application that was chosen for use in the class. It’s integrated suite was well suited to cutting and pasting different forms of data between different types of documents.

Clarisworks get heavy use every day for keeping track of data, presenting data in graphical form, and writing up lab reports.

DragThing

In quickly became clear that with so many programs being used by the students, a way was going to have to be developed so that students could easily find and open the programs they needed without having to search all over the hard drive.

A program called “DragThing” provided the answer and was an incredibly simple and effective solution. DragThing creates a “icon dock” at the bottom of the computer screen (Figure F); students simply click once on the icon representing the software they wish to use.

![Figure F - Example of a DragThing Icon Dock](image-url)
FoolProof

This software was used to prevent unauthorized changes to the contents of the computers, and also guided the students as to where to save their completed documents and documents in progress.

The Incredible Machine (TIM)

Young and old students alike thoroughly enjoyed using TIM software, although it was used mostly with the energy and machines component of the science eight curriculum.

TIM is a series of physics puzzles that can only be solved with knowledge of basic machines and how they work. The puzzles are presented in a very comical and entertaining way... students have so much fun with how the puzzles are presented that they do not even realize they are solving physics problems!

Students can also compete with each other head-to-head on solving puzzles, and can also design their own puzzles to try to stump their classmates.

D) Unexpected Benefits of Technology Integration
D) **Unexpected Benefits of Technology Integration**

The computer equipment and software ended up being applied in many ways that were not foreseen by the teacher. I would like to make note of these as further benefits of the technologically integrated classroom.

For example, when students were asked to do systems projects in science 10, some of them decided to do their projects completely on the computer. These system projects involved researching an internal system of a particular animal (such as the digestive system of a fish) and presenting the information in such a way that others would want to learn about it. Typically, students in the past would make a verbal presentation, make a poster, an illustrated essay or even a video. However, computers in the classroom obviously inspired new ideas; several students decided to do their presentations in Hyperstudio format. Hyperstudio is the previously described multimedia presentation software that allows users to integrate movies, pictures, texts, sound and animations into presentations. Video camera, digital camera and scanner equipment was borrowed from the computer program in the school to collect the images and movies that were used in the presentations. Several excellent presentations have been produced so far.

The way students seemed to find Hyperstudio so easy to use brought on the idea of involving students in the production of tutorials. Students in my class have produced several very good tutorials on a variety of physics and science topics - this has involved the students directly in their own instruction. I was very aware of a feeling of pride among the students who created tutorials when other students used them for their learning.

Certain students used digitizing equipment in the school to digitize movies for their presentations.

On one particular day, students were working on Hyperstudio presentations when other teachers from another school were in the classroom visiting the technology integration project. They were quite impressed at the work of the students and commented that they wished that they could take some of the work to show their own administrators to convince them of the usefulness of technology and computers in the science classroom. My students seized upon this idea; they suggested that we could put together a selection of Hyperstudio stacks and somehow distribute them... I modified this idea slightly into a team effort between my students and I to produce a promotional Hyperstudio stack that would espouse the virtues of the technologically integrated classroom.

The idea eventually resulted in a series of Hyperstudio stacks that were put onto a compact disc (CD). The school owns a recordable CD “burner” which made the production of the CDs possible. To this date, over 50 CDs have been distributed to schools far and wide (at no profit).
4. MATERIALS AND EQUIPMENT

The materials required for a project such as this are quite extensive. They are also expensive in the short term but it must be stressed that there is the very real potential for technology integration to save money in the long run, considering the large amount of science equipment that can be replaced.

The computer platform chosen is Macintosh - however, every computer aspect of this proposal could easily be IBM compatible equipment. The interface equipment chosen is completely cross platform (as is most of the aforementioned software).

I’ve broken the following list of materials and costs into four parts;

- Computers and Printers
- Interface Equipment
- Software and Licenses
- Accessories

Computers and Printers
7 Macintosh 5400/180 student computers
1 Macintosh 5500/225 teacher computer (with video out)
1 Laser Printer

.............$17,000.00

Interface Equipment
4 Science Workshop 500 interfaces
1 Science Workshop 750 interface (new since project originally started)
(The interfaces were purchased in “bundles” which included basic sensors)
The following sensors and sensor accessories;

- Input Adaptor Box (x1)
- Magnetic Field Sensor (x1)
- Respiration Rate Sensor (x1)
- Heart Rate Sensor (x1)
- 50N Force Sensor Bracket (x2)
- Student Force Sensor 12V (x2)
- EKG Patches (x4)
- Chemistry Lab Manual (x1)
- Alligator Plug Cords (x15)
- Photogate Mount Bracket (x1)
- Large Rod Stand (x2)
- Angle Rod Clamp (x6)
- Photogate Timer and Accessory (x1)
- Tape Timer (x1)
- Plunger Cart with Mass (x2)
- Super Dynamics System (x2)
- Digital Stopwatch (x4)
- Colorimeter Curvettes (x2)
- Radiation Cans (x2)
- IDS Picket Fence (x4)

- Colorimeter (x1)
- Barometer (x1)
- EKG Sensor (x1)
- Force Sensor Adaptor Bracket (x2)
- Teflon Sensor Covers (x1)
- Force Sensor Pan Balance (x2)
- 4-to-1 Adapter (x1)
- Biology Lab Manual (x1)
- Projectile Launcher (long range) (x1)
- Pkg. 10 Plastic Balls (x1)
- 120 cm Rod (x2)
- Free Fall Adapter (x1)
- Laser Switch (x2)
- Tape Timer Supplies (x1)
- Ballistic Cart Accessory (x1)
- Phone Jack Extender Cord (x4)
- Hooked Mass Set (x2)
- Medium lab Jack (x1)
- IDS Photogate Bracket (x4)

.............$18,000.00
Software and Licenses

A perfectly accurate dollar figure for software is very difficult to give due to some of the software being licensed at the jurisdiction level. For the couple of items that this applies to, a best guess was made as to how much it would have cost the school to purchase the license ourselves.

All items of software were purchased for site license based on the eight computers in the room.

The list of software is as follows;

<table>
<thead>
<tr>
<th>Interactive Physics</th>
<th>MacMolecule</th>
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<tbody>
<tr>
<td>Atom in a Box</td>
<td>Convert</td>
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<tr>
<td>CalcWorks</td>
<td>Electronics Workbench</td>
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<tr>
<td>Gravitation</td>
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<td>WaveWindow</td>
<td>YP Physics Applications</td>
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<td>Pearls</td>
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<tr>
<td>ClarisWorks</td>
<td>DragThing</td>
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<tr>
<td>FoolProof</td>
<td>The Incredible Machine</td>
</tr>
<tr>
<td>LXR test (to be described in evaluation section)</td>
<td>..................$4,800.00</td>
</tr>
</tbody>
</table>

Accessories

Before a price list is given, an explanation of the variety of accessories in necessary;

A 37 inch RCA TV was purchased and mounted in the upper corner of the classroom (Figure G). This TV was linked to the teacher computer via the video out and audio out ports - this allowed me to demonstrate software to all students at once. I found this to be an incredible time-saving training technique. Notes are also displayed on this monitor.

Figure G - 37 Inch TV and LazerDisc Player

The presence of the TV also made viable the purchase of a lazerdisc player (lower part of
The presence of the TV also made viable the purchase of a lazerdisc player (lower part of Figure G). Several groups of lazerdiscs were purchased as a method of displaying thousands of scientific images and movies to students.

It was a goal from the beginning to *seamlessly* integrate computers into the science lab. This meant getting the equipment up and out of the way of laboratory surfaces. This was accomplished with the purchase of IKEA brand stands - this also provided necessary storage area for sensors underneath the computers. Some of the computers were built right into the existing cupboards. The following pictures (Figures H, I, J) illustrate this implementation.
The list of necessary accessories can therefore be summarized in the following list:

37 Inch RCA TV
Pioneer Lazer Disc Player
Lazer Disc Collection
Printer and Network Cabling
IKEA stands
TV mounting hardware ...............$6250.00

Total Cost of Implementation ...............$46050.00
5. **EVALUATIVE METHODS**

The theme of technology integration was continued in evaluation by using software to evaluate student progress. LXR© test software was used to produce the tests in class.

A companion application to LXR test called Interactive Student was used to deliver tests and quizzes on computer. Some of the exams in class were delivered traditionally, printed out for the students. Tests delivered by Interactive Student meant the pupil would go to the computer, initiate the evaluation, and take the test on the computer screen. The software made it possible for students to immediately get feedback (without changing their answers!); it also allowed for the results to be printed out for the teacher.

After students were evaluated by the computer method, they were given the opportunity to analyze their results and correct their mistakes by redoing the evaluations on the computer.

Having large banks of LXR questions on compact disc (purchased from the LRDC) allows for tailor made reviews to easily be made to meet individual needs.

As for the Physics 30 diploma examination course, results were considerably better during last years technology integration than in previous years.

The graph above illustrates that the number of students reaching the standard of excellence for Physics 30 at Onoway High School has been steadily increasing since the integration of technology began. The vast majority of technology integration has occurred during the 97-98 year, so there are great expectations from this teacher for future result improvements as the technology integration is further refined.

Student reaction to the technology integration was gauged in part by the inclusion of relevant questions in our school satisfaction survey that we deliver to parents and students every year. The survey in past two years has shown more students and parents are satisfied with technology implementation in our school than in previous years.
6. GENERAL COMMENTS

When I first embarked on this technology integration project, I had my reservations. To be specific, I had two major concerns.

One was that I would be adding computer technology to a science laboratory but not actually integrating it. I was afraid that the technology would be too overwhelming and it risked sitting unused. The second concern was the project was simply too ambitious in its scope and I could not possibly learn all the software and hardware intricacies necessary to implement everything successfully.

I am most happy to report that my fears were in error in regard to both these concerns!

While there were moments in the project where I was frustrated while getting specific items to function properly, these moments were few and far between. I truly believe we have now progressed to an era where software and hardware is user-friendly enough that it can be implemented successfully on a wide scale. I doubt this was the case even a few years ago! As a teacher with only intermediate knowledge of computer technology before embarking on this project, I can now confidently say that I can operate this technologically integrated science lab and do all of the basic maintenance. I strongly believe that any science teacher should be able to do what I have done with a little bit of effort and training.

As for my second concern, I was amazed to have accomplished more in the project than what was proposed in the first place. Again, I must say that I believe that the technology applications have matured and come of age to the extent that they can be integrated into the science classroom with a reasonable amount of effort.

What is a reasonable amount of effort? Can we legitimately expect teachers and students to go through the upheaval of absorbing new methods teaching and learning? I believe we would be making a mistake if we did not follow the successful model of this project.

Real world science is now completely interwoven with computers. Any modern laboratory now collects data and manipulates it with computer programs - the demanding nature of science today necessitates the power of computers to handle massive amounts of data. It is computers that allow scientists to change experiment parameters in thousands of different ways and still produce data in reasonable amounts of time. It is computers that allow chemists, engineers, physicists and biologists to run simulations to test hypotheses. It is computers that allow scientists to view data as it is collected and view it many different ways to facilitate understanding.

Why would we continue to instruct our students with antiquated means when we know that they will be unprepared for real world science? In this respect, I am most happy to be a trailblazer in proving that computer technology belongs in the science classroom. I feel that the effort I have gone through will benefit my students greatly in their future endeavors. Let’s hope that my efforts can also ease the pain of technology integration for teachers as well - I’d be very pleased to see other schools copying this model and benefiting from it.
7. **WAYS THE PROJECT IS NEW**

When Merlan Scientific (a science technology supplier) of Ontario discovered (through the grapevine) the unique nature of my classroom they asked to come visit and were extremely impressed with the technology integration project. They asked me if I would like to do some presentations showing other teachers how integrate technology into their classrooms - in return for the advertising they would be getting I had my expenses paid and got some equipment donated to the school. I was eager for the opportunity to share with other educators.

As I presented to various teacher conventions, I quickly realized that most teachers were completely unaware of interface equipment or the possibility of including computers in their science classroom. Most knew about the internet and its potential for gathering information but that was about it. When I first began sharing with others, I thought that I would simply be supplementing the technological integration efforts of others. I couldn’t have been more wrong!

It seems that in most schools, science is way down on the priority list when it comes to allocating funding for technology integration. It seems that computer instruction, CTS, libraries, typing instruction, business education and others all come before science when it is time to consider where to put computers. This is not necessarily the fault of the respective technology integration committees; most science teachers are unaware of the possibilities and are not bringing the potential of computer integration to the attention of the committees.

Putting computers directly into the science classroom and using state of the art interface technology are not the only reasons why I consider my project new. This project made a wholehearted effort to integrate technology into *every* mode of science instruction, from note taking to data collection to testing and more, I believe computer technology has made an improvement to all aspects of my instruction. Whereas others may have in the past proven the usefulness of a particular software program, I believe that I have proven that a single teacher, with a little effort, can manage complete integration of technology into a science classroom - that means using a wide variety of software and hardware (as described in this project) to supplement instruction.

I would also like to point out that this project not only had students as recipients of a new form of instruction but also included students in the actual development and implementation of their own instruction. Students designed computer tutorials, designed instructional simulations, contributed to web pages, helped train peers on different pieces of software, developed promotional materials, actively participated in troubleshooting and participated in self-directed learning on the computer in many different forms.

I am extremely proud of the students who were involved with the first year of this technology implementation project. At first, most couldn’t even believe they were getting access to such “cool” technology on such a grand scale. Soon however, they took full advantage of the opportunity by making the most of absolutely every technological application - and reveling especially in the ability to express their creativity that the equipment provided.

I strongly feel that all science students should get the same opportunity.
Ways in this project can improve teaching

Besides all the improvements that the technology itself affords, I believe that this project has made me a better teacher for a number of reasons.

First, I believe I am now more attentive to the needs of my students to express their creativity. When my classroom did not have any technology implementations, I feel that my teaching lacking the diversity of approach that allows students to expand their horizons. Now that I know students can complete assignments in so many new ways with the use of computer technology, I can encourage other students in the future to try these new methods. I have discovered that if students are given the appropriate tools and guidance, their learning and progress will leap forward in ways that the teacher never imagined.

Second, I now have so many more tools at my disposal to improve my instruction. For instance, with the ability to easily design custom tutorials (with programs such as Hyperstudio and LXR interactive) I can more readily tailor my instruction to individual student needs. Once students are given instructions on how to operate software, they can use many opportunities in class to learn at their own pace. It is through time on the computer working through problems on particular applications that students have made breakthroughs in their understanding of concepts all on their own. The self paced learning that the computers make possible also allow gifted students to explore greater levels of learning than would have been possible without computers in the science class.

Third, I think my instruction is much less pedantic and is now more interactive. The technology fosters this approach - with different experiments going on at the computers and with students at different stages, a much more realistic, comfortable environment in the laboratory is created.

Science instruction on the whole has improved greatly in my classroom directly due to the integration of the technology.

Of all the improvements, I think that the greatest is that teaching can now reflect real world science lab situations that students are likely to encounter in the future.

Visual learning is greatly enhanced with the availability of computers to illustrate difficult to visualize concepts. Most students have a great deal of difficulty, for example, interpreting physics graphs because they must always imagine the motion of the object that created the tracing on the graph. With computer and interface technology, students can see a graph being drawn as the object is actually moving.

Instruction can now include illustrating scientific concepts that students may otherwise never be able to experience. For example, with computers in the class, students can visualize the moving structures of atomic orbitals. They could also use sensors with interfaces to safely and accurately measure the presence of radioactive particles.

Teaching science can now offer students a reasonable level of accuracy and reliability with the use of computer technology. In the past, students and teachers couldn’t expect much from balls rolling across a floor or balloon powered pucks gliding across a table. Now students can expect highly accurate data they can take seriously.
Teaching with computers has allowed me to deliver concepts and experimentation with far greater speed and efficiency. This has proved to be an enormous benefit to my instruction; I have much more time to spend with individual students and I can expand the range of experimentation to include many different parameters that we just wouldn’t have time for in the past.

The last and perhaps greatest instructional advantage I now have with the use of computer technology in the science lab is the much wider range of science experiences that I can present to my students. With the use of the internet, I can show students the latest advances in all fields of scientific endeavour. With the use of simulation software, I can now help students understand scientific concepts they could never hope to experience without the aid of technology, such as visualizing a meteor shower, visualizing the motion of objects on different planets, and seeing the effects of increasing water pressure on a biological system (to name just a very small few).
Appendix A - Curriculum Match of Interface Experimentation

The availability of computer technology in the science classroom provides a myriad of opportunities for improving science instruction. This technology is applicable to all science topics and disciplines. With the wide variety of input devices available for the collection of data, these computer workstations find use in nearly every class of every day of science instruction.

There are areas where these units are of particular use; the following specific learning applications broken down by subject provide some perspective on how the computer technology is used to meet specific learning objectives in the curriculum. It should be noted that the following objectives will be under represented in the areas of high school biology and chemistry, only because these are areas currently out of the author's scope of instruction.

The Science 14-24 stream is not included in the objectives below; there is much overlap with Science 10 in basic curriculum aims. Obviously, many of the computer applications for the subjects below can also be applied to Science 14 and 24 classes.

*Note...."CID"=computer input device

**Physics 20:**

- Use CIDs to measure the motion of object and display them graphically.
- Visualising vector analysis; manipulation of vector quantities.
- Visualising resultant vectors and instantly observing the effects of changing component vector quantities by changing computer parameters.
- Using CID accelerometer data to prepare acceleration graphs.
- Use computer graphing software to compare motion of different objects on distance-time and velocity-time graphs.
- Applying best-fit-line methods of interpreting large amounts of data.
- Observe graphical and visual displays of conservation of mechanical energy.
- Perform circular motion experiments, observing changes in motion with changes in experiment parameters.
- Relating gravitational force to planetary and satellite motion problems.
- Design and perform experiments demonstrating that simple harmonic motion can be observed within certain limits, and relate the frequency and period of the motion to the physical characteristics of the system.
- Observe the phenomenon of mechanical and acoustical resonance.
- Determine wave speeds and the effect of changes of amplitude and frequency parameters.
- Diagram resultant waves using the CID data and the principle of superposition.
- Observe the phenomena of reflection, refraction, diffraction and interference of mechanical waves.
- Perform experiments demonstrating reflection and refraction of light at plane and uniform curved surfaces.
- Perform experiments to determine index of refraction of several different substances.

**Physics 30:**
Physics 30:
- Design and perform experiments demonstrating the law of conservation of energy, and the relationship between mechanical potential and kinetic energy.
- Analyse CID data graphically, using curve-straightening techniques and software, to infer mathematical relationships.
- Perform and analyse experiments demonstrating the conservation of momentum and the principle of impulse.
- Approximate, estimate and predict results of interactions, based on an understanding of the conservation laws.
- Perform experiments demonstrating the electrical nature of matter.
- Use safe practices when conducting electrical experiments.
- Perform experiments demonstrating relationships among magnitude of charge, electric force and distance.
- Perform experiments to explain the relationships among current, voltage and resistance.
- Design, analyse and solve simple resistive DC circuits.
- Design and perform an experiment demonstrating the heating effect of electric energy.
- Perform experiments and computer simulations to demonstrate the wavelike behaviour of electromagnetic energy.
- Utilise computer simulation software to determine the charge to mass ratio of the electron.
- Use CID data to demonstrate and interpret the photoelectric effect.
- Use computer simulation and CID data to measure radiation and graphically analyse radioactive decay.
- Observe representative line spectra of selected elements.

Science 10:
- Identify manipulated, responding and controlled variables.
- Observe and record physical properties of water.
- Collect and graph CID data on the heating curve of water.
- Graph and analyse CID data on the variability of water density with temperature.
- Interpret weather maps and analyse the motion of simulated weather systems.
- Calculate and graph surface area to volume ratios of a variety of model cell sizes and shapes, when one variable is changed at a time.
- Observe simulations of nutrient acquisition at the cellular level.
- Visualise the three dimensional structure of the first 20 elements of the periodic table.
- Simulate various types of chemical reactions and analyse their changes of energy.
- Analyse an object's distance, speed and acceleration using CID data.
- Graphically represent areas under speed-time, distance-time and force-distance relationships and analyse the effects of changing variable quantities.
- Perform experiments to demonstrate the conversion of energy from potential to kinetic form.

Science 7:
Science 7:

- Identify and differentiate between experimental variables.
- Use CID data to interpret changes in physiological variables.
- Identify and label physiological parts and processes on a variety of organisms.
- Utilise simple architectural principles to build structures.
- Use computer simulations to analyse the effects of stresses and design methods on structures.
- Measure forces and demonstrate inertia.
- Observe detailed structural views and 3-D representations of microscopic organisms.
- Graphically represent growth curves of bacterial populations.
- Visualise long term geologic effects caused by glaciation and erosion.

Science 8:

- Solve practical problems in solution chemistry.
- Compare practical approaches of energy conservation and interpret their effects on global and local environmental conditions.
- Visualise the rich history of invention and the first practical uses of simple machines.
- Design complex machines with simple machine components.
- Design experiments for product testing, and observe the effects of changing test variables on experimental outcome.
- Visualise the dynamic changes in the Earth's crust.
- Simulate catastrophic events in the Earth's crust and analyse their effects.
- Manipulate computer models of volcanos and earthquakes and observe the effects changing tectonic plate variables.
- Catalogue various specimens of plant life using computer key criteria.

Science 9:

- Solve practical problems in reaction chemistry and observe different types of chemical reactions.
- Demonstrate the dynamics of a hydraulic system.
- Become aware of the mechanical applications of fluid and pressure technology.
- Construct basic electronic circuitry.
- Observe the effects on electronic devices when circuitry variables are changed.
- Use computer database keys to categorise and classify living organisms.
- Change environmental variables related to pollution and use computer atmospheric simulations to analyse changing atmospheric conditions in the short and long term.
- Use CID data to analyse heat and temperature effects.