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ne Minister's Awards for Teaching Excellence

EXEMPLARY PRACTICES

in Science, Technology and Mathematics

1995
Recipients

About the Prime Minister's Awards program

The Prime Minister's Awards for Teaching Excellence in Science, Technology and Mathematics are given at the national, regional and local levels to recognize the efforts of outstanding teachers in these fields. Award recipients are selected based on criteria that measure their ability to have a major impact on students' interest and performance. The selection is done on two levels by regional and national committees comprised of representatives from teacher and parent–teacher associations, provincial and territorial ministries of education, relevant post-secondary faculties, and business, labour and other groups with expertise in science, technology and mathematics teaching. The committees review detailed nomination packages in making their selections.

Recipients receive cash awards that are shared in part with their schools, as well as certificates signed by the Prime Minister. National-level recipients receive their certificates at a ceremony on Parliament Hill. Regional and local recipients are honoured in their communities by Cabinet ministers or members of Parliament as well as by their colleagues and students.

For more information about the program, you may contact us on the Science and Technology Hotline at 1-800-268-6608, E-mail us at *pmawards@ic.gc.ca* or consult our Web page at *http://www.schoolnet.ca*

The Prime Minister's Awards
for Teaching Excellence in Science,
Technology and Mathematics
Industry Canada
235 Queen Street
Ottawa, Ontario
K1A 0H5

ISBN: 0-662-24920-8

Cat. No.: C1-6/1-1996E

51142E

Aussi disponible en français sous le titre de *Modèles de réussite : Prix du Premier ministre pour l'excellence dans l'enseignement des sciences, de la technologie et des mathématiques, Lauréats de 1995*

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in Science, Technology and Mathematics

1995 Recipients

CANADA

PRIME MINISTER • PREMIER MINISTRE

It was my privilege again this year to meet some of the dedicated teachers who received the Prime Minister's Award for Teaching Excellence in Science, Technology and Mathematics. Being a good teacher is one of the greatest contributions a Canadian can make to the lives of his or her fellow citizens. This program exists to encourage and support those who make teaching their passion as well as their vocation.

However, we are doing much more. We have asked the teachers who have received awards in this and previous years to help us maintain a dialogue about science, technology and mathematics teaching. This book is part of that conversation. In it, this year's Prime Minister's Award recipients have contributed some of their best teaching practices. *Exemplary Practices* is being made available to teachers across the country.

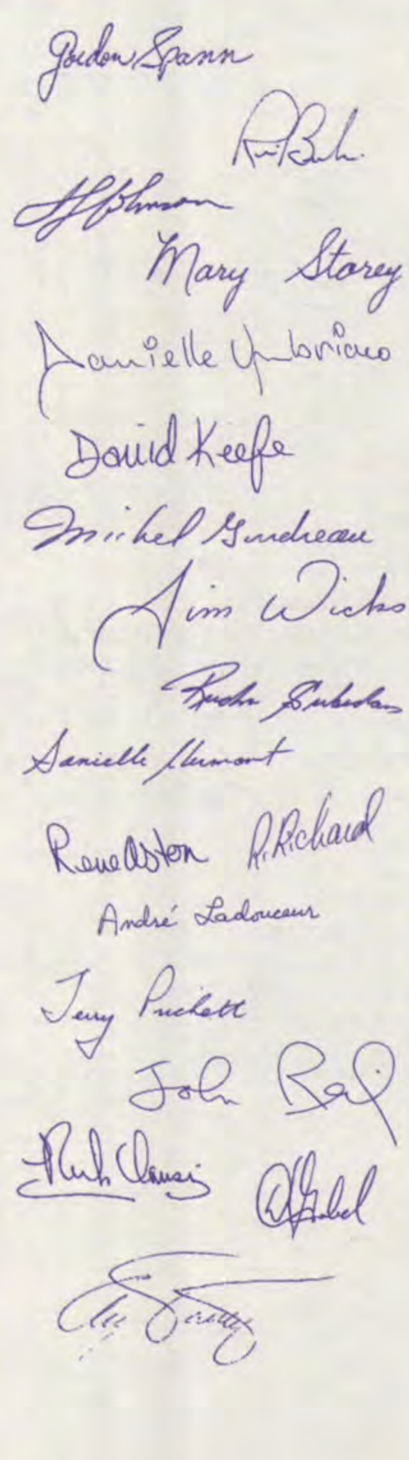
We are also using new technology to make it easier for Canadian teachers to share ideas and take advantage of these innovative teaching methods. Hence, the information included in this book is also available on SchoolNet. This electronic forum offers all teachers, not just award recipients, a chance to share knowledge, techniques and tips. It is my wish that the teaching community, the students they teach and, indeed, the country will be enriched by this exchange.

Jean Chrétien

Ottawa

1996

Greetings from the 1995 national recipients



When we met in Ottawa in February, the first thing we all wanted to do was to share ideas and techniques. This book grew out of those enthusiastic discussions.

There is a constant flow of new ideas in education. Some of the approaches that have come along have proven to be effective; others have not. It is our belief, however, that the most important factor for success in the classroom is enthusiastic teachers teaching enthusiastic students. We are not blessed with magical vision that enables us to determine ahead of time what will work. But we can say that any teacher who strongly believes in what he or she does and uses classroom techniques that capture and hold students' interest will make a major and important contribution to his or her community.

In this book, you will find a wide variety of thoughts and ideas, tips, teaching techniques and extra-curricular activities related to science, technology and mathematics that have been proven in classrooms all across Canada.

We have each contributed an article outlining an effective practice that we use. Each section begins with a short description of the philosophy behind the best practice followed by an explanation of the context in which each approach is used, the level of students for which it is intended and how it is done.

It is our hope that this material will be useful to other teachers. You will find essential details and contact information for any other resources required. We encourage you to experiment and modify the approaches presented here to suit your own unique needs.

We also hope that this information exchange will not be a one-way process. We have all benefited from advice and help from other teachers over the years and welcome the chance to hear from you. There are a number of avenues open for Canadian teachers looking to share ideas. We encourage you to join the PMA listserver, an electronic mailing list, that we all belong to. Visit the PMA web site (*http://www.schoolnet.ca*) for subscription information. You will also find lots of other information and ideas, including an electronic copy of this book, which features special information not included in the print publication, as well as links to other award programs and some of our personal home pages.

PMA recipients come from all parts of Canada. Due to space limitations, only national-level recipients can be profiled here. However, all local and regional recipients are listed along with their schools and communities in the back of this book. Maybe you will be inspired to contact a PMA recipient near you. If you want more information, please call *1-800-268-6608* or send an E-mail to *pmawards@ic.gc.ca*

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Math is for real

$2(3p + 4e + 2g)$

It is easy to get bogged down in blackboards full of equations when teaching mathematical concepts. But often the students get bogged down too, in memorizing equations and methods without having any real understanding of what all the numbers and letters mean.

Ivan Johnson from British Columbia, Richard Clausi from Ontario and André Ladouceur from Ontario have each developed ways of emphasizing the "real" aspects of mathematics: getting students to solve practical problems in the field; demonstrating how complicated, abstract mathematical concepts can be simplified into natural, intuitive terms; and showing students phenomena described by equations and curves.

Math camp

Ivan Johnson
Burnaby South Secondary School
Burnaby, British Columbia

Ivan Johnson

Ivan Johnson firmly believes that the best way for his students at Burnaby South Secondary School in Burnaby, British Columbia, to work is co-operatively. In his more than 30 years of teaching, he has encouraged his students to work in pairs and help one another to learn rather than simply to rely on their teacher for assistance. As head of Burnaby South's mathematics department, he has also worked to introduce computers into the classroom and has produced a significant improvement in student interest and achievement through programs such as the math camp.

Ah, the great outdoors.... hiking, fishing, canoeing... and math?

Mathematics is not a subject that most people associate with field trips. It usually conjures up images of chalk, blackboards, paper, pencils and calculators. Ivan Johnson has made it his mission to change that.

In 1990, he organized British Columbia's first math camp on behalf of the British Columbia Association of Mathematics Teachers to show students how people in business and industry use mathematics to solve problems in the field. Since then, those invited to the first camp have held their own events across the province.

The British Columbia Association of Mathematics Teachers has an information kit about math camps that it will gladly send out to teachers interested in setting one up. To obtain a copy, please contact Ivan Johnson at (604) 733-2168.

Remember to bring your sleeping bag!

In the beginning, my colleagues in the association and I wanted to explore connections between mathematics and British Columbia industries such as fishing, hydro, logging and agriculture. When we tried to interest representatives from these sectors in helping us, they were unenthusiastic; they felt that the classroom was too artificial an environment. When we suggested setting up outdoor activities at a camp, the change in their attitude was amazing. In this setting, it would be possible to create problems that were much more realistic than those typically handled in school.

For our first camp, we had 20 teachers and 60 students from across the province come to a facility owned by the North Vancouver School Board, north of Burnaby, where I teach. A math camp could be set up virtually anywhere in Canada. In early October, most summer camps are not busy and are available at relatively low cost. Besides renting a camp, the only other costs are for a bus to get everyone there, food and some supplies.

During our three-day session, we introduced the students to real-life mathematics challenges and were able to teach the teachers some co-operative learning strategies. Industry experts were on hand as resource people.

I strongly recommend contacting local industries for help with setting up the problems and activities, even if there is only one industry in the area. For example, if agriculture is the only local outdoor industry, a camp session could deal with problems related to soil science, pesticides, meteorology and mechanical engineering (farm equipment). The key is to avoid classic "textbook" problems that could be done in a classroom.

Here are some examples of problems the students worked on in groups of three.

1. How many worms are there in a farmer's field? The field in question was far too large to dig up to count the worms, so some sort of projection was required. We gave the students no hints about how to do this. We had an expert available from the University of British Columbia to answer questions, but not to give the students any help with the actual problem.

2. The students were asked to estimate how many cubic metres of wood there were in a tree without cutting it down. These were Grade 10 students so they didn't know calculus yet. As a result, they had to take measurements of the tree and determine what shape best fit it (e.g. cube, cone, sphere, etc.) and then do the calculations. Similarly, they had to figure out how tall the tree was without climbing it.

3. The big problem of the weekend was to determine how much water flowed down a nearby river in a day. To start, we gave students a simpler problem: calculate how much water flowed through a culvert that carried a smaller stream into the river. The culvert had a very definite shape and size.

   From there, they had to move on to the much more difficult problem of figuring out how much water went through the actual section of river. In addition to having an unknown and irregular shape, the river was also too wide and deep for the students to cross.

Despite these challenges, the students were able to extrapolate from the culvert problem and came up with very good solutions for the river. Because we were getting help from B.C. Hydro, which has a dam upstream from the camp site, we actually knew how much water flow there was. One group came much closer than ought to have been possible given their skill level and methods. They insisted for the rest of the weekend that it was their careful and thorough approach to the problem, not luck, that had made the difference!

At the end of the weekend, we held an open session in which each group of students presented their solutions. Some of these discussions were very interesting. For example, one problem required the students to estimate the length of a lake's shoreline. A couple of questions came up in the field: How much detail is appropriate? Did we want to know the length around every bay and point of land? Because every team had to decide this for themselves, they came up with widely different answers. During the discussion, the kids got into chaos theory without any prompting from the teachers.

The big lesson of the camp for both teachers and students was that real problem-solving, the sort of work that people in industry do every day, is usually done by a group and not by individuals. If an issue is really important to a company, a team of professionals will work on it.

What is a **problem?**

Ivan Johnson
Burnaby South
Secondary School
Burnaby, British Columbia

It has always seemed to me that a problem you know how to solve is not a real problem. What we call problems in most math textbooks are really just exercises. The problem about whether Mr. Johnson will catch his bus is really just a different formulation of the problem about how long it will take Mrs. Green to pay off her car loan. I don't have any objections to this; these sorts of exercises teach valuable skills, but I think it is important also to give students a real problem to solve.

Every once in a while, I like to give my students a problem that I have no idea how to solve. Generally, they will work at it for about five minutes and then ask me for the answer. The looks on their faces when I tell them that I don't know are amazing.

But that is how real problems work. If we can't figure out how to solve them, then we will never know the answer. Students need to learn that some problems may take hours, days, a whole term or even a lifetime to solve.

From addition and subtraction to chaos one step at a time

Richard Clausi
Elmira District Secondary School
Elmira, Ontario

Richard Clausi

Richard Clausi, the head of the mathematics department at Elmira District Secondary School in Elmira, Ontario, has fun teaching mathematics and invites his students to have fun "playing" with mathematical concepts as well. A long-time advocate of looking ahead and preparing for the future, he has also spearheaded a movement to introduce computers into the curriculum, explored leading-edge topics such as chaos theory in his classes, and helped his school prepare for destreaming. To help teachers handle new destreamed report cards, for example, Mr. Clausi and his senior students created a special database into which teachers can easily enter marks.

For Richard Clausi, mathematics is the ultimate game. Although there is a certain degree of rigor involved — mathematics is a discipline — he likes to show his students that the problem-solving in mathematics is not unlike that used in playing games. Card games, Monopoly and Scrabble are all played according to rules that work in similar ways to the rules governing mathematics. If you enjoy playing these games, then you should also enjoy "playing" mathematics.

Students are sometimes confused by the jargon and concepts of mathematics because the rules for this game are taught over a long period of time, and the notations are abbreviations for concepts that are not easily recalled. Mr. Clausi draws on two types of history to put the concepts into a human and tangible context for students.

He uses historical anecdotes to show how mathematical concepts are solutions to real-life problems set in the historic context. He uses the students' personal history and experience to show them how "new" techniques are really just variations on things they already know.

For example, consider multiplying a monomial by a polynomial as discussed below.

Don't worry, you already know how to do this

When students begin to learn algebra, they start seeing multiplication problems that look completely new to them. These new equations can be very intimidating: for example, consider $3(3x + 12y)$, or $(7x + 6)(3x + 9)$, or even $(2x + 5y + 4z - 6)(7x + 2)$.

Not surprisingly, many students just freeze when they encounter expressions like these for the first time. And yet, students can deal with this intuitively because they have encountered it before.

I try to draw on tangible experiences that feel natural to the student. In the example of expanding the expression $2(3p + 4e + 2g)$, students must apply the distributive law. I prefer to present this rule in a way that does not seem particularly mathematical at first.

For example, I will often start this discussion by talking about Ian, a good-natured student who comes to class with three pencils, four erasers and two girlfriends. Of course, the person who laughs the loudest, and is also of good humour, is identified as having *two times* as many of each. Every student will tell you (sometimes rather eagerly) that our lucky student will have $2(3p + 4e + 2g) = 6p + 8e + 4g$. The rule is intuitive!

Another example of a seemingly complex question that students already have the intuitive tools to deal with is multiplying binomials; for example $(7x + 6)(3x + 9)$. Traditionally, the FOIL rule is used: that is, we multiply the First terms, then the Outside terms, then the Inside terms and, finally, the Last terms.

Try to imagine how complicated this gets when you increase the number of terms.

Now, the amazing thing about this is that multiplying numbers with multiple terms is not new to these students. It is very similar to what they do any time they multiply multidigit numbers. The expression 32×16 could be solved using the FOIL rule: $(30 + 2)(10 + 6)$ becomes 30×10 (first) plus 30×6 (outside) plus 2×10 (inside) plus 2×6 (last); $300 + 180 + 20 + 12 = 512$.

There is no particularly good reason for doing so, though, as most students already know another way to do it. (See equation A.)

If you use the same approach for multiplying binomials, the students instantly understand what is going on. (See equation B.)

As I go through these steps on the blackboard, the class knows what I am doing and why. They will often shout, "Don't forget the shift," when I move to the second line. The neat thing is that this method is easy to remember. The FOIL rule and the formal treatment of the multiplication of polynomials are intuitive — not rules to be memorized.

The discussion of multiplication of binomials can even be extended to include some of the most recent discoveries in mathematics, such as the Mandelbrot set, which is used in chaos theory. Benoit Mandelbrot was trying to find a way to mathematically describe a phenomenon that Ivan Johnson has his students thinking about at his math camp (see page 9). Mr. Johnson talks about measuring a shoreline and the problem of knowing how much detail to include. Do you measure around every point of land and bay? Perhaps you should measure around every grain of sand? The closer you look at it, the longer and more complex the shoreline becomes.

The mathematics that Mandelbrot used to represent a phenomenon known as the Mandelbrot set is an application of the multiplication of polynomials. By squaring the complex number $a + bi$ where i is the square root of -1, we generate a series of coordinate points by using the real and imaginary parts of the result. Students are astounded by the fact that an imaginary or non-real (non-tangible) value like the square root of -1 can be used to produce a rather tangible, graphic result. The graphic rapidly becomes more complex and, well, beautiful, in the same way that Mr. Johnson's shoreline does when you look at the intricacies in greater detail. This is especially exciting since this mathematics dates from the 1980s, and so this discovery is "younger" than the students in my class are. Hence, mathematics is not an "old" set of "recipe" methods, but rather a dynamic and contemporary experience that they can become a part of!

Nobody is going to do the calculations required for this by hand. Computers can do this very easily, however. My class can use a simple program based on the multiplication rules we developed to "explore" the design for themselves. (See page 26.) Perhaps someone will find something truly new here!

A

$$\begin{array}{r} 32 \\ \times\ 16 \\ \hline 192 \\ +\ 32 \\ \hline 512 \end{array}$$

B

$$\begin{array}{r} 7x + 6 \\ \times\ 3x + 9 \\ \hline 63x + 54 \\ 21x^2 + 18x\phantom{{}+54} \\ \hline 21x^2 + 81x + 54 \end{array}$$

The real events the language of math describes

André Ladouceur
Collège catholique Samuel-Genest
Ottawa, Ontario

André Ladouceur

André Ladouceur arrived at the Collège catholique Samuel-Genest in Ottawa, Ontario, with a mission to replace teaching by rote with more effective methods. He has used his time as head of the mathematics department to set up a program that helps students become independent learners by emphasizing comprehension skills and the connections among the concepts being taught. He is currently working on problem-solving and on the use of advanced electronic calculators in math classes.

One of mathematics' greatest strengths is the way it uses symbols to represent powerful ideas. Traditionally, students have been taught the "language" of mathematics in abstract terms and then taught how to apply this language to the real world. For example, a typical textbook will go through mathematical skills first and leave the practical applications, in the form of problems, until the end of each chapter.

André Ladouceur believes that this approach is counter-productive, and that it is better to approach things the other way around. He likes to begin by having his students do a lot of problem-solving, occasionally at a very basic level, so that they can get a grasp on how the abstract symbols of mathematics can be connected to the real world, before focusing on developing the skills involved. Below, he describes one exercise he uses to achieve this end with senior students at Collège catholique Samuel-Genest in Ottawa.

How to tackle any curve they throw at you!

In this exercise, we begin by conducting a simple physical experiment. The data we collect are plotted on a graph and students are asked to decide which of several curves best fits them. This helps students develop an intuitive grasp of which real-world situations match up with which abstract curves and with which (even more) abstract functions that describe those curves.

The experiment is a very old one originally done by Galileo in the 16th century. A ball is timed as it rolls down a ramp set at different angles. The results are plotted on a graph in which the vertical axis corresponds to the time and the horizontal axis corresponds to the height of the top of the ramp.

The materials required to do this are quite simple. I use a piece of concave molding between two and two-and-a-half metres long, a small rubber ball, a stopwatch, some graph paper and a ruler. One piece of apparatus I allow myself that was not available to Galileo is a graphical calculator. It serves as an authority to provide us with the basic curve that best fits the data.

I have the students work in a group placing the ramp at different heights at regular intervals — for example 10, 15 and 20 cm — and recording the time that the ball takes to roll down. They record this information as a series of points on the graph paper.

In this case, the points follow a curve slanting down, very steep at first and then levelling off, a shape similar to a slide at a playground. The graphic calculator provides four families of functions that could produce a downward slanting curve.

I now ask the students to help me eliminate any of these curves that could not possibly fit the phenomenon in question. During the discussion, students are asked to explain fully the reasons why they would like to eliminate a particular curve. By considering the variables in the experiment, my students are usually able to ask questions that will lead to the elimination of all but one of the four families of functions.

First, is it possible for the curve to cross the horizontal axis? In other words, is there a height at which the ball would reach the bottom of the ramp instantaneously? Since there isn't, students can eliminate the linear-function curve immediately as it clearly does cross the horizontal axis. A little extra thought will make it clear that, if we follow it far enough to the right, the logarithmic-function curve will also eventually cross that axis, so it too can be eliminated.

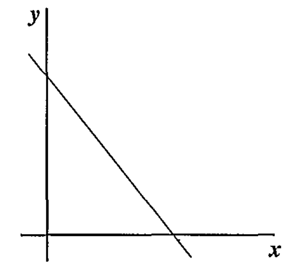
Similarly, we can ask whether the curve that best describes this phenomenon could cross the vertical axis. Since the ball would not move if the ramp was perfectly horizontal, we know that there is no value for the time variable if the height is equal to zero. This allows us to eliminate the exponential function, leaving only the power-function curve.

After we have thoroughly discussed the example, I use the graphical calculator to confirm our conclusions. (For more on these tools, see page 24.) I have it perform a regression analysis using the power-function model. This will determine the values of the constants *a* and *b* for the function. For example, one recent experiment gave the following results:

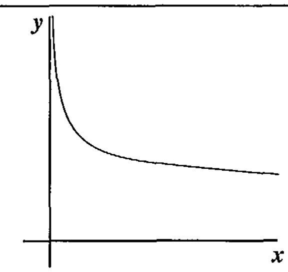
Height (cm)	5	10	15	20	25	30	35	40
Time (seconds)	4.32	3.28	2.74	2.46	2.07	1.84	1.82	1.50

The regression analysis gave values of 9.98 for *a* and -0.49 for *b*. In other words $t = 9.98 \times h^{-0.49}$. (The correlation co-efficient was equal to -0.989.)

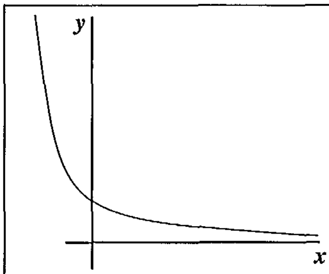
This equation compares favourably with the theoretical model, which is $t = \frac{a}{\sqrt{h}}$ or $t = a \times h^{-0.5}$.



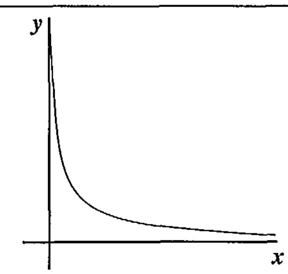
Linear function: $y = a + bx$



Logarithmic function:
$y = a + b\ln x$ $(b < 0)$



Exponential function:
$y = a \times b^x$ (b < 0)

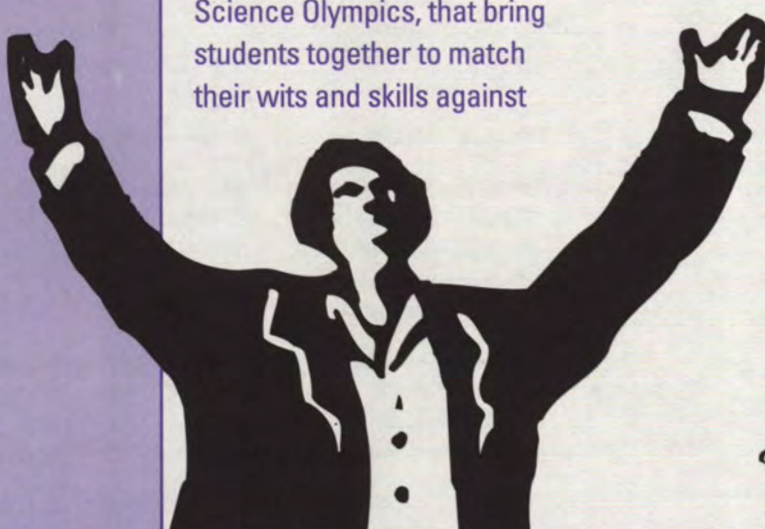


Power function:
$y = a \times x^b$ (b < 0)

Competitive advantage

Parents often tell their children that being competitive is a bad thing. In David Gabel and Rudra Subedar's opinion, that just isn't so.

Mr. Gabel from British Columbia and Mr. Subedar from Manitoba are both big fans of competitive events, such as science fairs and the Science Olympics, that bring students together to match their wits and skills against those of their peers. These events offer all sorts of benefits to the students: they learn to focus their ideas and energies, to research a subject thoroughly, to work in teams, and to participate in fun activities outside the classroom. And, if a little glory comes their way in the form of a ribbon or medal, well, that's okay too.



Creating and maintaining a culture of excellence

David Gabel
Sir Winston Churchill Secondary School
Vancouver, British Columbia

David Gabel

In addition to a solid science education, David Gabel offers three basic things to the students he teaches at Sir Winston Churchill Secondary School in Vancouver, British Columbia: encouragement, challenge and praise. Mr. Gabel has been working to provide more opportunities for physics students throughout his entire career. He began with curriculum reform in 1973 and today continues to work on such projects as new textbooks, seminars and resource reviews and his active and successful Science Olympics program.

David Gabel, his students and fellow teachers have a long and successful track record behind them. His school has consistently produced winners in the Science Olympics and other competitions. Not content to rest on his laurels, however, Mr. Gabel endeavours to maintain the level of achievement and to make the Science Olympics program work for all students, not just the ones who bring home prizes.

Mr. Gabel has also developed innovative ways to help students succeed in the classroom. One of the techniques he teaches students is briefly described below, along with some of his suggestions for a successful Science Olympics program.

Whether in school or out, there is a common thread to his efforts. He wants his students to understand that participation, teamwork and learning are what really matter. The trappings of success — be they trophies or high marks — come only as a result of the groundwork.

Participation and teamwork first

I think that my work on the Science Olympics is one of the most important things I do as a teacher. It is a very effective way to get kids involved outside the classroom. At Sir Winston Churchill Secondary School in Vancouver, where I teach, the program just seems to grow every year, by involving more students.

Not only do students prepare for the Science Olympics on their own time, they also get some feeling for why they are learning science in school and how that knowledge can be applied. There is also a lot of science that cannot be covered in school that students can learn about through these activities.

Problems of scale is one example of this sort of knowledge. A successful structure will not continue to work if you increase the size of everything in scale. The famous giant insects of science-fiction movies would, in fact, collapse under their own weight rather than pose a threat to human beings. Because of the dimensions involved in these problems, it is not a topic that is easy to introduce in class. Put students in a competition in which they have to produce structures capable of supporting mass, however, and they will teach themselves this very quickly and effectively.

I don't completely separate the Science Olympics work from what is going on in the classroom. I make a point of talking about it in class, so everyone knows what is happening. The extra-curricular work is also a valuable launching pad for discussion. I think that focusing outside of the classroom gives you a focus inside.

The key to creating a successful program for the Science Olympics and other competitive science events at any school is to introduce students to it in the right way. I like to emphasize the importance of participation and teamwork. In setting up a program like this, you are introducing students to something much more important than competition and that is the pursuit of excellence. This is new to most students and, as a result, it is a little daunting.

The biggest challenge is getting the program started. Once you have a critical mass of participating students, you are free to concentrate on giving them the support and resources they need. It is best to begin with your own classes; talk it up among your students. Try to encourage the younger ones especially (from Grade 8 up). Once they have participated one year, they will be keen to return and will spread the word to their friends.

To get other teachers to help, you have to give them support. I make sure that I give them some rules and ideas about the program that they can share with their students. If you want to create a program at your school, you should be prepared to be the co-ordinator. The teachers who are spreading the word for you can then just tell any interested students to get in touch with you.

Once you have a core of students coming back each year, you can begin to use teamwork to extend the program. You can set up teams to participate in events and appoint one of the more experienced students captain. One of the most valuable things you can do for your students is to get them working together to meet challenges, to get them working as a team against the world, not against themselves.

The other crucial message to get to students if you want to have a program that attracts and holds their interest is that anyone is welcome to join in. I have a constant battle with the organizers of competitions to get more teams from my school admitted. I am not interested in only seeing the best take part; I want everyone to have a chance to participate.

The irony is that participation is the very thing that ultimately brings success. Left to themselves, students tend to focus only on competition results or marks and don't realize that excellence is really the end of a long process.

The context for success

It is not surprising that students should fail to see success in the right context, given that, as teachers, we encourage them to learn, but give them precious little information on how to do so. I have found that there are a variety of techniques for note-taking and increasing memory retention that can help, and I pass these along to my students.

I begin with a challenge. I tell my students that, come year-end, they should be able to review the entire course in a couple of hours. This is a radical departure for most of them. They generally can't imagine preparing for exams without hours of cramming.

The key to improving memory retention is to make connections and associations among ideas. There are a number of different approaches for doing this. One I find particularly effective for my students is having them draw "association patterns" to help them organize their thoughts for learning and study.

When we encounter material for learning, it isn't necessarily in the same form that is best for our minds to use. For example, studies have shown that more than 90 percent of what students record in their notes is unnecessary for later recall. The remaining 10 percent is made up of key words — that is, words that provide essential information and stimulate images in the reader's mind.

I have my students experiment with drawings that combine words and pictures into an association pattern that is more useful than notes as an aide for recalling information. The drawings make use of colour to enhance the information further.

To help my students get started, I provide them with a list of suggestions that will help them create an image that offers a clear message so they can easily absorb information. For example, I point out that they should

- use a page with no lines
- build the pattern around one central image
- use three or four vivid colours
- print the words neatly
- try to avoid clutter
- use lettering of different sizes
- use geometric shapes such as circles, rectangles or triangles
- use unusual or unique images
- make the pattern beautiful.

I do not evaluate the images. My job is to provide suggestions and ask questions that will help students design an effective learning tool for themselves. This ultimately depends on whether the following three conditions are met: the key ideas being presented in a striking manner; the appropriate connections being made among ideas; and the student liking what they have produced.

Building a science fair program

Rudra Subedar
Austin Elementary School
Austin, Manitoba

Rudra Subedar

Rudra Subedar, of Austin Elementary School in Austin, Manitoba, has spent his entire teaching career helping students succeed despite limited opportunities. During the past 10 years, students from "disadvantaged" schools in northern and rural communities have consistently received top honours at regional and national science competitions they have prepared for following Mr. Subedar's program. Some of the honours accumulated during this period include 200 medals and other major awards at the regional, national and international levels as well as 21 trips to Canada-wide and world science fairs.

Although he is a successful science teacher, Rudra Subedar dedicates considerable time and effort to a guidance program. His primary aims are to help students develop self-esteem, confidence, compassion, assertiveness, poise and communications skills. He sees science education as a way to help students do this; if he can show them how they can achieve excellence in science, they will realize that they can do so in other areas of their lives. Similarly, when a student is struggling, Mr. Subedar draws upon their strengths to help rebuild their self-confidence in the area that is challenging them.

Learning to succeed

When I help students prepare for a science fair, I make sure they get more than just the chance to create a project. I hope that they will be able to improve their communication, research, reading and writing, scientific-thinking, logic, mathematics and problem-solving skills. This is not an easy thing for students to do, so I take them from the simple to the complex. They begin with small projects until they develop an interest in and awareness of an area. As this knowledge base grows, each student can then come up with more difficult problems to solve in that discipline.

As students move up the scale, I require a greater and greater commitment of time and effort. From the students' perspective, however, the success at the lower levels builds their self-confidence so that they can make the commitment required. As they go along, they begin to encounter problems that require more intense study, longer hours and a broader research base. Once each level of problem is solved, the students have a much richer knowledge base that will help them at the higher levels.

The overall process of developing science fair projects leads both the student and myself from the known to the unknown. A student might begin answering questions that are quite familiar to me and end up two years later working in an area that is completely new to both of us.

The process begins with a research project. For this assignment, the student is asked to compile a 15- to 25-page research paper that uses information from a number of published sources plus original data. When the paper is finished, the student does presentations and entertains questions from his or her peers. Each student also meets with me for an extended discussion so that I can ascertain the depth of his or her knowledge.

The subject for the research paper could be one that the student chooses; it could be an area that he or she has some connection to, perhaps because of a relative who works in the particular scientific or technological field; or it could be an idea from the idea bank that my students and I develop for just this purpose (see next page).

After I am satisfied that the students have put in the level of work required to move on, they begin a series of experimental studies. These could take anywhere from a few hours to several weeks. The intent is that the students develop an understanding of many of the laboratory techniques that are associated with that field of science. I play a large role helping to design the experiments, supervising the students' procedures and monitoring how the data are handled.

This stage is very important because experimentation will vary to some extent from one field to another. Procedures are very different in fields such as life sciences, chemistry or psychology, and you have to cover this material carefully if the student is going to succeed in the independent work.

Now, as I mentioned, each subsequent stage requires a greater commitment from the student than the previous. Their success has prepared them to do this and that is important because, in the final stage, the actual science fair project, the student is asked to find an area to work in that is innovative and has no scientific precedent. This project must be something that the student could not have looked up anywhere — something that, to the best of the student's knowledge, no scientist has ever done before.

One of the consequences of this is that all the important work happens long before the science fair itself. On the eve of the event, I like to be able to tell the student that they have already achieved everything they have to, that the actual results matter little now. And they believe me, because they have done an immense amount of work and have a track record of success they can look back on. I have pushed them hard and they have come through and they know it.

Much of the time, the student has, by then, enough experience that he or she can actually come up with innovations that produce positive results and that are applicable in the real world of science. The student is then set for an incredible amount of scientific success. And that is the goal of science — to develop new innovations and technologies that produce positive results that make life easier or cheaper or more enjoyable.

The big motivating factors here are achievement and teamwork. Students will put a lot of hours into an activity that pays them back with a sense of accomplishment. Similarly, we should never underestimate the attraction that structured activities have on students. In this sort of atmosphere, it is possible to work successfully together, something that we all crave. For some students, this is especially important because they are not finding that sort of success in other areas of their lives.

The idea bank

Don't get the idea that students work only with me on these projects; there is another aspect to the program: there is co-operation involved at each and every stage.

One area in which it is easy to see this co-operative principle in action is the development of the idea bank. My science fair students and I begin this by considering where the school is situated — the local environment, the local industries, the types of interactions that local people have with science and technology. We make lists of the different types of industries in the area. For example, here in Austin, Manitoba, we have farming, honeybee-keeping and the related beeswax industry. There is also a food-processing plant down the road and a fertilizer plant about 40 miles away.

Using the list of industries, we brainstorm and then do research to generate lists of as many of the processes that happen within those industries as we can identify. For each task or process that takes place within an industry, we generate statements: "It would be nice if someone were to develop an easier way to...."

We end up with a list of several hundred processes. For each item on the list, there tends to be, among a group of 100 kids (I have worked with up to 200 at a time), at least one who knows something about it, or one student who has a parent working in that field so that he or she can begin research in that area.

Two teachers talk about **competition**

Even though they work halfway across the country from one another and had never met until this February in Ottawa when they received their Prime Minister's Award, Rudra Subedar and David Gabel share a common philosophy about the value of competition among students.

Rudra Subedar
Austin Elementary School
Austin, Manitoba

Competition is one of the biggest forces for achievement in our culture. There are negative aspects to it, but I think that teachers sometimes allow these to prevent them from using one of the most powerful tools available. The key is to use competition in the right way.

One of the most effective ways to do this is to encourage teamwork and participation. The competitive event itself is really just the tip of the iceberg. Underneath, there are many long hours of co-operative work within the school to prepare for the event. When a student goes to a science fair, the important part — the preparation and development of projects and the co-operative learning — is already behind them.

It is also important that students understand that the judging at these events is a very human system with all the imperfections that human systems always have. There are valuable lessons about competition that we can teach students through these programs that will help them to prepare for the other competitions that life forces on them.

David Gabel
Sir Winston Churchill Secondary School
Vancouver, British Columbia

One of the most important things that I do for my students is to make sure that the pressure to succeed in competition does not come from me. My students know that success in competition is not what we expect, but rather participation and hard work.

Science competitions also give teachers an opportunity to counter the negative effects of other competitive environments student face. For example, many of my students put themselves under intense pressure to get the marks they need to get into the university of their choice. This is not constructive competition because they are putting the thing that really matters, learning, behind the success that comes about because of it. If you want to convince students that, if they take care of the learning, the marks will take care of themselves, it helps to have a way to show it; science competitions can be that way.

Similarly, if someone doesn't do very well at a science competition, you can sit down and talk to them about what they have learned from the experience. They have done something very important by giving it a go and they can use the experience gained next year. If you do this well, the students will figure out all by themselves how to apply this to the rest of their lives. This way, you leave a legacy of people who will spend their lives beyond school challenging themselves and who will not give up when they face future disappointments, which they inevitably will.

Tools for the times

Computers, satellites and digital communications, among other types of new technology, are changing the way the world works. They can also help teachers change they way they teach and show students new and exciting things they previously could only read about in a textbook.

Aubry Farenholtz and Gordon Spann have acquired a wide variety of interesting technology to use with their science students in British Columbia. These tools make possible experiments that their schools could not otherwise afford.

Using new technology effectively

Aubry Farenholtz and Gordon Spann
D.W. Poppy Secondary School and
H.D. Stafford Secondary School
Langley, British Columbia

Aubry Farenholtz
Gordon Spann

Aubry Farenholtz and Gordon Spann developed and then implemented a computer-based physics program for their respective schools, D.W. Poppy Secondary School and H.D. Stafford Secondary School, in Langley, British Columbia. The Technology Enhanced Physics Instruction (TEPI) program has greatly increased both interest and achievement among students at the schools. Mr. Farenholtz and Mr. Spann are now conducting a pilot project to introduce TEPI strategies into other science disciplines in other British Columbia schools.

Aubry Farenholtz and Gordon Spann have gained a lot of experience working with new technology in the classroom. For the past few years, they have each been implementing the Technology Enhanced Physics Instruction (TEPI) project in their respective classrooms.

The two high school physics teachers have become big advocates of the TEPI program because of the way it fully integrates computer and multimedia technologies into their students' daily learning routines. Using the program, Mr. Farenholtz and Mr. Spann have found that students develop a wide range of skills beyond the prescribed learning outcomes in the B.C. science curriculum. Their students also become computer literate and acquire skills useful for time management, resource management, collaborative group work and goal setting.

Here Mr. Farenholtz and Mr. Spann talk about the philosophy behind the TEPI program and two pieces of technology that they use in their classroom.

Integrating technology into the classroom

For us, the chief advantage of the TEPI program is that it provides a way to integrate technology into a wide variety of activities that suit a range of learning styles. It gives students the ability to control (within limits set by the teacher) the sequence and variety of activities they take part in to better reflect their learning style or areas of interest. Our role has also changed, from being "disseminators of knowledge" to facilitators who monitor, motivate, tutor, or provide "just-in-time" small-group instruction.

Typically, four or more activities will often happen simultaneously in our classroom — ranging from hands-on experiments, possibly using computer-based data collection methods, to interactive testing at a computer station. More traditional activities, such as working through problem sets, one-on-one instruction or group lectures still take place, but the timing of these is determined by the students' pace and levels of success.

As our work with the program has evolved, student participation in senior physics has increased. Despite working with a progressively larger sample of the graduating class, student achievement on final exams has been maintained at the provincial average, suggesting that the TEPI classroom can help students of varied abilities to be successful.

In the paragraphs below we introduce two pieces of technology we use in our classrooms and describe some of the activities for which we use them. If you would like more information about TEPI, please contact us: *Aubry_Farenholtz@mindlink.bc.ca* or *Gordon_Spann@mindlink.bc.ca*

The adventures of Sonic Ranger and the Force Probe

Some of the most exciting things we have discovered are electronic instruments that can be hooked up to a computer to measure and record lab data. These devices make possible a whole range of experiments for which most schools do not have the resources.

The first of these is the Sonic Ranger. This device is very similar to the hand-held radar guns used by police, except that it uses sound waves to measure the position, velocity and acceleration of an object. It collects the information and can plot it on a graph as the object being studied moves.

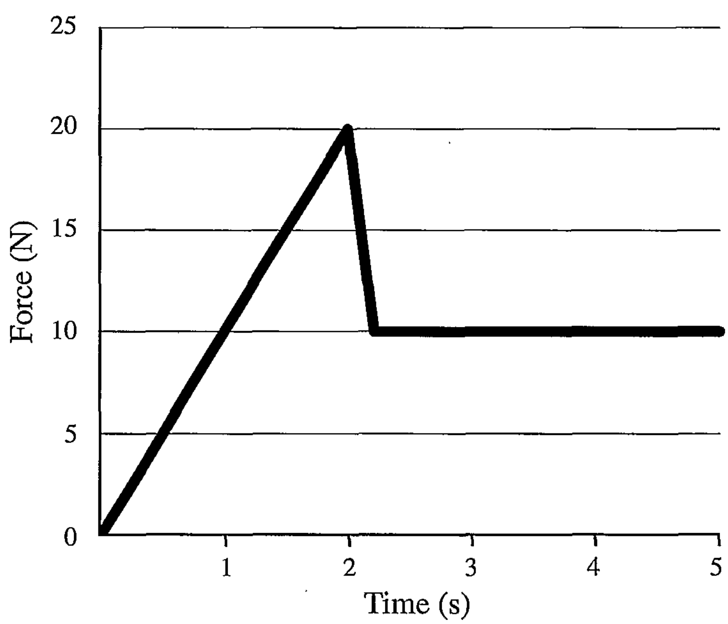
To introduce students to the related concepts, we begin by having one student move about a room while another tracks him or her with the Sonic Ranger. They quickly gain an intuitive understanding of which graph curves correspond to which types of motion. The computer can help this along by drawing a particular curve that students can try to duplicate by moving in different directions and with varying velocities.

When they get the data collected with the Sonic Ranger in the computer, students can use the software to construct their own graphs and interpret the data. This way, the students spend more time actually studying physics rather than focusing on measurements and calculations.

There is an equally useful device called a Force Probe that we use in the dynamics section of our courses. After using traditional measuring devices, we found this new technology to be just amazing.

Consider, for example, teaching students about the static and kinetic co-efficients of friction. You can describe, when you try to move a stationary object, how the friction developed rises sharply to a peak and then levels off once the object is moving.

Force vs. time graph for stationary block until moving with constant velocity



Showing them this phenomena is usually very difficult. However, the Force Probe changes all that. If students attach it to the line they are using to pull a block, it will record the force required and immediately display this information on screen. Students can point with one hand at the area on the curve that shows the change from one type of friction to another while pulling on the block to produce the data with another. There is no other way to record this data so simply and elegantly.

Graphical **calculators**

André Ladouceur
Collège catholique
Samuel-Genest
Ottawa, Ontario

Although computers are very exciting, I find that graphical calculators are often more useful, and flexible, in my classes. The basics of their operations are easy to figure out and the menus that give access to the more complicated functions become easier to use with each succeeding generation of machines.

At between $100 and $200 each, these calculators can be had for considerably less than a computer. I also find that it is very hard to use computers for less than an entire period. Graphical calculators, on the other hand, can easily be brought out for 15 minutes in a class and then put away so that you can go on to activities that don't require the technology.

One example of the way I use these calculators is to introduce young students to curves. Previously, these students were solving equations where *x* is always equal to a unique number. By moving the calculator's cursor along different curves, they easily come to grasp how the values of *x* and *y* change all the time and how this corresponds to the curve in question.

How many computers do you need for a **math lab?**

Ivan Johnson
Burnaby South
Secondary School
Burnaby, British Columbia

I like to have one computer for every two students.

When every student has a computer, the teacher is like a one-armed wallpaper hanger, running around the class helping students with their problems for the whole period. When students are in twos, they can easily work together to solve a problem on their own.

I find that having more than two students per computer doesn't work because one student inevitably ends up being left out.

You can make Mandelbrot **graphs too**

Richard Clausi
Elmira District
Secondary School
Elmira, Ontario

You can download the simple computer program to graph the Mandelbrot sets described on page 11 from the Exemplary Practices Web page on SchoolNet (*http://www.schoolnet.ca*). It runs using QBASIC, found on any DOS computer, and produces beautiful images.

As with the Sonic Ranger, the Force Probe can be used to collect data from a wide variety of labs. The only limit is the teacher's and students' creativity.

There are lot of other phenomena that are either impossible or very difficult to duplicate in the classroom, for example, launching a projectile. For a student to keep track of the trajectory, he or she would need a very complex set-up involving strobe lights and a camera. Conducting the same experiment without air resistance is just about impossible in a high school.

This situation is very easy to simulate on a computer screen using Interactive Physics. Students can change the conditions, such as launch velocity and angle and even the atmospheric conditions and gravitational force, with just a few keystrokes.

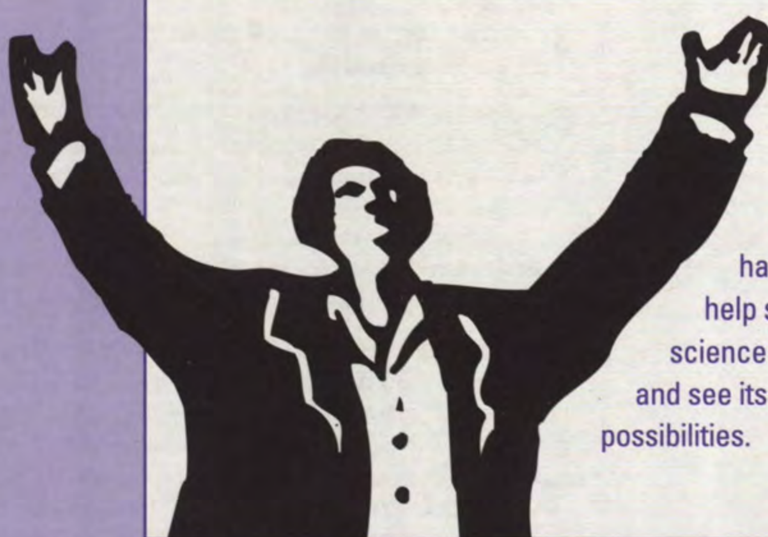
A computer capable of handling the required hardware and software can be bought for about $2000 as of the time this is written. The various probes needed for physics labs cost about $500. The complete set of probes for physics, chemistry and biology will run you about $1000. There are also some software costs.

Unlike a lot of other lab equipment, this investment will meet many needs right through the year. Compare this to an air table, for example. An air table can be purchased for about $2000 and it is very useful for performing certain experiments, but once you have finished the relevant unit, it just sits in the corner collecting dust.

Up to your elbows in **science**

Scientists in laboratories the world over do not spend their days doing problems out of textbooks. Nor should students in the classroom, according to many of the Prime Minister's Award recipients.

Reni Barlow from Ontario, Prince Edward Island's Jim Wicks and John Reily from British Columbia all get their students doing things in their science classes, from playing with toy submarines, to guessing which way forces act on things, to discovering the sound qualities of cymbals. These hands-on activities help students explore science in their own way and see its limitless possibilities.



Creating effective hands-on activities

Reni Barlow
Heritage Park Public School
Scarborough, Ontario

Reni Barlow

Reni Barlow's former students at Churchill Heights Public School in Scarborough, Ontario, still talk about The Shreddies Submarine, The Singing Tube and The Mystery Bottle. These aren't the titles of the latest *Goosebumps* books, but the names of units for an inspiring and challenging science program Mr. Barlow instituted. Today, he continues to develop new teaching techniques, encourage hands-on learning and serve students with special needs at Heritage Park Public School in Scarborough.

Reni Barlow has devoted a lot of effort, both in the classroom and as an education researcher, to figuring out which hands-on science activities lead to successful learning.

Early in his career, he discovered that many so-called hands-on activities do not live up to their reputation as pedagogical tools. Based on this work, Mr. Barlow developed an approach that places the emphasis on activities that do not have a predetermined outcome. Neither the teacher nor the students know where they are going to end up or how they are going to get there. Every experiment his students do really is an experiment. That is, the students are actually testing something; they are not simply verifying something somebody else has already done. This approach, which is very different from the standard textbook-type of activity, is described below.

From wide-eyed curiosity to organized research

Like all teachers, I have to make sure that a certain amount of content is taught in my courses. And I don't disparage exercises and demonstrations; they have their place. At the same time, however, we teachers also have students do activities that are presented to them as experiments or research when, in fact, they are not. The outcome is predetermined and the teacher knows this full well.

Students figure this out very quickly. By Grade 7, they are easily able to distinguish between what is real and what is not. It is only the real exploration work that is going to build their curiosity, their sense of wonder. In my conversations with practising scientists and university professors, they tell me that this is what they long to see in the students that the schools turn out — people who can identify fascinating questions for themselves and others, and who have a set of strategies for finding answers.

Research backs this up. An academic review of a number of studies done in 1978 confirmed that there was no cognitive advantage for students whose instruction included lab work over those whose instruction did not. This is not surprising if you look at the sorts of lab work students are typically asked to do. A casual survey of science textbooks, especially for the Grade 7 to 10 levels, reveals a series of cookbook-like instructions that the student is expected to complete, usually followed by "discussion" questions for which written answers are expected.

The challenge, then, is to come up with activities that can add something to students' learning.

I like to begin with something that is fascinating to play with. Toys are often an inspiration for me. I have presented my classes with such challenges as a toy submarine that alternatively surfaces and sinks when placed in water and a bottle that contains a liquid that changes colour when shaken. The first of these came out of a cereal box and the second can be made with fairly common chemicals.

When confronted with objects like these, students will play and play. Out of this play will come questions: Why does this happen? What is in the bottle?

A smart teacher resists the desire to direct the students or to point out what approach they should take. I encourage students to decide for themselves what they would like to explore. I ask them to find out what is interesting and to develop a set of questions to investigate. As a result, in a class of 25 kids, you may very well have 15 different questions. If the kids are working in pairs, it is not inconceivable to have 12 or 13 groups working on a different problem.

An added benefit of this is that when we get back together and discuss what they have been doing, the students actually have something to say to each other because they weren't all doing the same thing. This is very different from what often happens with textbook experiments, after which, once one person says, "Oh, it turned purple," the discussion is over. Everybody else just nods and says, "Yeah, ours turned purple too." What else could they say?

The toughest part of this approach is finding the things to spring on the students as "problems." Some, such as the cereal-box submarine and the mystery bottle, are just inherently fascinating and they come into our lives by accident. The key is never to let the opportunity to use them in your class go by.

I also get ideas from demonstrations I have seen. There is plenty of chemistry and physics "magic" that is usually done as demonstrations with the teacher explaining what is happening as he or she goes along. Take these out of their intended context and you can just do them without any preamble and then ask the class, "Why and how did that happen?"

My role in the classroom is to guide the students so they figure out for themselves what they want to know. For example, one group of students asked me if they could add some vinegar to the bottle. I asked them what they thought would happen when they did this. They told me that they thought the liquid would turn a certain colour. I then asked them what they planned to do if they didn't get the expected results. After all, I pointed out, adding the vinegar to the bottle will make it impossible to do any further research on the original substance. Through this line of questioning, they settled on the more cautious approach of removing some liquid from the bottle and mixing it with vinegar in another container.

When kids get stuck, I use a lot of questioning — What have you thought of? How else could you look at this problem? — and, sometimes, I will give them a clue — Have you thought about such and such? or, If what you say is true, what would you expect to see happen under these conditions?

One of the most common questions from students is, "Is this the right answer?" I never answer that one and I am quite up front about not doing so. That is always quite frustrating for a class, at least initially, because they have never encountered it before.

After thinking about my answer for a while, they usually then ask me, "What if we get it right? How will we know?" My answer to that is to ask them to tell me who answers these questions for adult scientists. If a scientist believes they have found a cure to a disease, is there someone who comes and says, "That's it. You have it right?" Of course there isn't, and this raises the whole question of how these scientists do check their own work.

The students slowly get the hang of testing something and then testing it again. Once they are confident enough, they try their ideas out on the other groups in the class. When they get to that stage, they are using skills they will never outgrow.

In a way, science operates much like a game and you have to buy into it. Unfortunately, not all kids do; some firmly believe and carry on, despite my best efforts, as if science, and all its answers, is found in textbooks and encyclopedias. My hope, especially through the introductory activities I use with kids when I first encounter them, is that we'll work on questions that won't have an answer in the back of a book.

That is difficult stuff for Grade 7 and 8 kids, but by encouraging them to do it, I find that they eventually understand. It works with both gifted kids and regular program kids too. The only difference I find is in the rate and the speed at which they work.

Newton and a spool

Jim Wicks
Bluefield High School
Hampshire, Prince Edward Island

Jim Wicks

Jim Wicks' students at Bluefield High School in Hampshire, Prince Edward Island, get excited by his science classes — even the students who normally don't like science. Mr. Wicks not only gains students' interest, he also takes the time to prove to them that they have learned something each day. His physics students, for example, are given assignments that, although they don't initially appear to be related, help them to understand how the concepts they have just learned can be applied in other areas.

Jim Wicks believes that the greatest challenge in teaching is to expand students' thinking envelope. He does not want to produce students who can only give back the sorts of knowledge they have been given. To avoid this, he has developed a number of activities that take students to a point where they think they know the subject. He then pushes them a little bit further.

One of Mr. Wicks' activities is perhaps the simplest and least expensive to implement in this book. It certainly works when it comes to making people think hard about Newton's second law of motion — it had a roomful of Prime Minister's Award recipients in deep debate for 30 minutes.

Which way will it go?

I use this activity after I have completely covered Newton's laws of motion. At this point, the students have thoroughly discussed the conceptual and mathematical aspects of the second law and have performed a number of experiments to confirm it. Although it sounds very simple when you put it on paper, this exercise never fails to rock the boat a bit and make students a little less sure of what they know.

My real purpose is not to show how a spool will act when a certain kind of force is put on it. What I want to do is to make my students think about the second law and to explain why they think the spool will behave in a particular way. This forces them to push themselves to a higher level of understanding and to challenge themselves to examine all the concepts we deal with more closely.

To do this, you need an empty spool of the sort on which wire or light line is sold, a small piece of wood (a 20-cm x 20-cm x 2-cm block works well), a screw eye and two lengths of string. You should be able to get the spool from a hardware store for free if you explain to the staff that you will be using it for the school.

Tie a length of string to the spool and wrap it around it a few times. Attach the screw eye to one face of the block of wood, approximately three centimetres from the end, and tie a short length of string, about one metre, to the eye. Then, put the piece of wood out of sight and concentrate on the spool.

You can position the spool in two ways: so the string comes over the top the way Emily Post says the toilet paper is supposed to go, or, if you turn the spool around, so the string comes out from the bottom. It is this second position that is to be the subject of discussion.

The question is quite simple: What way will the spool go when I pull the string towards me? Now, it is easy, too easy, to just pull on the string and find out. So I tell the students that this is what we are *not* going to do.

At this point, I remind them of Newton's second law: the acceleration of a body is directly proportional to the net force applied and in the direction of the net force.

I set the spool up with the string coming off the top and ask them which way it will go when I pull on the string. I ask them to explain why and they will respond with, "Acceleration is in the direction of the net force."

Then I flip the spool over and repeat the question.

Having set up the problem, I have the class break up into groups of three to discuss the issue. This is when it gets interesting. The more the students are forced to think and talk about this, the less certain they become. We then come back together to discuss it as a class.

By now, there is usually considerable uncertainty. Some students are arguing that the spool will move away from me when I pull. Others think it will come towards me and still others think it will stay in one place with the spool spinning the way car wheels spin when you step hard on the gas pedal. As the discussion proceeds, I ask each person who comes up with a theory to explain how it fits into Newton's second law. For example, if someone suggests that the direction the spool travels depends on how hard I pull on the string, I ask them to remind me just where in the second law it says that the vector component is dependent on how powerful a force is applied.

This moment is the point of the whole exercise: to make the students explain what they think will happen, and more importantly why, in terms of the concepts they have learned.

To help make things clearer, I now pull out the piece of wood. I set it up once with the eye on the top and once with the eye on the bottom and pull the string.

No matter how I set up the wood, it always comes towards me when I pull on the string.

Now, I pull the spool out again and ask the class which way it will go. Usually, there is a consensus that the spool will come towards me at this point. I confirm this by asking the students to vote on the issue. After announcing the results of the vote, I put the spool away and start another activity...

They never let me get away with this. They demand that I take the spool back out and show them.

What is preying on their minds is other demonstrations they have seen during the school year. Demonstrations are often used to make points that are counter-intuitive. This builds student confidence in what they have learned and starts them applying their physics knowledge rather than relying on "what they think will happen." When I finally do demonstrate what the spool does, I like to watch the students' faces rather than the spool. They really don't know which way it will go.

Of course, the science teachers reading this book will already know which way that is. They know Newton's second law after all!

Making young **Galileos**

Jim Wicks
Bluefield High School
Hampshire,
Prince Edward Island

I send students home after the first day of school to try their hand at a problem of Galileo's — to find out which will fall fastest, something heavy or something light. I ask them to write out the results of their experiment and submit it to me.

There is no telling what results they will come back with because some will do the experiment in a way that air resistance is a factor and others will not. One student may compare the speed a binder drops to the speed a single sheet of paper drops. Another may use the same objects but crumple the paper into a ball and get a completely different result. The point is not that the students get the right answer. I only want them to do the experiment and write out why they think they got the results they did.

After a few weeks, I ask them to repeat the experiment using different light and heavy objects and again write out their thinking. You can do this with any number of simple experiments.

At the end of the term, I give the students back all the papers they have written so they can see how their thinking has changed.

Big science in small things

John Reily
Maple Ridge Elementary School
Pitt Meadows, British Columbia

John Reily

John Reily's efforts helped his fellow teachers at Maple Ridge Elementary School in Pitt Meadows, British Columbia, overcome a big challenge — to implement a new science program even though little science was being taught in the elementary classrooms of the district. Mr. Reily led the team that developed the FLASH program. Today, the local school district has 36 dedicated teachers who approach their science classes with new-found enthusiasm.

John Reily believes that science teachers should have a program that makes the subject fun and challenging, and that the materials and equipment required should be cheap and easily obtained. Practising what he preaches, Mr. Reily has spent the last few years developing the FLASH program (Framework for Learning Activities-based Science — Hands-on). By working with FLASH, elementary school teachers can develop their own "sciencing" skills.

One of the key philosophies behind the program is that if you can energize and excite teachers, they will pass that excitement on to their students. The activities included in each of the many FLASH units are entertaining and designed to encourage hands-on participation by the student and teacher. They are designed to start with experiments rather than textbooks. The accompanying booklets illustrate basic principles of good science.

Below, Mr. Reily introduces us to one set of activities that encourages children to follow their natural tendency to question how the real world works.

What's that sound?

It all started with one of those great "aha" moments. While supervising recess, I saw a child on the playground tossing a big brass cymbal as if it were a discus. I grabbed the cymbal for safekeeping and took it back to my classroom for the rest of the day. To mark the end of the period for my Grade 5 class, I held the cymbal aloft by a string and stood before my students not saying a word. The classroom became hushed in expectation as they realized what I was going to do — some held their ears, others just smiled.

I gave the cymbal a whack with a pair of scissors. The sound filled the room. Everyone was silent while the cymbal rocked back and forth on the string. I was urged to hit it again when the sound stopped. Before doing so, I asked the students to put their hands up when they could no longer hear the sound. I hit the cymbal again, a bit softer this time, and hands shot up as the sound died. Some of the kids noticed that those furthest from the source put their hands up sooner than those at the front of the class.

While we were pondering this, one student asked "The cymbal has no moving parts; Where does the sound come from?" I handed the cymbal around the class while the students tried to answer this question. They tried a lot of different things — some tapped it daintily, others gave it a gigantic hit.

Some of the students noticed that the sound died if they touched the cymbal after striking it. This prompted a student who had rarely raised her hand in the past year to say, "You stop the vibrations if you touch it." The word "vibrations" had a big impact — all eyes travelled to the girl at the back. She quietly said that the cymbal vibrated and that was why it made the sound. She went on to point out that the vibrations went into your hand.

That comment brought out an explosion of discussion. One student said he had noticed the cymbal moving up and down really fast and wanted to know if that had anything to do with the sound being made. A boy in the back asked if it was vibrations that had hurt his hand when he hit a post with a baseball bat. Another pointed out that he could make vibrations with his ruler. He held the ruler over the edge of his desk to show us how. That really did it — everyone's ruler came out and they experimented by lengthening and shortening the portion sticking over the edge of the desk to make different sounds.

During all this activity, one of the students said to me, "I've done this before but I never knew that I was doing science."

Their enthusiasm fueled me and we spent several classes talking about vibrations and sound waves. For my part, I introduced them to molecules and what part they play in the creation of the sounds we hear. I was amazed at how many links to the real world these kids could make. They asked questions such as, "When you hit two rocks together under water, why do they sound different than on land?" "Is that why bees buzz?" We started a list of all the things that make sound through vibrations. It was an impressive list, from hummingbirds' wings to guitar strings.

I looked at my students' faces as they worked together to come to an understanding of this phenomena. They were engaged in learning and were clearly enjoying it. Everyone was taking part and many had insights to offer based on their personal experiences. It was good science and it was child-centred rather than text-driven. For homework, I asked them to bring a sound-making device from home. For the next few days we were flooded with suggestions from students and their parents. There were links being made between the world of school and the world the children lived in outside of school.

It was important for me to listen to and encourage the questions that the children were raising and refrain from giving too many answers. Nothing stops creativity in children more quickly than a teacher giving them the "right" answer. Instead, I helped them by grouping their questions into themes, getting them materials to further explore these questions, adding content to the discussion when required and offering direction when they got stuck..

Working together, my students and I came up with many activities during our study of sound. For example, we used balloons to simulate the way sounds are made in the throat. A balloon was inflated to simulate the lungs and the hole at the top was stretched out as the air was released. This way you got a slot that allowed air to escape. As the amount of stretch was increased or decreased, the rubber on the sides of this slot affected the sound in a way that is similar to what our vocal cords do. The students found this activity tactile and visually exciting.

The unit I developed later for the FLASH program came, by and large, from the questions and activities my students and I worked out in the classroom.

In another activity, we used a small, hand-cranked hurdy-gurdy similar to those used in music boxes to study how sound travels through different media. When we held the hurdy-gurdy in the air, we found that it made hardly any sound when it was cranked. However, when it was placed on a tabletop, the song it was set up to play, Scott Joplin's *The Entertainer*, filled the room. Soon the hurdy-gurdy was tried on every surface available to test the sound-carrying nature of different materials. We discovered that cloth was a poor conductor of sound but that my filing cabinet worked very well. Braces on teeth worked too (although it did make the child's mouth itch — another avenue to explore).

We read about various animals and looked at their ears to see how size and shape corresponded according to the importance of hearing in animals' survival. Later, students made a number of different kinds of "enhanced ears" using cardboard and foil and experimented with these to see what effect they had on humans' ability to detect sounds coming from various sources.

One student who had a brother with a hearing difficulty brought in a decibel tester. It was used to test various homemade noisemakers. After studying the normal decibel chart to see how loudness was rated, we used the noisemakers and created our own version of a decibel chart. Groups of students looked carefully at the noisemakers and predicted where on a scale of one to ten the noise level produced would be. After testing the devices, we discussed any surprising results.

I ended the unit by having the students form bands. Some made string instruments or drum sets or combinations of instruments. One group used small glass pop bottles of a uniform size and filled them with different amounts of coloured water. Using their knowledge of sounds, they created music. They produced a short tune by blowing over the top or hitting the sides of the bottles. After much practice, their musical creation was played for the class. They even created a very simple colour-coded notation system to remember the tune.

During the course of the unit, the students learned a great deal about sound and how it is generated. More importantly, the content of the unit was the vehicle for developing science process skills. Students explored how science is carried out and how it affects all of our lives. They used some special tools such as tuning forks but most of the unit was undertaken with "found materials" such as paper rolls, coat hangers and garden hose. They wrote out their scientific observations, designed and conducted their own experiments and constructed devices. They did what scientists do and they referred to themselves as scientists.

Children must see the applications of the science they are studying. Links to the world they experience everyday are essential. If something taught in the classroom is not relevant to a child's world view, then it has little value.

If you would like more information about the FLASH program, please contact Deputy Superintendent M. J. Suddaby of School District #42 at 22225 Brown Avenue, Maple Ridge, British Columbia, V2X 8N6.

Extra! Extra!

Many students learn just as much, if not more, about a subject such as science from activities they do outside of school hours as they do in the classroom. Clubs and other extra-curricular activities bring students learning and social opportunities that help make them well-rounded individuals.

Extra-curricular activities can be rewarding for the teachers involved. They can also be challenging; students must see that the activities are interesting and worth their while or they will not participate, at least not for long.

David Keefe from Newfoundland, Terry Prichett from Ontario and Rocque Richard from Alberta have all found ways to keep their students, and themselves, interested and enthusiastic about science, even when they are not in class.

Organizing a star party

David Keefe
Menihek Integrated High School
Labrador City, Newfoundland

David Keefe

David Keefe decided to make sure the science education of his students at Menihek Integrated High School in Labrador City, Newfoundland, did not suffer because the school is in an isolated mining town. He made the most of the resources available and took advantage of funding from corporate sponsors to expose his students to a wide and varied science program. In Labrador City, and now at Ascension Collegiate High School in Bay Roberts, Newfoundland, he has exposed students to the joys of scientific observation through his star parties and has shown them how science applies to everything from automobiles to model rockets.

Although he gets great satisfaction out of teaching students who go on to careers in science, David Keefe believes that one of the most important contributions he can make as a teacher is to introduce science to students who will leave the official world of science behind when they graduate. He wants every student in his class to realize that there is a place for them in science, even if it is only as a pastime.

In his years of teaching, Mr. Keefe has enthusiastically organized extra-curricular activities such as astronomy and rocketry clubs. He is proud to say that these clubs have added a little enlightenment to students ranging from really exceptional learners to those who absorbed very little science outside of what they picked up in his clubs.

Mr. Keefe has organized clubs around subjects that he is passionate about, believing that his passion will communicate itself to students. He began with an astronomy club and that began with a star party.

How to get students to reach for the stars

We live in a world where people rarely look up into the night sky. For centuries before us, though, that night sky was a source of wonder and awe to humans. It can still have that effect on today's high school students.

The purpose of a star party is to get students out and looking up. For every star party you have, there will be some participants who will embark on a life-long interest in astronomy. Others will not be so powerfully affected, but they will remember; years later they will tell a child, "Look up there; that is the pole star. Let me show you how you can always find it."

To organize a party, I build interest by talking it up in my classes. I also make up some posters to place around the school telling students to show up and BYOB (Bring Your Own Binoculars).

Besides bringing themselves and possibly some binoculars, the students don't have to do anything else to prepare. They do not have to have very good quality binoculars either. Serious star gazers like to use more powerful binoculars (10 x 50 at a minimum) than what most people have in their homes (usually anywhere from 6 x 50 to 8 x 40). Less powerful binoculars are just fine to start with, however. Anything that has a lens wider in diameter than the human eye will increase light-gathering ability.

Those of us who live in small communities have a big advantage over people who live in big cities when it comes to stargazing. The bright lights of a city produce a lot of "light pollution" that blocks out the ability to see heavenly bodies. It is best to get outside of town if you can. But even in the centre of town you will be able to see some things if you find a place where there is no light shining in your eyes.

To prepare for the event, I usually organize a few activities. If the moon is going to be out that night, I will have people try to spot some of the more visible surface features. I will generally try to introduce people to some new constellations besides the Big and Little dippers — perhaps Orion, Cassiopeia and the Andromeda nebula.

I try to keep the structured activities to a minimum so that everyone has lots of time just to look. To help people navigate their way around the sky I provide them with photocopies of a simple star map. Most astronomy magazines regularly publish good ones.

Almost any night will produce some surprises, ranging from shooting stars to, if you are really lucky, the aurora borealis. One of the most dependable treats is spotting satellites. In the hours just after the sun goes down, it is at the right angle to shine brightly on earth-orbiting satellites. These look just like stars only they move, generally crossing the sky in one or two minutes. Most move from north to south or vice versa. Some satellites twinkle because they are tumbling in space.

Just seeing the night sky and any surprises that we are lucky enough to catch produces what I call the "Wow Factor." It is a sense of wonderment and excitement in people, which I take advantage of to slip a little bit of science into the discussion — not enough to scare anybody, but just enough to firmly establish the link between the wonder and the science.

Some students will want to do more than wonder. They will want to find out much more about the night sky, and that is how the astronomy club comes in. There is a wide variety of books and magazines that will help you organize and maintain a club for these keen students.

In many ways, the astronomy club is the easiest part because that is where you learn together. You and the faithful members become partners, all looking for and sharing information. Astronomy is one of those things whereby the more you see, the more you want to know. It has ever-increasing returns.

The hands-on **universe**

David Keefe
Menihek Integrated High School
Labrador City, Newfoundland

I have long found that many students are excited by space science. I have recently discovered the Hands-On Universe, a very exciting resource for young astronomers, thanks to a friend at Industry Canada's St. John's office.

The Hands-On Universe allows students from around the world to request observations from an automated 30" telescope, to select and download images from an archive of more than 1500 images, and to learn the math and science involved in professional astronomy. The big appeal of this project is that it allows me to give students a chance to do some real leading-edge science work — the program puts kids in the shoes of professional astronomers.

The program was created by the American National Science Foundation and Department of Energy. There are currently efforts under way in this country to encourage more Canadian participation in the program. To learn more about the Hands-On Universe, look up its World Wide Web home page at *http://hou.lbl.gov/* I have also established a link to this home page, and several other science education pages, from my personal home page *http://calvin.stemnet.nf.ca/~dkeefe/index.html*

Space to learn and grow

Terry Prichett
Lisgar Collegiate Institute
Ottawa, Ontario

Terry Prichett

At Lisgar Collegiate Institute in Ottawa, Ontario, Terry Prichett uses simulations to teach his students important concepts in mathematics, computer programming, physics and chemistry, among many other subjects. Students have been exposed to computer-based community planning games in which they learn the multiple effects of decisions, and a space program that shows them how science can be applied to practical problems. Mr. Prichett has, even during a period of financial restraint, expanded the space program to make it available to the entire school board.

Terry Prichett has studied and participated in a large number of simulations in the past 15 years. He has put everything he learned into a space station simulation exercise he currently runs with students at Lisgar Collegiate Institute in Ottawa.

The main goal behind the simulation is not to promote knowledge of space itself. Rather, Mr. Prichett is concerned with developing the sorts of problem-solving and technological skills students require to be confident and productive and that are needed for Canada to remain competitive in the international economy. These skills can be, and are, regularly taught in the classroom, but Mr. Prichett is convinced that the role-playing required for simulations is too effective a teaching tool to pass up.

He also places considerable emphasis on the integration of different subjects that takes place as part of the simulation. Although increasing awareness of technology is important, he is also careful to see that all the skills required for a real space mission — from computer science to public relations — are covered.

Preparing for launch day

In teaching, the biggest part of the battle is getting students involved. Very few activities that you can do in school will attract and hold kids' attention the way a simulation will.

In this simulation, the students set about creating a 72-hour space mission, but there are other equally powerful ones that deal with subjects such as the stock market. The space simulation works in real time: one hour during the simulation is equal to one hour in the real world. Other types of simulations may require time to be compressed.

Our simulation is based on one that was first done in Houston about 10 years ago. We made one crucial change, however. For the Houston mission, students applied for particular jobs — astronaut, capsule communicator, computer specialist, video specialist and public relations specialist. We found that not only did the kids prefer to assume multiple responsibilities, but also that we could enhance the integration of subjects this way. In our simulation, students whose main strength is in arts and languages learn a lot about technology, but the learning process also goes the other way.

The students' first task was to design and build a simulated habitat and a mission control. They also designed and built a simulated space shuttle to get them to the habitat.

My first task was to provide the students with a facility and some equipment that they then used. The basic materials required include communications equipment, construction materials and whatever computers I can buy, beg or borrow.

What we had at the beginning, in 1992, was pretty basic. It certainly didn't look like the sort of thing that they do at the big U.S. space camps, where a larger budget translates into a very realistic mission control. But that matters very little. My experience has been that students learn to focus on the aspects of the simulation they can control and to live with what cannot be changed. In our simulation, for example, it is not possible to provide an independent power source so we use an electrical system that is somewhat unrealistically plugged into a wall of the building where the simulation takes place. On the other hand, the students have created a very impressive plumbing system for the planetary habitat.

Role-playing is a powerful tool and the students are very willing to suspend any skepticism or disbelief they have about the accuracy of some of the things that go on. They will, however, insist on being very strict about what they can control. For example, one year I let a press photographer enter the habitat in a way that was not at all in keeping with the integrity of the mission. They were not happy about this and I won't be doing it again.

I always consider the age of the students when deciding how proscribed the simulation should be. As a rule of thumb, the younger the children, the more structured you should be prepared to be. That said, the kids themselves will rapidly become the biggest force for increased realism in the simulation.

The students have been making piecemeal improvements to every aspect of the mission over the years that have turned what began as a humble project into something quite impressive. Some of these improvements include an airlock entrance to the habitat and a very realistic space suit that one student researched, designed and made. Similarly, a number of computer simulations now monitor oxygen use and allow the students to keep track of their position in space.

Another important facet of the program is the extension of it beyond our own school. As part of the program, students had to learn how to make an effective presentation to the school board. This included written and videotaped material.

One aspect of the presentation that really impressed the board was a proposal to extend the program to include elementary students. From the board's perspective, that was real added value. We were able to deliver on that promise because the students found the opportunity to educate others very attractive.

They designed the education program themselves — my role was largely supervisory — and it has become a very successful program. The students now provide it to 1000 to 1200 elementary students every year. This part of the program significantly increases the range of skills that my students learn through the simulation.

As you would expect, the elementary school missions are short and quite structured. They are run under the close supervision of the high school students. From the elementary school teachers' perspective, the advantage of this program is that it does not involve a great deal of additional work on their part, although many contribute to the evolution of the program through their creative efforts.

There is much that could be told about this program. A lot has happened over the years. The simulation is an extra-curricular activity for the high school students and part of the regular school program for the elementary classes across the city that choose to get involved. By building a little more every year, we have also managed to get a lot of publicity, not to mention significant support from corporations and other organizations.

We now have enough experience that we are in a position to provide help to others seeking to create simulations of their own. Anyone seeking additional information should write to me and I will put together an information package for them.

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or

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Lunch-time meetings with the fix-it guys

Rocque Richard
École Our Lady of Perpetual Help School
Sherwood Park, Alberta

Rocque Richard

When a student at École Our Lady of Perpetual Help School in Sherwood Park, Alberta, approached Rocque Richard with a broken toy vehicle, a lot more than that toy got started. Mr. Richard's Fix-It noon hours, during which students learn to use their problem-solving skills, is only one example of the many initiatives that he has launched to benefit Grade 5 and 6 students. Other projects have included developing an environmental education program and soliciting private sector support for education.

Rocque Richard's Grade 6 students mostly come to school by bus, often from some distance. It was while trying to keep these kids occupied during the long lunch hour that Mr. Richard came up with the Fix-it Club.

He found that the club was a much bigger draw than the athletics programs also being offered. Now, instead of the 10 to 12 athletic students he used to coach, Mr. Richard has an activity that draws anywhere from 50 to 60 students per session. The participants bring broken toys and other gadgets from home and, in fixing them, they learn about electricity and mechanics and acquire problem-solving skills. As an added bonus, the students get introduced to tools they are unlikely to be able to use at home.

A simple idea with big dividends

Given all the things that I have done in education, I am more than a little surprised at how excited people get when they learn about this crazy Fix-it Club. It was such a simple thing — driven partially by a desire to do something that I really enjoy with the kids — and yet, looking back, I am amazed at how much time my students and I have put into it and how much we have all gotten out of it.

It all began when one student brought in a remote-control car that no longer worked. As a father myself, I have taken apart more than my share of broken toys, so I sat down and started to take it apart while he and his friends watched. Like any teacher, when I saw the simple electric circuit inside I started to talk about it with them. This sort of circuit is part of the Grade 5 and 6 curriculum and the students were immediately interested. Not one to miss an opportunity like this, I shifted things around and got them doing the work while I watched. There was a break in the circuit that this little group easily found and before long, the car's owner was soldering a circuit together for the first time in his life.

This idea quickly caught on and other students began bringing things in. I formalized this and we now have a special area where things are accumulated until we have enough to hold a club meeting. Often the students will come to me and ask if they can have a session on days when the weather is a little rough or just when they want a little excitement.

Starting with that remote-control car, we have had an incredible variety of toys come through the club. There is a lot of really good science in toys and the kids get a whole new perspective on them once they realize how much goes into them. As I write this, we are working on a real antique. This is quite a challenge for the kids, because it has no screws and is being entirely held together by flaps of metal that are folded over other parts of the toy.

Some other things we have fixed include a popcorn maker and a couple of electric pencil sharpeners.

There are some things that I do not allow. Obviously, anything that plugs into a wall socket is off limits to kids this age. Even though we could probably fix some of these things safely, I would not want to encourage kids to open them on their own. The message I give is that higher voltage items are simply not to be touched.

Similarly, I discourage anyone from bringing in items that are going to be really complex. A clock, for example, has too many parts for students this age. It also seems to me that this would have to be a restriction if you wanted to start a club with slightly older kids in junior high. At that age, kids begin playing with very complex things, such as walkie-talkies and electronic games, that would be well beyond the science concepts they learn in school.

The work is done in groups of three to five kids during the club session. I teach them to do things in a logical order. For example, they have to use a volt meter to test the batteries first, because there is no point in taking a toy apart before you make sure the battery isn't the problem.

While taking the toy apart, the students have to keep careful notes on what they are doing so that they will be able to put it back together again. Once disassembled, the first order of the day is to give everything a good cleaning. Most of the time, probably 9 times out of 10, this is all that is needed to make the toy or gadget work again. This is especially true of these new educational toys that require children to push buttons to learn answers to questions. There is a very valuable lesson about electricity and conductivity in this and I make sure the students grasp this.

Other science that is not directly related to fixing the toy often comes up. For toy cars, for example, I have the kids count the gears on the drive mechanism and figure out what the gear ratio is.

After opening and cleaning the toy as well as discussing the science involved, we have to fix the toy if we can. The students begin by going through all the functions that have to take place for the toy to work. Are all the connections required for the circuit in place? Is there a current flowing when the toy is turned on? Are the mechanical parts in good order? Sometimes, the news is really bad and a motor will be seized, making the toy beyond repair. In that case, the students have a choice: they can either take the toy home or they can donate it as a source of spare parts for future repairs.

That is it. It seems pretty simple and it felt pretty simple as my students and I were doing it. Along the way, however, we all had to develop our brains and that takes some work. It all comes back to science. With each toy, we have to do some careful observation. We have to be methodical and to write down everything we do so we can figure a way to get out of trouble if we get stuck. When it comes time to fixing something, everyone has to make a prediction of what they think will happen. If it doesn't work out the first time, I tell them, you have to give it three or four good tries. Even when they get the results they want, they know that a good scientist goes back and checks everything again anyway.

Destination **Conservation**

Rocque Richard
École Our Lady of Perpetual Help School
Sherwood Park, Alberta

This is a really great program that my Grade 6 students have used to help the school save money on its energy costs.

The key to the program is that the kids who take part in it get to split the savings with the school. If they manage to save $1000, they get a portion of that to spend on things related to their Destination Conservation activities.

One example of what we did at our school was to check the entire building for energy wasters such as leaking faucets and missing caulking. We used an audit sheet provided by Destination Conservation to help us. We also made suggestions about changes that could be made to the school's energy-using systems to save money. For example, we were able to suggest a modification to the fluorescent-tube lighting system.

For each money-saving idea we put forward, the kids had to interview the staff responsible for the systems involved and prepare a written proposal to sell the idea to the principal.

Incredibly, these measures make a huge difference when they are put into practice. Both the kids and the school administration were amazed when the first year's savings amounted to $1000. The next year, they doubled that, and the year afterwards they doubled again to reach $4000.

Another benefit for the kids is that they get to go places they otherwise would never see in the school. They have visited the furnace room and the roof and learned how the systems in those locations work. They got to poke their noses in every little corner of the school.

We currently have $6000 to spend on a project, but we are in no hurry to do so until we carefully consider all our options. Some of the available choices include buying a piece of the rainforest or perhaps adopting a whale. Then again, maybe we should spend it to buy some motion detectors that would be used to make sure that lights in the less-used sections of the school only get turned on when they are really needed.

Destination Conservation began here in the West, but it is going national. If you are interested in setting up a program like this in your school, contact:

Tom Yohemas
10511 Saskatchewan Drive
Edmonton, Alberta
T6E 4S1

Telephone: (403) 432-9151
Fax: (403) 439-5081

World Wide Web: *http://www.ccinet.ab.ca/dc/*

The whole **story**

Rather than learning about only one aspect of a subject, students who study in an integrated environment get to approach a topic from many angles. As a result, they see the broader scope of the material and can more easily learn how subjects combine together in real life too.

Science, technology and mathematics fit together nicely in the classrooms of Rene Aston and Mary Storey in Ontario; students look at the human body and bones in many different ways in Danielle Clermont's classes in British Columbia; and Danielle Umbriaco and Michel Goudreau's students learn about many subjects on their way to and inside a cave near their school in Quebec.

Ramps on the road to learning

Rene Aston and Mary Storey
Central Park Public School
Markham, Ontario

Rene Aston
Mary Storey

Parents of Rene Aston and Mary Storey's students at Central Park Public School in Markham, Ontario, were very happy when their children were introduced to a science, mathematics and technology program that is fun, but still strong on basics. Ms. Aston and Ms. Storey teach an integrated program they developed that has students spending entire afternoons working on science, technology and mathematics. The program has proved to be especially beneficial for students who previously showed little interest in or aptitude for science.

Research shows that when science, technology and mathematics are integrated in a teaching program, learning is more effective because students understand the relevance of these subjects better than when they are taught in isolation. Rene Aston and Mary Storey have designed a year-long integrated program for their Grade 7 and 8 students.

The following activity is just one of many that are combined in a program they have developed to cover the entire Grade 8 curriculum. The two teachers use this particular unit to have students apply the Pythagorean theorem, to reinforce their knowledge of linear measurement, to emphasize the importance of controlling variables in an experiment and to have them develop the technological skills necessary to build the apparatus required in the experiment.

Getting the angle on the Pythagorean theorem

We start with the building of the necessary technology. The materials required are an eight-foot length of drywall bead to act as the structure for the ramp, some wing nuts and small bolts, a piece of cardboard for the floor of the ramp, a ruler, a protractor and an identical car for each group of three to five students. We also borrow some tin snips to cut the drywall bead to the right length.

For those not familiar with it, drywall bead is a strip of soft metal bent at a 90° angle that is used to form corners of interior walls in house construction. It is especially useful for our project because it has a series of holes along its length through which small bolts can be inserted to hold the structure together. It is also one of the cheapest and most common construction materials around.

We provide the students with a sample ramp on which they can base their own. We allow them some creativity in how they do this, provided they end up with a structure that can be adjusted for height and angle and that has a ramp that a small car can run down. They already have the measurement skills needed to copy the model, but the use of the tin snips is new to most students in this age group. When teaching them how to use a new tool, we find it is essential to show them how to hold and work with it properly. Safety is also a concern here because the tin snips are sharp and the material will have some sharp edges.

For the cars, we use a number of Lego 1032 kits so the students can construct cars that are as near to identical as they can make them. A teacher on a really tight budget could substitute any one of a variety of cheaper toy cars. The important thing is that each group be using the same type of car so that they can compare results. We find that repetition of key skills is crucial to children's learning and this skill, learning to control the number of variables in an experiment, is one that they will be using again and again in their science education.

Once the ramps are all completed, the students carry out a multipart activity that requires them to use their linear-measurement skills as well as to apply the Pythagorean theorem, which is being introduced to them for the first time in Grade 8. The basic activity is to run the cars down the ramp from a variety of different height settings. The students also experiment with having the cars run over a number of different surfaces, such as a desktop, carpet, sand and gravel, to see what effect these surfaces have on the distance the car travels.

While they are doing this, the students are required to keep track of a variety of data. We also have them verify the Pythagorean theorem as they change the angle and height of the ramp. The structure forms a right angle in which the ramp itself is the hypotenuse. The ramp remains a constant length, but the other two sides change as the height of the ramp is changed. The students take measurements at each angle, after first using their protractor to ensure the structure is square. They then use their calculators to see if the sum of the two changed dimensions still adds up to the square of the hypotenuse. (We prepare them for this by doing some textbook-based teaching about the Pythagorean theorem ahead of time.)

The chief advantages of this unit are the interest it develops in the students and its extremely low cost. You could teach the students the same information quite adequately with pencil and paper, but you don't get the magical excitement that comes from putting materials in their hands and having them build something. Using manipulatives is something that is often done with younger students, but it works just as well with students in Grades 8 and 9.

Introducing girls to **technology**

Rene Aston and Mary Storey
Central Park Public School
Markham, Ontario

A number of other contributors to this book have talked about occasionally allowing students free time to go where they want with scientific equipment and materials. We agree and believe that this is especially important when introducing girls to technology. Rather than giving girls narrowly defined tasks, we allow them free time to make innovations of their own.

This is important because girls are often very concerned with the appearance of the objects they are making (such as putting curtains on the mealworm hotels that we build in our biology sessions). Allowing them the time to work on the aesthetic aspects of their project greatly increases their interest in technology.

Design is a very important part of technology development and we can discuss this with our students and tell them about the very important contributions both women and men designers make.

Communicating ideas **in math class**

André Ladouceur
Collège catholique Samuel-Genest
Ottawa, Ontario

For the past few years, we have been insisting that our mathematics students write out, using complete sentences, explanations of the steps they use to solve problems. At first, this was very difficult because it is a different approach to that normally used in a math class. But, as the years have gone by, both teachers and students are finding that it is very helpful. When you ask students to explain their answers, you are really forcing them to think things through. Otherwise, we often find that students are good at what they are doing, but that there is fuzzy thinking behind their actions. By having them write things out, we can see the thinking behind what they are doing right away and can zero in on any weaknesses.

Sticking to scale

Danielle Clermont
Marlborough Elementary School
Burnaby, British Columbia

Danielle Clermont

Danielle Clermont has made extraordinary efforts to ensure that her students at Marlborough Elementary School in Burnaby, British Columbia, get hands-on experience putting scientific principles to work. Her Grade 4 classes regularly carry out such activities as building and launching rockets and comparing the density of bones from different animals. These activities occur as part of several integrated units, such as the one described here, that bring sciences, language arts and other subjects together.

Danielle Clermont has long used integration of subjects as a way to get students interested in science. In the past few years, she has been putting that experience to good use by creating complete classroom programs. She also led a team of 12 teachers working under her leadership to put together a series of study units for the school board in Burnaby, British Columbia.

The exercise described is from a unit that Ms. Clermont developed for her own use and is a perfect example of how students can be inspired and can learn skills from several different areas of the curriculum. If you would like more information about the complete integrated program, please contact Danielle Clermont:

Marlborough Elementary School
6060 Marlborough Avenue
Burnaby, British Columbia
V5H 3L7

Tracing Leonardo's route to knowledge

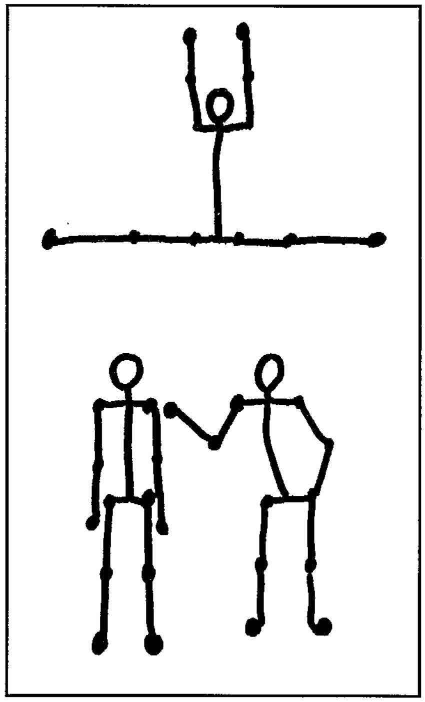
What I like about this activity — producing simple scale drawings of the human body — is that it pulls a number of topics together into a meaningful exercise. It is not the flashiest thing I do, but I am not sure that flashy is always the best way to go. This activity can be implemented in any classroom in Canada using commonly available materials, and it provides a solid foundation on which students can build their studies of the human body.

I have found that elementary school students are fascinated by the history of science. They really enjoy learning about how people in different eras have interpreted the world around them. One figure who really captures their imaginations is Leonardo da Vinci. They are very impressed by the way he understood and explained the world around him. With this activity, students get to retrace the great Leonardo's footsteps and move from observation to new knowledge.

Observation is something I stress in my classes. It is very easy for any of us to look at a situation and simply repeat something we learned by rote. Real observation is a process of looking and reasoning, and then explaining that reasoning to others. This activity requires the sort of active observation that leads to deeper understanding.

A good example of what I mean by this came up a few years ago during a discussion of an experiment that "proved" that hot air rises. In the experiment, a piece of paper is cut into a spiral shape and suspended over an electric light bulb. When the bulb is turned on, it heats the air, which rises and makes the spiral rotate. By itself, however, this experiment proves nothing about the behaviour of air. All it proves is that the spiral will rotate when held over an illuminated light bulb. A very interesting discussion ensues when you ask children what you could do to prove that it is actually the air that makes the paper move.

The central component of my drawing activity is to produce on paper scale representations of the human body in different positions. The drawings are very simple using just lines and dots, the lines representing body parts and the dots representing joints.



I begin by introducing some concepts related to the human body, such as the role of the skeleton and the need for joints if we are to move our body parts. We also talk about the similarities and differences between human bodies and those of other animals such as dogs and cats.

The first issue for the class to resolve before beginning to draw their bodies is the scale at which they will work. I explain the idea of scale to them briefly and point out only that their drawing must fit on an 11" x 17" sheet of paper.

The students then divide up into groups to collect the required data. They help each other measure their various body parts, work together to figure out where all their joints are and decide what scale they are going to use. During the discussions about scale, my role is to encourage the students to each contribute their ideas, and to ask them questions to get them going, if necessary, not to give them the answer.

After completing all the measurements of their bodies in varying positions, the students work out the corresponding numbers that will allow them to prepare the new drawing. Then, using a ruler, they draw the body parts (as lines) according to the scale they have determined. They have to observe closely, and decide together what positions they will draw and how they will realistically depict them.

To do this activity, the students need an 11" x 17" piece of paper on which to draw, another sheet of paper to record their data, a short ruler with centimetres marked on it, a metre stick, a pencil and eraser, and a calculator to work out the scale.

We follow up the actual drawing exercise with discussion. I like to impress on my students that the object of the exercise is not so much to finish a drawing as to learn as much as we can from it. Some of the things to learn include the following:

- that the human body needs joints in order to move
- how to write measurements with proper notation
- how to choose a scale
- how to draw scale models.

What is more, they have learned in a way that integrates this knowledge with other things, such as teamwork and the language skills required to explain their ideas.

All about caves

Danielle Umbriaco and Michel Goudreau
École St-Joachim
La Plaine, Quebec

Danielle **Umbriaco**
Michel **Goudreau**

Danielle Umbriaco and Michel Goudreau have set up a learning laboratory at École St-Joachim in La Plaine, Quebec. This new environment has helped build curiosity about science among the students, many of whom are not doing well in school generally, and teaches them how to use a wide variety of learning tools. Since the laboratory was set up, and activities such the cave exploration trip have taken place, interest in science has risen significantly among students at the school, and a number have gone on to take part in local science fairs.

Danielle Umbriaco and Michel Goudreau have set up a classroom the likes of which their students have never seen before. It is located on the second floor of a converted barn next to the main school building. In this new classroom, the two teachers have created an environment designed to fascinate and excite children. Every inch of the room is full of things to look at and use and the students are strongly encouraged to do so.

It is very appropriate that these students should leave the traditional classroom behind because they have not been well served by it. These are all students who, for different reasons, have not performed as well as they could have in school.

The strategy the two teachers have worked out to help these students is based on the integration of subjects. They find activities that fire the students' imaginations and build so much interest that they can act as a motor to drive explorations in several other areas. Science activities, such as the cave exploration outing described below, play a large role in their teaching.

Going underground

One of the things we look for in our activities is novelty. We want to introduce our students to things they are unlikely to have a chance to do otherwise. In addition, many of our students come from homes run by single parents. These parents, who are working to raise their children and to provide a roof to live under and food to eat, are unlikely to have the time or energy to do a lot of outdoor activities with their children.

The parents have been very enthusiastic and supportive of our efforts. They have eagerly helped with preparations and some have made themselves available to supervise on our trips. Some have also come along on activities such as a skiing expedition and on the cave trip because they were just as curious as their children were to try these new things.

The primary objective of the cave expedition is to serve as a launching pad for integrating a variety of subjects. That is why it is so important to make the activities exciting and new to the students. We want to develop enough curiosity to fuel their mental engines so that we can get them to cover the entire Grade 6 curriculum. Scientific expeditions are ideal for this purpose.

We introduce cave exploration in the context of a larger unit on earth sciences. The students are asked to brainstorm and come up with as many questions about caves as they can and to put down on paper everything they ever wanted to know about caves. Some examples of what they have come up with include the following: Is there air in caves? What does it sound like underground? Why are there caves? What are they made of? These were questions that they wondered about even without any outside direction or research. We next have them do some research on caves. This allows us to integrate reading skills into the activity.

We then have a speleologist (a scientist who studies caves) visit us and talk with the class. There is an association of speleologists in Quebec that is very eager to put teachers in touch with members who are, in turn, keen to spread the gospel about underground exploration. Other provinces may have similar organizations. This scientist talks with the students about how speleology is done. He discusses the safety issues and the scientific work involved.

Following the visit, the students are asked to duplicate the equipment and procedures he had discussed with them. They assemble outfits — these are made up of a hockey, bicycle or construction helmet with a flashlight taped to it, old raincoats, rubber boots and a notebook and pencil to record results. Speleologists work so that there is always a safety team on the surface that is ready to initiate emergency procedures; the students are asked to set up similar teams and to train to be ready for emergencies.

The provincial association of speleologists has worked out a series of rules that all their members follow. These are rapidly becoming an international standard, which the class, after discussing and agreeing to them, follows. Many of these regulations concern safety, but others govern how scientists should operate underground. For example, as real speleologists, we do not take anything out of the caves we visit.

On the way to the caves, which are located in Crabtree, Quebec, we incorporate some other activities, such as studying trees and a discussion about a river.

Underground, we do a variety of experiments such as exploring the behaviour of sound, determining the presence of oxygen and recording the temperature. The students also have their very first introduction to complete darkness.

This expedition serves as a beginning for a whole month's activities. For example, class discussion leads to the compass and from there we look at angles and geometry. Similarly, because the caves are a calcium formation, the students look at the crystal structures of calcium as compared to sugar and salt.

Scientific activities, as we have noted, are an ideal way to fire children's curiosity. Because our students have often had difficulties in school in the past, this is especially important. It is very helpful to allow them to do "real" things — to be real speleologists, real geologists, real scientists. We reinforce this by making no distinctions among the students. If we know a child has a learning disability or socialization problems, we still treat him or her exactly the same as the others. Every student in our class does work that is every bit as important as what every other student is doing.

The other really big advantage of science activities such as this is the rigour associated with them that students learn. The activities give us an opportunity to introduce the students to a methodology, an organized way of working.

The 1995 regional and local Prime Minister's Award recipients

The 1995 regional and local level recipients are listed here by province, along with a short write-up about them, their schools and communities. If you are interested in contacting one of these outstanding teachers, please call 1-800-268-6608 or send an E-mail to *pmawards@ic.gc.ca*

Yukon

Local recipient

Trevor Ratcliffe, the math and science curriculum leader at Riverdale Junior Secondary School in Whitehorse, doesn't just encourage his students to excel. He creates opportunities for them to do so. He organized the Yukon's largest science fair and urged Riverdale students to participate; some 275 students took up the challenge. He has also helped coordinate the Canada-Wide Science Fair, and Riverdale students have represented the territory in that fair for the past three years.

British Columbia

Regional recipients

Selwyn Lewis, the science department head at Vancouver Technical Secondary School, in Vancouver, disagreed that the students at his inner-city school could not meet high enough academic standards in physics. He insisted that standards should be raised, not lowered, and was proven right. More than 85 percent of students get credit for both Physics 11 and Principles of Technology, a course designed as an alternative to the traditional physics course.

Math teacher **James Nakamoto** is behind much of the success of Sir Winston Churchill Secondary School in Vancouver in math contests. It is the only public British Columbia school to win the Canadian mathematics competitions more than once — Pascal and Euclid (1989) and Fermat (1995). The school has also been named provincial champion of these competitions more often than any other public school. Mr. Nakamoto, who has been developing curricula for many years, also freely shares his expertise with other teachers.

Stephen Taylor wants to invoke a higher order of thinking skill in his mathematics students at J.N. Burnett Junior Secondary School in Richmond, British Columbia. Every week, he gives students a word problem that can be solved in several ways. This not only encourages students to approach problems from different angles, but also builds communication skills. Mr. Taylor's problem-solving approach has now permeated the school's entire mathematics department.

Peter Vogel set up a Grade 12 physics course and created a computer science program from scratch at Notre Dame Regional Secondary School in Vancouver. Along the way, he introduced students to new challenges such as a bridge-building contest, which has proven extremely popular and successful at the school. As a result of his enthusiasm, more than half of Mr. Vogel's Grade 12 physics students go on to careers in engineering or a related field.

Local recipients

Terry Bateman's students at Aldergrove Elementary School in Aldergrove, British Columbia, are quite a mix. Some are gifted, while others have learning disabilities. All of them enhance their learning with HyperCard, a multimedia software package. One project had groups of students use HyperCard in their study of different aspects of the Fraser River. In the process, students learned useful computer skills, as well as more traditional research, language and organizational skills.

A strong advocate of young women in pursuit of science careers, **Maria King** teaches Grade 5 students at Corpus Christi School in Vancouver. As the school year progresses, she watches children warm to science after field trips, guest speakers and hands-on experiments. These activities bring science into the classroom and within the real-life perspective of Ms. King's students.

Visitors to **Susan Kovach**'s class at Walnut Grove Secondary School in Langley, British Columbia, had better be prepared to duck. Ms. Kovach regularly resorts to throwing things, such as coloured balls, to demonstrate difficult-to-understand scientific concepts. She has carried this "learn science by doing science" approach into a wide variety of areas, including having her class adopt a nearby stream and work to return it to a state such that salmon will begin using it again for spawning.

A former student clearly remembers **Zaitun Mahedi**'s science classes at Crofton House School in Vancouver. She describes "ravenous faces eager to absorb more fascinating knowledge." Ms. Mahedi has a knack for making science, and in particular biology, relevant to her classes. One lab has students draw the face of their own future babies by comparing their own phenotypes and genotypes to those of ideal future husbands.

Daniel Major's students at West Bench Elementary School in Penticton, British Columbia, use computers daily for assignments in language arts, science, math and social studies. On Tuesday and Thursday evenings, in a drop-in program Mr. Major founded, students share their knowledge with their parents in the school's computer lab. Mr. Major, who is the school's computer co-ordinator and a Grade 5 teacher, has received district, provincial and national awards for his work.

For three days each year, **Philip Mendez**'s students at Cariboo Hill Secondary School in Burnaby, British Columbia, live and breath calculus at his home. Billed as a "retreat," this concentrated study session helps students prepare for their Advanced Placement exam. It works, too. Mr. Mendez's students regularly score better on the tests than the provincial average. His approach has spread to Advanced Placement programs in chemistry, biology and physics at the school.

The girls at Ballenas Secondary School in Parksville, British Columbia, where **Laurie Mitchell** teaches, are doing better in science and mathematics than are the boys. Ms. Mitchell gets girls involved in such projects as the Ms. Infinity Conference, which brings together girls in grades 8 through 10 to promote careers in math, science and technology and the Girls in Science program, which gives girls ages 9 to 12 a hands-on technology learning experience.

When **Holly Turner** realized that students at Lillooet Secondary School in Lillooet, British Columbia, were not getting enough lab time, she created a new course to ensure they did. Ms. Turner has long worked to ensure that all her students get the support they need to succeed in mathematics, chemistry and in a Forestry and Fisheries Career Preparation program offered at the school.

Alberta

Regional recipients

At Oilfields Junior/Senior High School in Black Diamond, Alberta, **Chris Hughes** and **Marion Florence** created several multimedia software programs that help students learn mathematics at their own pace. One of their programs, OHS STATISTICS, presents Grade 9 and 10 students with real-world problems. For example, after analyzing United Nations data, students are asked to decide which countries should receive financial assistance. The software guides the students through the basics, giving teachers time to answer difficult questions.

Stephen Jeans scrounged four computers for his Grade 7 and Grade 9 science classes at St. Stephen Elementary and Junior High School in Calgary, and 11 more that he found are shared among students and teachers. Mr. Jeans believes that a computer offers the motion and colour to make abstract scientific concepts easier to view and manipulate. Computers can, for example, explain the universal theory of gravitation in a fraction of the time it takes to explain it using a traditional medium such as a chalkboard.

Local recipients

Margaret Dart's students at Dr. Elliott Community School in Linden, Alberta, don't study in a vacuum. They learn how science and technology relate to their village of 400 people and to the larger world. Ms. Dart teaches career and technology courses, as well as science and computer science at the school. In one of her innovative programs, "Bridging the Gap," Grade 8 students help adults who have no computer experience to learn basic computer skills.

In Strathmore, Alberta, principal **Douglas Erickson** takes his students at Brentwood School birdwatching. Back at the school, Grade 4 students become "creature keepers," as they tend to the animals who make their home in Mr. Erickson's classroom. These are just two examples of Mr. Erickson's hands-on approach to teaching, which was a large part of Brentwood's response to the provincial government's new science curriculum.

Saskatchewan

Local recipient

Leo Carteri's students at "33" Central School in Fillmore, Saskatchewan, have made quite a splash at the Canada-Wide Science Fair. Rarely does a year go by when students from this small school don't take home at least one prize. Mr. Carteri believes that competitions like these not only widen a student's academic horizons, but also expose them to the corporate world through business sponsorships.

Manitoba

Regional recipient

Mark Blieske brought the Internet to Selkirk, Manitoba. The Selkirk Junior High School technology education department head proved that the Internet and multimedia can be exactly the tools poorly performing students need. Yet Mr. Blieske has also shown a sensitivity to the human side of technology. He has resisted other job offers because he believes that tomorrow's competitive workplace will depend on the resources spent and the effort made for students at the junior high school level.

Local recipients

In November 1994, **Judith Hattie**'s students at Edward Schreyer School in Beausejour, Manitoba, had a chance to talk to some of Canada's astronauts. The students, all members of ASK, the Agassiz Science Klub, had come to Ottawa, where they also visited a space science lab and the Museum of Science and Technology. Ms. Hattie formed ASK 10 years ago to give her students a year-round science activity beyond occasional science fairs.

At Virden Junior High School in Virden, Manitoba, **Ron Kalinchuk** teaches a class that combines the creativity of art and the technology of computers. Ten years ago, Mr. Kalinchuk was at the forefront of computerizing the classroom and introduced his students to TRS-80s and Commodore 64s. As the computers grew more powerful, Mr. Kalinchuk organized a curriculum that covered a wide range of computer skills. Today, he uses multimedia extensively in the classroom.

Stephen Khan has been a very effective role model and mentor for the students at St. Norbert Collegiate in St. Norbert, Manitoba, who come from a wide variety of racial and socio-economic backgrounds. He shows students advanced problem-solving techniques and demonstrates how mathematical concepts are linked to other areas such as physics, chemistry and general science. More than two thirds of his Grade 12 students go on to pursue mathematics, engineering or computer sciences at university.

Ronald Mihaychuk has set up programs to help everyone at John de Graff Elementary School in Winnipeg — from kindergarten students to senior staff — use computers with confidence. In one of his many successful programs, he co-ordinated efforts to set up a weather station on the school's roof. Grade 6 students use computers to get readings and then use this information to do a weekly weather synopsis for a local TV station.

The students at Cecil Rhodes School in Winnipeg who work on computers several times a week can thank **Bruce Young**, the school's computer coordinator and Grade 8 science teacher, whose efforts make it possible. One popular project is the school's World Wide Web home page. Mr. Young motivated students by explaining that people around the world would be able to read their work. The students were thrilled to discover that students in South Africa had enjoyed the Cecil Rhodes home page.

Ontario

Regional recipients

Raymond Bowers is a godsend to students at Bathurst Heights Secondary School in North York, Ontario, who are at risk of dropping out or who speak English as a second language. To teach these students, Mr. Bowers uses graphics and other visuals to make his points. As a result, students with special needs learn more and stay in school longer. Mr. Bowers has been sharing the secrets of his success at workshops. He was such a hit at the 1994 Science Teachers of Ontario Conference that he was asked to come back in 1995.

Pearl Bradd is sometimes called a "Pearl of Wisdom" at Riverside Secondary School in Windsor, Ontario, advocating as she does for her students, science and the environment. Her concerns are reflected in projects such as one in which students measure ultraviolet (UV) radiation behind the school. The results are noted on a poster that is updated daily. Students also prepared an information kit on UV radiation. It is this kind of dedication that won Ms. Bradd the Roberta Bondar Award for Educational Achievement in Science and Technology.

A huge banner in **Katie Branovacki**'s classroom at Forster Secondary School in Windsor, Ontario, says "Mathematics is enjoyed here." And her students do enjoy math. So much so that many willingly put in extra time to tutor younger students. Students who graduated in previous years sometimes return to help as well. Adult and junior students alike spend their lunch hours working to improve their math skills — all under Ms. Branovacki's supervision.

Allan Burston's mentorship program at Downsview Secondary School in North York, Ontario, has sparked enthusiasm for science among both secondary and elementary school students. Grade 12 and OAC students prepare labs for Grade 4 and 5 students. The younger students get excited about science by watching metals react violently with water and by learning to use microscopes. High school students increase their understanding of scientific concepts by researching and explaining them.

Diane Gervais has had a significant impact on elementary and secondary students and their teachers in northern Ontario from her home base at École secondaire MacDonald-Cartier in Sudbury, Ontario. As a mathematics, science and technology consultant for the Ontario Ministry of Education, she has developed a new science program for elementary students, integrated science, mathematics and technology into other subject areas, and created extra-curricular activities for students interested in science.

Walter Howard, the recently retired head of mathematics at Jarvis Collegiate Institute in Toronto, didn't want his students to fail at university. So he decided to give them university-level challenges in high school. The result was Jarvis' "double math" and "triple math" programs, which integrate two or three OAC-level mathematics courses into one class. Students take rigorous exams, and Mr. Howard helps them develop strong study habits. As a result, many go on to excel in mathematics at university.

Raymond Letheren assigns projects to his technology students at W.A. Porter Collegiate Institute in Scarborough, Ontario, that reflect his wide-ranging education: he has degrees and credentials in design, art history and philosophy. Assignments have included building a scale model of a medieval cathedral and designing a futuristic mass transportation system. These projects show students how to find and use knowledge from various disciplines, such as architecture, philosophy and environmental studies.

Robert McLeish's impact as a teacher extends far beyond the doors of J.S. Woodsworth Secondary School in Ottawa. Mr. McLeish is one of the main authors of an "Exemplar Booklet" that has ensured that Grade 10 standards are applied uniformly throughout the local school board and that all students are subject to the same set of expectations. His hard work in these and other areas, such as planning the first Ontario Mathematics Olympics, has made him universally respected by faculty and students.

Every Christmas, **Roberta Messinger**'s Grade 10 chemistry students at St. Matthew High School in Orleans, Ontario, experiment with the partial degradation of mixed polysaccharides with protein inclusions. The students simply call it the peanut brittle experiment. Another popular event is the crystal growing championship put on by the Chemical Institute of Canada, in which schools compete to grow the largest crystal. As Ms. Messinger says, "Students can only learn science from doing science."

Dalia Naujokaitis has pioneered the use of computers, interactive media and the Internet for effective learning within the Ottawa Roman Catholic Separate School Board, for which she is a special assignment teacher for gifted students. Students from 21 schools are bused to Ottawa's St. Elizabeth School, which is Ms. Naujokaitis' home base. Once there, they are introduced to her discovery-based teaching program that integrates science, mathematics, creative problem-solving, database management and Internet communications.

Alphonse Orlando, the head of the science department at St. Joseph-Scollard Hall in North Bay, Ontario, often finds physics problems for his classes in the movies. For example, Indiana Jones hopes to avoid setting off a trap by replacing a gold idol with a bag of sand of equal volume. As Mr. Orlando explains, "Which is more dense: sand, gold or Indiana Jones?" For another program, Mr. Orlando used a video camera and VCR to create Phreeze Phrame Fisix, in which freeze-frame video footage helps illustrate physics principles.

Daniel Thorsley, the science and technology co-ordinator at the G.A. Wheable Centre for Adult Education, is part of the team that is bringing the Canada-Wide Science Fair to London, Ontario this year. Mr. Thorsley has been meeting with potential sponsors and producing a newsletter called *Science 2000*, to raise awareness of science and technology in the London area. He also designed a computer program that shows how a lens works, and another for students to test the upper limits of their own hearing.

Robert Watt, of Centennial Public School in Ottawa, believes that technology should fit the student rather than the other way around. And he's not afraid to ask for corporate help to get the tools he needs. For example, one of his students had a serious speech impediment. Mr. Watt found multimedia that could help with therapy, and the student's speech and language skills soon began to improve dramatically. The communication disorder also became less of a barrier to the child's education.

As a Grade 2 and 3 teacher at Bala Avenue Community School in York, Ontario, **Geoffrey Winship** regularly used the skills he picked up while working as a demonstrator at the Ontario Science Centre. His students learned fractions by doing Japanese paper folding; discovered problem-solving through chess; and studied astronomy during stargazing evenings. And, at Mr. Winship's invitation, 30 adults visited the school to explain how they use science in their jobs. Mr. Winship now teaches Grade 4 at Fairbank Memorial School.

Charles Wolfe set up a program that allows students at Collège catholique Samuel-Genest in Ottawa, Ontario, to concentrate their efforts in the sciences throughout high school. He draws students in by focusing on their science and technology-related interests and then provides them with progressively more challenging subject matter each year from Grade 9 to Grade 12. Mr. Wolfe previously won the Roberta Bondar Award for Educational Achievement in Science and Technology.

Local recipients

Jacqueline Aird knows an assignment is working well when her students at Green Acres Public School in Stoney Creek, Ontario, not only master the knowledge being taught, but apply new knowledge to the activity at hand. The students had to create paper boats that could float on water. While decorating the boats, some students realized that the crayon could keep water from soaking into the paper. These boats could not only float in a sink, but could survive a trip down a creek.

A typical scene in **Norbert Axtmann**'s drafting class at Acton High School in Acton, Ontario, looks like this: two students are building a bicycle out of recycled parts; two other students are creating a 3-D computer simulation of long-gone Acton buildings; and another student is doing an interior design for a townhouse. Thanks in part to computer-aided drafting, Mr. Axtmann has generated a real fire for learning in his drafting students.

Deborah Brown makes every day an educational adventure for her students at Power Glen Public School in St. Catharines, Ontario, by integrating sciences into other classroom activities. For example, she uses literature as a focus to develop and enhance students' understanding and enjoyment of science, math and technology. She also uses it to show students the role both male and female scientists play in our society.

Carol Browne, a teacher at Metcalfe Central School in Strathroy, Ontario, believes that teachers should stop fighting trolls and embrace them. While it is true that children in Grade 1 don't need to know anything about trolls, says Ms. Browne, their strong interest in these imaginary animals is a great way to draw them into other subject areas. Using a variety of hooks such as this, she has been able to make her students more aware of their natural environment and of the importance of science.

Inge Buchardt has created a natural-balance environmental garden at Kawartha Heights Public School in Peterborough, Ontario. The project has led to learning opportunities for the students in many science-related fields. Both students and teachers have learned about designing and laying out a garden, environmental issues, planting trees, flowers and shrubbery and bridge-building.

Alfred Chan's Mentorship Program for the Toronto Board of Education is helping the University of Toronto Faculty of Medicine increase the number of students in Health Sciences who are of aboriginal or black ancestry. Practising physicians act as mentors for targetted students and encourage them to pursue medical careers. All of the participating students thus far have stayed in school, and some went on to university, including a few who could not before have imagined even finishing high school.

After spending 25 years as a secondary-level mathematics teacher, **Nick Christian** turned his efforts towards younger students at Bloordale Middle School in Etobicoke, Ontario. By initiating math projects, contests and clubs, and a Family Math program, he developed a high level of excitement among his students. He has proved that it is possible to show students how powerful and exciting mathematics is rather than to just tell them how important it is.

A few years ago, **William Crane** of Westmount Public School in Peterborough, Ontario, began puzzling about why students who did very well in some subjects could not maintain that level of achievement in other courses. Today, his students have the benefit of the work he has done to develop a mathematics program that can be individualized to meet each student's needs. Mr. Crane's approach makes room for students who learn at different rates and have different knowledge bases.

In Brampton, Ontario, teams of **Terry Da Silva**'s students at Turner Fenton Secondary School form "companies" and find clients for whom they produce a range of stationery. Through these companies, Mr. Da Silva, a communication technology teacher, shows his students the real-world relevance of their studies. Their clients include the Canadian Red Cross Society, the Junior World Figure Skating Championships and the Lions Club, all of whom benefit from student enthusiasm that goes well beyond the classroom.

Maurice Di Giuseppe played a key role in developing and implementing a high-quality, self-paced program in sciences at Mary Ward Catholic Secondary School in Scarborough, Ontario. He worked on the physical design of the school, wrote the curriculum and developed a laboratory program. The school's new science area is today a hub of activity with students doing research, working on problems, coaching peers and performing hands-on work in the lab.

In 1995, science teacher **Kerry Dupuis**' students at Sacred Heart Catholic High School in Newmarket, Ontario, were excited when they observed brook trout in a local stream for the first time. Since 1990, successive classes of Mr. Dupuis' students have worked to rehabilitate what was once a barren stream. They raise brook trout for release into the stream, plant trees and shrubs, and construct water deflectors to make the stream more hospitable to fish.

Over the past 16 years, **John Eix** has inspired hundreds of students at Upper Canada College in Toronto with his enthusiasm for chemistry and computer science. He combines a passion for his subject matter with humour. He has brought a wide variety of expert speakers to the school and has introduced new activities, such as a desktop publishing program.

Bradshaw Elliott has shown his students at Orchard Park Secondary School in Stoney Creek, Ontario, the value of technology by having them build things they can see are worthwhile. Over the years, his students have built buildings for a residential centre for adults with disabilities, a residence for immigrant fruit pickers on the Niagara peninsula, a kiosk for service clubs at a local mall and many similar projects.

When **Gary Forsyth** came to The Dr. G.W. Williams Secondary School in Aurora, Ontario, two departments shared 43 computers and a file server. Mr. Forsyth changed that. Today, 11 departments share 145 computers, 5 file servers, a CD-ROM tower, a MIDI lab for music, 3 laser printers, 2 scanners and an Internet connection. This computer science department head has tirelessly integrated computers into all aspects of the school's general curriculum.

Holly Garrett's special education students at Parkdale Public School in Hamilton, Ontario, pick over the ruins of Mayan civilization in Belize and see volcanoes explode on Jupiter's moon Io without ever leaving the classroom. With the help of satellites, Ms. Garrett takes her students live to these far-flung places. By working with the JASON Project, Ms. Garrett's students have shown remarkable development in their reading and mathematical skills, and are learning far more about geography and science than they would otherwise.

Kevin Graham teaches technical theatre at Stamford Collegiate in Niagara Falls, near the annual Shaw Festival. His courses integrate video production, design technology, photography and graphics. Mr. Graham also played a key role in creating his school's Barbara Frum Communications Centre. This centre's unique approach to video, theatre, film and other aspects of the dramatic arts has attracted the attention of technical teachers throughout the province.

The parent of one of **Janet Gravlev**'s students at Merwin Greer School in Cobourg, Ontario, was shocked by the words coming out of her son's mouth. The Grade 1 student was talking about planes and levers, gears and wedges. This precociousness is entirely the result of Ms. Gravlev's efforts. She believes that children are "like sponges, just waiting to soak up whatever is offered to them." Unfortunately, children are also offered television violence, so Gravlev encourages "No TV" weeks in her students' homes.

Diane Hammond teaches at Cameron Street Public School in Collingwood, Ontario; **Marjan Glavac** at Bonaventure Meadows Public School in London, Ontario; and **James Robertson** at Ingersoll District Collegiate Institute in Ingersoll, Ontario. But thanks to the Internet, three teachers in three different locations, and their classes, are able to work together on such projects as NewsOntario, through which students create their own Internet newspaper. Their students are also able to work with new friends from all over the world. Classes have participated by E-mail in an Arctic expedition, sent messages to world leaders gathered in Denmark and worked with a California author.

Sherry-Lynne Kirschner spent part of her own honeymoon at NASA's Kennedy Space Centre collecting videos and information for her Grade 7 and 8 science classes at Arthur Stringer Public School in London, Ontario. Ms. Kirschner's students return this dedication in an annual mock trial of Dr. Seuss' Onceler, who cuts down Truffula Trees. Students imaginatively defend or prosecute the Onceler, often to the beat of rap music, or while dressed in a lawyer's robe and wig.

By tirelessly organizing and judging science fairs, and helping his students compete successfully, **Victor Kuisma**, of Ernestown Secondary School in Odessa, Ontario, has earned the respect of students and colleagues alike. Mr. Kuisma has taught science at the school since 1967. In that time, the students have consistently shone at science fairs. In 1995 alone, Ernestown students collected 19 awards at the Kingston District Science Fair — a brilliant showing for a school with only 700 students.

This isn't how shop class used to be. Students in **Nick Lacoppola**'s automotive technology class at Marian Academy in Rexdale, Ontario, have been converting two gas-powered cars to electrical power. The students are designing and building their own parts. Mr. Lacoppola has spent hours talking to engineers and industry leaders getting advice and support. The school sent a car to the 1995 APS-500 electric car race, and the students were featured in a video on how to build an electric car.

Vincent Macdonald met **Thomas Cox** in London, Ontario, where the pair teach mathematics and science. Together, they have worked on a variety of technology-based projects for the London and Middlesex County Roman Catholic School Board. For example, they integrated design technology into the math and science curricula and made sure that technologically based material addressed gender equity. The pair also helped students use telecommunications technology. Students talked with First Nations schools through the Kids From Kanata Network and Mr. MacDonald and Mr. Cox arranged a live videoconference in which Canadian and British students discussed the environment.

John MacLeod has used the interest of his students at Gananoque Secondary School in Gananoque, Ontario, in meteorology to introduce them to high technology. The school operates its own rooftop weather station and students have recently begun downloading information from satellites to analyze on one of the school's computers. His students are learning how technology fits into the curriculum and are getting a better understanding of the natural environment.

Lauriston Maloney works hard to make sure that students at Thistledown Collegiate Institute in Rexdale, Ontario, can get technology to work for them. He shows students at this multicultural inner-city school how to use technology to make things happen. As the school's technical director, he has introduced and maintained programs on television production, food preparation, photography, computer-based graphic arts, cosmetology and transportation technology.

Ronald Mayeda moves through the halls of William Lyon Mackenzie Collegiate Institute in North York, Ontario, followed by a cloud of eager math students raining fractal questions down on him. Mr. Mayeda introduces fractal geometry as early as Grade 10, and his enthusiasm for the subject is infectious. One particular tool Mr. Mayeda likes to use to teach geometry is Geometer's Sketch Pad, a computer program that uses geometric principles to create illustrations.

Dean Murray's students at Milton District High School in Milton, Ontario, wait years for him to spring the legendary Pub Question on them. A man is on a shore, and he wants to go to a pub on an island. To get there, he (and the students) must use difficult mathematical concepts such as derivatives. Mr. Murray rewards the efforts of his students to solve these hard problems with the kind of recognition normally reserved for school athletes. Winners of math contests are now congratulated in the halls by their peers.

Susanne Quan, a Grade 4 teacher at Woodland Heights Public School in London, Ontario, teaches math holistically. She uses daily planners to involve students and parents in education. The planners are part of Woodland Winning Ways, which encourages excellence at the school. Another such tool is the Family Math program, in which a student, together with her or his family and teacher, applies mathematics to everyday living. The family might track their own heart rates, for example.

Sheila Ryan has shown her Grade 4 students at Our Lady of Sorrows Separate School in Petawawa, Ontario, that there's more than one way to eat spaghetti. Students created implements to eat spaghetti as part of a science unit on invention. In other projects, Grade 1 and 2 students designed boats to learn about floatation, and Grade 6 and 7 students took part in a cryogenics demonstration presented by nuclear physicists from nearby Atomic Energy of Canada Limited.

As head of science at Fellowes High School in Pembroke, Ontario, **Paul St. Louis** looks for ways to motivate his students. His methods must be working: his students regularly place well in national contests and go on to study sciences at university. Mr. St. Louis emphasizes the industrial and entrepreneurial relevance of each concept he teaches. He also makes a point of assigning female teachers to each grade so female students have a role model and will consider pursuing careers in science.

Marilyn Spearin of Jarvis Collegiate Institute in Toronto has developed a special Grade 9 program to help recent immigrants quickly adapt to their new environment so they can begin to succeed in their science studies. She teaches students who are still learning English and adjusting to the culture of their new country how they can develop the necessary skills to keep up with other students in their classes. Ms. Spearin's explanations are clear and concise, and she uses plenty of demonstrations.

Wayne Stewart of Howick Central Public School in Gorrie, Ontario, has spent the last 16 years developing innovative ways to teach science. He has creatively integrated science and technology themes into other subject matter in the Kindergarten to Grade 6 curriculum. Over the years, he has also planned special activities on such subjects as pendulums, water, snow, dandelions and ponds.

Few of **Siria Szkurhan**'s chemistry students at Saint Mary's Secondary Catholic School in Hamilton, Ontario, get grades lower than 50 percent when spurred on by her efforts to help them improve. In fact, chemistry classes taught by Ms. Szkurhan have produced some of Ontario's top university students. Many of these students are happy to come back to the school to serve as role models. Ms. Szkurhan also links her students with professors, who demonstrate how to use equipment not found in high school labs.

Caroline Toffolo, has designed innovative activities for students at Park Elementary School in Grimsby, Ontario, that integrate math, science, technology and other disciplines. In Up, Up and Away, for example, students build hot air balloons and kites. In Caring Enough to Make a Difference, they create Christmas wreaths. She even devised "science sacks" that include lab materials and instructions, which students take home and work on with their parents.

Larry Tracey has been very successful at motivating students, especially girls, at The Elms Junior Middle School in Etobicoke, Ontario, to tackle mathematics with enthusiasm. He has used a wide variety of tools, including music and dance, to teach mathematics, and has encouraged his students to take part in mathematics competitions and science fairs. The success of his female students at these activities has attracted considerable attention from the local press.

Paul Weese led the process to implement the province's new Common Curriculum at Lambton-Kent Composite School in Dresden, Ontario. He did this by developing a seven-unit course on mathematics, science and technology that is taught by the same teacher. Each unit has a Design and Build activity, a theme that runs through all seven units, which sees students create technological items such as terraria, solar ovens and periscopes.

Harold Wright's dedication to his students at Oakwood Collegiate Institute in Toronto has resulted in at least one dedication from a student. In 1994, an alumna dedicated her chemistry PhD thesis to him. Mr. Wright, head of Oakwood's biology and chemistry programs, teaches with an entertainer's flair. He once hosted a TVOntario series on science. Each year, he treats his students to his skit, "The Sermon on the Mole," which he performs in costume as the "Bishop of Chem."

Quebec

Regional recipients

Students in **Yvon Lapointe**'s Secondary 5 (Grade 11) physics classes at Polyvalente Sainte-Thérèse in Sainte-Thérèse, Quebec, are expected to learn the qualitative aspects of science as well and the quantitative ones. Students can become very good at problem-solving, Mr. Lapointe explains, without ever really grasping the concepts behind the physics they are using. To remedy this, the students often participate in practical demonstrations that show the relationship between the numbers on the textbook page and reality.

Claude Ménard was the right man for the job when École secondaire Joseph-Charbonneau, a Montreal school for students ages 13 to 21 with multiple disabilities, needed a new laboratory. For 15 years now, thanks to Mr. Ménard's efforts, the Montreal school has been able to deliver a full lab program in physics, biology, chemistry and other subjects to its students whose movements are limited by disabilities such as muscular dystrophy, spina bifida and paralysis.

Suzanne Turcotte of École polyvalente de l'Érablière in Gatineau, Quebec, has been a resource person for science students and teachers throughout the local school board. She conveys her love and enthusiasm for science to all she helps. Over the years, she has led her school's science club and supervised many science fair projects, including those on subjects as varied as medicine and nuclear science, space garbage, microwave technology and nutrition.

Local recipients

Solange Bouthillier of École Pierre-Dupuy in Montreal, has spent her entire career inspiring students in their final two years of high school to appreciate the beauty and power of mathematics. Former students say she was a kind but exacting taskmaster who constantly challenged them. Students who struggled with mathematics also praise her for never giving up on them, even when they were ready to give up on themselves.

Colleen Carter, a biology teacher at Richelieu Valley Regional High School in McMasterville, Quebec, persuaded Jane Goodall to come to town to speak about her work with chimpanzees. Ms. Goodall came to the school because she was impressed with its ecological activities. Ms. Carter organized an ecological centre so students can plant trees, study pollination, monitor ultraviolet radiation and track the progress of the zebra mussel up the nearby Richelieu River. Her class even sponsored six whales.

At St. George's School of Montreal, **Heather Friesen**'s biology classes don't exist in isolation from other science classes, from the rest of the school or from real life. Ms. Friesen uses the University of Alabama's integrated science program for students in grades 7 through 9. Students learn the physics, chemistry and biology related to each topic in the same course. Ms. Friesen also helps students publish research in the school's own scientific journal.

Experiments in **Thérèse Huang Kinsley**'s chemistry classes at Centennial Academy in Montreal are a little different from most. She works on a smaller scale, assigning experiments that are equipment-friendly, environment-friendly and student-friendly. Students are less worried about experimenting on plastic than on glass, for example. Ms. Huang Kinsley's activities are meant to be as simple and as applicable to a student's everyday life as possible.

Céline Paradis teaches her students at Polyvalente Jean-Dolbeau in Dolbeau, Quebec, not only the course content, but also how to approach a subject. She began using this technique when she noticed that students were having difficulty dealing with a new physics curriculum. Her approach helped students identify basic concepts so that they could tackle the material in a more organized way. Having proven her concept, Ms. Paradis has since gone on to write a textbook that can be used by students elsewhere.

New Brunswick

Local recipients

After Lorne Junior High School in Saint John, New Brunswick, burned down in 1981, **Robert Matthews** insisted that a full science lab be included in the renovations to the building. The department head for mathematics and science, Mr. Matthews continues to champion mathematics in his new classes. Part of his approach is to make his science class a math class, an English class and a life lesson all at once. For example, by balancing chemical equations, students appreciate the connection between chemistry and mathematics.

Anne Spinney, the mathematics department head at Moncton High School in Moncton, New Brunswick, has had a significant impact on the province's mathematics curriculum. Ms. Spinney was either the major author of, or collaborated on, four key documents about the high school mathematics curriculum. She has frequently led in-service sessions for teachers on those documents. Ms. Spinney is also an accomplished teacher, and knows how to find the tools that focus her students' learning.

Nova Scotia

Regional recipients

Greg De La Lis' Grade 11 and 12 chemistry and physics students at J.L. Ilsley High School in Halifax not only stay after class, they're willing to stay there for 12 hours at a stretch. Mr. De La Lis organized a marathon class to raise money for the World Wildlife Rainforest Fund. With the help of local entertainers, scientists and community members, the school managed to raise $4200. This environmentalism also extends to his classes' efforts to rejuvenate Halifax's MacIntosh Run, a river near the school.

Peter MacDonald, a chemistry teacher and the science department co-ordinator at Charles P. Allen High School in Bedford, Nova Scotia, sees his subject as a chance to improve students' critical thinking skills, since chemistry focuses on the scientific method of investigation. Mr. MacDonald tries to teach his Grade 11 and Grade 12 students not simply the rules of chemistry, but also the process whereby chemical knowledge is discovered. One way he does this is by having students track recent scientific issues in the press.

Newfoundland

Regional recipient

Allan Neil has consistently helped advanced math students at Bishops College in St. John's, Newfoundland, to fulfill their potential. Math teams coached by Mr. Neil have shown that Newfoundland can compete with the best schools from the rest of Canada: from 1991 to 1994, Bishops College was the provincial champion in the Grade 12 Euclid mathematics contest. This repeated success has resulted in the school being named to the Canadian Honours List of Mathematics.

Local recipients

Under the coaching of **Ruth Mercer**, students at Ascension Collegiate in Bay Roberts, Newfoundland, are becoming mathematical champions. Soon after being appointed head of the mathematics department in 1990, Ms. Mercer set up an accelerated program that allows students to complete three years of mathematics courses in two years. An enthusiasm for mathematics now pervades the whole school. Ascension students have placed first in the province in several competitions.

Science and technology teacher **Cyril O'Reilly** and his Grade 7 and Grade 8 students at St. Edward's Elementary School have made Placentia, Newfoundland, a cleaner place. Since 1990, Mr. O'Reilly has gotten the school, and the community as a whole, behind a variety of recycling programs. A "Trashathon" in 1993, for example, taught students about the town's litter problems. This enthusiasm helped St. Edward's win the Provincial Youth Environmentalism Award in 1994-95.

Brenda Stamp's mathematics students at Gonzaga Regional High School in St. John's, Newfoundland, call her Mom as she guides them in their studies. A trend-setter in computerizing the classroom, Ms. Stamp introduced her school's first Advanced Placement mathematics course. Ms. Stamp also single-handedly wrote the mathematics component of a special Grade 9 curriculum for students who lack literacy and numeracy skills.

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