Submission of Articles

The *Ontario Mathematics Gazette (OMG)* is looking for articles, news and "good ideas" useful to mathematics teachers or mathematics teacher education. We are seeking submissions from mathematics teachers K-12 and tertiary, that describe teaching mathematics content in an innovative way.

The criteria for manuscript submission to the *OMG* includes the following:

- The ideas/activities are of interest to the readership
- The article/ideas are not widely known or practised and are innovative.
- The mathematics content is appropriate for the readership.
- The mathematics content is accurate.
- The article is well written and grammatically correct.
- The article/ideas are free of sexual, ethnic, racial and other bias.
- The article has not been published previously, nor is out for review by other publications.

Articles must be original. Your article must be word processed, preferably using *MS WORD*, double spaced on one side with wide margins, not exceeding 10 numbered pages of text and prepared according to the *Publication Manual of the American Psychological Association Fifth Edition*. Diagrams and figures should be drawn by computer if possible or neatly drawn in black ink in camera-ready form. Embedded images should also be submitted separately in jpeg or tif format. Proof of the photographers' permission is required. For photos of students, parent or guardian permission is required.

You must submit **4 hard copies** of your article to the Editor **Marilyn Hurrell** whose address appears on page 2. Your name may not appear anywhere in your article, including websites. Your name and full mailing address and e-mail address must be included on a separate sheet. Your article will be sent out for blind review. If it is accepted as is, or with major/minor revisions or rejected, you will be notified. Once an article is accepted for publication, computer files of text, original graphics and photos will be required. E-mail submissions are welcome but must be followed by hard copies.

The Editor reserves the right to edit manuscripts before they are published. Once an article is published it becomes the property of OAME.

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The views expressed or implied in this publication, unless otherwise noted, should not be interpreted as official positions of OAME.

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▲ About the *Ontario Mathematics Gazette*

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Submission of Advertisements

Advertisements for the *Ontario Mathematics Gazette* should be sent to **Dean A. Murray** at the above address. Courier is recommended to avoid possible delays. Deadlines for advertisements are January 23 for the March issue, April 1 for the June issue, July 1 for the September issue, and October 1 for the December issue.

Full page advertisements are to be on 8.5" by 11" paper with a minimum of 0.5" margins and single sided. Each advertisement should be camera-ready and colour advertisements should have no bleeds.

Advertising Rates

Advertising Rates are available by telephoning, e-mailing, or writing to the Advertising Manager.

▲ Editor's Message

MARILYN HURRELL, EDITOR



It is a new year, 2006, and we have a new government. Perhaps these events have made me reflective. I was a secondary in-class teacher for 30 years from 1968 - 1998 with a three year secondment as coordinator of a MST program for grades 10 - 12 at Lakehead University. I mention all this because I never had a connection to elementary mathematics and only a vague notion of what went on in grades 7 and 8. Even though I have been Editor of the *OMG* for 3 years now and have read over excellent columns and articles written for elementary teachers, again I never really appreciated the content. All this has changed in the past five months as I took on a post at the university, teaching a refresher course in math for students who needed a math credit to enter the university's Faculty of Education, but were not comfortable with or did not have the background to take calculus. (Of course I can handle all this math, I thought. After all, it's only elementary.) Wrong. I spent the first while confounded by the methods I read of how young children were to be given different addition, subtraction, multiplication and division structures. Then it was on to manipulatives and geometry and spatial sense and tessellations and... (my granddaughter in grade 6 cleared up tessellations for me by saying "no overlaps, no gaps"). Not a word yet about angles having to form 360˚.

It was about this time that I was grabbing for my former *Gazettes* as I recalled some articles about such things. And I acquired a set of manipulatives that I had spurned 10 years before. My classes are now quite tolerant of me and unafraid of math which was a primary goal of this course. We happily learn together with a lot of guidance from the course creator, Ann Kajander, and our scissors, glue, fraction bars, etc. Perhaps my most embarrassing moment was in October when I completely fell apart trying to explain division of fractions using egg cartons and elastics and pennies. I was delighted with the President's message this issue which identifies this as a tough one. And now the *Abacus* is much more meaningful.

I guess what I want to impart to you is that knowing about and participating in the mathematics continuum from K- 12 is valuable and to that end, all the articles and columns of the *OMG* are good reading for all teachers, no matter what your grade level!

Spring is on its way. Marilyn

▲ Letter to Editor

Dear Editor,

In 2005 on the long May weekend we held the first McTic Competition at Huron University College in London.McTic stands for Math Challenge Team Invitational Competition, and the acronym is deliberately irreverent, as we intend the contest to be fun rather than serious. We had eight teams attending from Windsor, Waterloo and London, and a good time was had by all.

We are holding our second annual contest this year on Saturday 20th May, 2006. Teams should arrive for dinner on Friday 19th and will leave after breakfast on Sunday 21st.The cost will be $1000 for the team and coach, which includes all meals, snacks and accommodation for the two nights.

A team is nine elementary and high school students, and level of questions is high school. The contest is in five parts, modeled on the American Regions Mathematics League (ARML), but with the questions somewhat more approachable. The parts are the Power Question, to be answered by the team as a whole; the Team Section of ten questions with one answer for each question done by the team as a whole; the Individual section, with team members submitting answers to eight questions; three relay questions with three-person teams, and the Mental arithmetic section, with every member submitting answers to ten questions and in which calculators and rough work are not allowed, and five seconds is allowed for calculation.

If you have a team and would like to be invited this year, please contact Tom Griffiths at tgriffit@uwo.ca.

Tom Griffiths

▲ Upcoming Events

For further information on OAME Chapter Conferences contact the Chapter Representative and for NCTM conferences, contact John Kersely, OAME/NCTM Rep. See the last page in this *Gazette* for contact information.

Chapters now have websites that are linked to the OAME See these for full information on upcoming events.

OAME Chapter Conferences and Events

March 23 2006	Building Our Math Community 4 pm St. Basil-the-Great College	TEAMS
March 30 2006	Dinnerlude - 4 pm Windsor Catholic Education Centre	SWOAME
May 3 2006	Spring Miniconference - Brock University	GOLDEN
May 26/27 2006	OMO 2006 - U of T: Scarborough Campus	SAME

OAME Annual Conference

May 11 - 13 2006	"Everyone Counts" - Fanshawe College	WOMA

NCTM Annual Conference

April 26 - 29 2006	St Louis MO	

▲ President's Message ~ Knowing and Learning Mathematics for Teaching

KATHY KUBOTA-ZARIVNIJ



Kathy Kubota-Zarivnij is currently program coordinator of mathematics for TCDSB, senior elementary mathematics textbook author, mathematics AQ course instructor, and doctoral candidate. She has been an OAME director for 5 years and served on the OAME Executive for 3 years. She has a variety of mathematics education experiences, such as: elementary school administrator; in-service and pre-service mathematics teacher, and mathematics curriculum and program consultant, writer, and/or workshop presenter for different organizations, such as CCC, EQAO, MoE, NCTM, OAME, OCC, and TLP.

Have you had a chance to view The Literacy and Numeracy Secretariat's webcast that featured Dr. Deborah Loewenberg Ball? Dr. Loewenberg Ball is a mathematics educator from the University of Michigan whose research includes the study of improving mathematics teaching through policy, reform initiatives, teacher education and mathematics knowledge for teaching. Tens of thousands of Ontarians have viewed this webcast since its initial presentation in November 2005. You can still watch it through video streaming at the Curriculum Services Canada site, **http://www.curriculum.org**.

During my final President's Message, I'd like to spend a few moments with you thinking through Dr. Ball's idea of knowing mathematics for teaching and discussing a few ways that you and your colleagues could explore the practices of learning mathematics for teaching.

Knowing Mathematics for Teaching K to 12

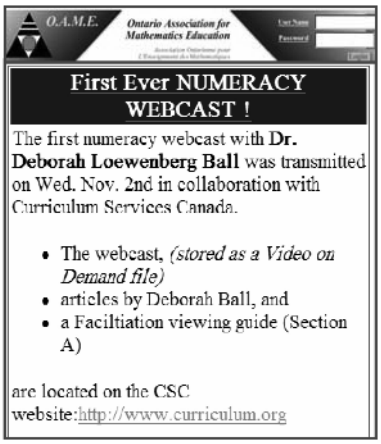
What do you think a teacher needs to know and be able to do, specifically, to teach mathematics?

Ball (2000) explained that there is a distinction between knowing how to do math and knowing math in ways that are usable in the practice of teaching. She identified two central aspects for the work of teaching.

"First is the capacity to deconstruct one's own knowledge into a less polished and final form where

critical components are accessible and visible. This feature of teaching means that paradoxically, expert personal knowledge of subject matter is often, ironically inadequate for teaching. Because teachers must be able to work with content for students in its growing, unfinished state, they must be able to do something perverse: work backward from mature and compressed understanding of the content to unpack its constituent elements" (p. 245).

The second aspect is to be able to use that knowledge for teaching. This specialized mathematics knowledge, that is, mathematics knowledge for teaching, often referred to as "pedagogical content knowledge" (Schulman, 1986, 1987; Wilson, Shulman, & Richert, 1987) is a combination of knowledge that links mathematics content and pedagogy. "Included here is knowledge of what is typically difficult for students, of representations that are most useful for teaching a specific idea or procedure, and ways to develop a particular idea … This kind of knowledge is not something a mathematician would necessarily have, but neither would it be familiar to a high school social studies teacher. It is quite clearly mathematical, yet formulated around the need to make ideas accessible to others. Pedagogical content knowledge highlights the interplay of mathematics and pedagogy in teaching. Rooted in content knowledge, it comprises more than understanding the content oneself" (pp. 245-256).


O.A.M.E. Ontario Association for Mathematics Education

First Ever NUMERACY WEBCAST !

The first numeracy webcast with **Dr. Deborah Loewenberg Ball** was transmitted on Wed. Nov. 2nd in collaboration with Curriculum Services Canada.

- The webcast, *(stored as a Video on Demand file)*
- articles by Deborah Ball, and
- a Faciltiation viewing guide (Section A)

are located on the CSC website:http://www.curriculum.org


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ARCHIVES OF PAST EVENTS

Dr. Deborah Loewenberg Ball
November 2, 2005

To make the most of this webcast, please download and print the Webcast Supports found to your right.

The third web cast of the current school year was on Wednesday November 2, 2005 from 4:00 - 5:00 p.m., and featured Dr. Deborah Loewenberg Ball, a numeracy expert from the University of Michigan. We were very pleased that Dr. Loewenberg Ball agreed to be a part of our web casts for the 2005-2006 school year. This web cast provided an excellent opportunity for educators to get an overview of the mathematics knowledge necessary for teaching in the elementary classroom and ask questions via e-mail.

Dr. Deborah Loewenberg Ball is an experienced elementary classroom teacher, who has spent many years researching the relationship between math instruction and content knowledge. She has received numerous awards for her involvement in research and teacher education. She will be sharing teaching strategies for getting students and teachers excited about mathematics.

To view more about Dr. Deborah Loewenberg Ball: www-personal.umich.edu/~dball/

ADDITIONAL MATERIALS

Webcast Supports
Facilitation Guide (PDF)
Shea's Numbers Transcript (PDF)

Articles by Deborah Loewenberg Ball
Knowing Mathematics for Teaching
Bridging Practices
Making Change Instruction
Toward A Practice Based Theory

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Therefore, let's think about new ways for teachers to develop knowledge of mathematics for teaching. Let's focus our thinking on what teachers need to know, how they have to know it, and ways that teachers can learn to use these ideas and strategies through classroom-based inquiries.

Doing Mathematics as a Teacher

I've noticed that it is not common practice for teachers to solve the lesson's mathematics problem prior to teaching the lesson. Some teachers do not read the teaching and learning strategies and suggestions from a teacher's guide prior to teaching a lesson. I continue to hear that the teacher's guide is more often used as an answer book rather than as a pedagogical resource guide. So, I'm wondering how teachers come to know the breadth of mathematics possible from solving a mathematics problem and the probable and diverse ways that students will demonstrate their mathematical thinking and knowing when solving a division of fractions problem.

There are many approaches to teaching the division of fractions through solving problems. Typically, teachers have students practise calculating the division of fractions in worksheets and in word problems, using a division algorithm. Ma (1999) reported that teachers often relate mathematics to every day life events so that students' mathematical thinking and doing was situated within a meaningful context. In Ma's study of Chinese and American teachers, she explained that the Chinese teacher's mathematical knowledge was rooted and intertwined with real world contexts. Yet, she noted that the American teachers identified contexts for problems that were often superficially connected to the mathematics. Fosnot and Dolk (2002) explained that context problems need to be connected closely to the students' lives. Such problems are designed to anticipate and develop students' mathematical modeling of the real world. As well, these problems have built-in constraints to support and stretch the students' mathematizing.

So, as you solve this problem, think about the aspects of division of fractions that are typically difficult for students. Think about the different representations that are most useful for teaching division of fractions and ways to develop students' understanding. Think about solving this problem, in terms of doing mathematics as a teacher.

What story contexts and models are appropriate for solving $1\frac{3}{4} \div \frac{1}{3}$ in different ways?

Understanding the Problem

What does the problem ask you to do? What mathematical ideas and details from the problem will you include in your plan to solve this problem?

Anticipating the Range of Possible Solutions from Students

As you make sense of the problem, what mathematical solutions are you seeing as being possible? In terms of the stories, are you thinking of real life contexts (e.g., sharing cookies, using ratios to predict the amount of total driving time, measuring lengths of rope using imperial units)? Or, were you thinking of a jingle like "Your job is not to reason why. Just invert and multiply". The solutions to this problem focus on these concepts: measurement model (quotative or grouping – how many $\frac{1}{3}$'s are in $1\frac{3}{4}$?), partitive model (ratio or sharing – finding a number such that $\frac{1}{3}$ of it is $1\frac{3}{4}$?). Though there is one numerical answer, it turns out that there are several different mathematical solutions representing each model. I think that learning to anticipate a range of possible solutions to a problem stems from solving the problem yourself with colleagues and noticing the breadth and depth of mathematics related to the problem. Now that you know the range of possibility, get your mathematical thinking tools together (e.g., manipulatives, grid paper, pencil) and generate many different solutions and story models for this problem. So, what did you do?

- Did you provide a numerical answer, one solution, or different solutions within the predicted range of possibilities?
- What different ways did you represent your solutions to the division of fractions problem?
- How do your stories relate to your mathematical models?
- How do your stories relate to your personal experiences? To your students' personal experiences?
- How is your story model useful for developing an understanding of division of fractions?

Keep talking, sharing mathematical thinking, and building on each other's ideas to develop several different solutions. Also, think about the possible solutions that students will provide and the mathematical reasons for their thinking.

Recognizing and Understanding the Mathematical Issues

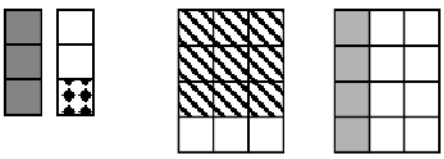
If you had your students (elementary or secondary) or colleagues at your school solve this problem, notice the mathematics in their story models and representations of division of fractions. Here are some sample solutions. A few of the solutions include typical errors.

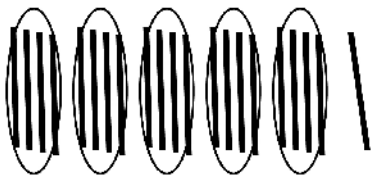
You want to split 1¾ m of rope evenly among 3 children. How much should each child get?

You have $1.75 and may soon triple your money. How much money would you end up with?

You are making a recipe for cookies that needs 1¾ cups of butter. How many sticks of butter (each stick is = ⅓ cup) will you need?

$1\frac{3}{4} \div \frac{1}{3}$ is the same as $1 \div \frac{1}{3}$ and $\frac{3}{4} \div \frac{1}{3}$
As ratios 1/(1/3) and (3/4)/(1/3) are equivalent to 3:1 and 9:4,
$3/1 + 9/4 = 3 + 2\frac{1}{4} = 5\frac{1}{4}$





thirds	1	2	3	4	5	$\frac{1}{4}$
quarters	4	8	12	16	20	21

$1\frac{3}{4} \div \frac{1}{3} = 7/4 \div 1/3$
$= 21/12 \div 4/12 = 21 \div 4 = 5\frac{1}{4}$

⅓	⅓	⅓(3)	1
$1\frac{3}{4}$	7/4	(7/4)(3)	21/4

$1\frac{3}{4} \div \frac{1}{3} = 1\frac{3}{4} \times 3/1 =$
$7/4 \times 3/1 = 21/4 = 5\frac{1}{4}$

Think about:

- How is the mathematics similar and different among the solutions?
- Which representations were more useful for learning division of fractions?
- How do the story models provide possibility for the use of particular mathematical models and strategies for dividing fractions?
- Which mathematical ideas and strategies were represented more frequently and less frequently among the collection of solutions?
- What aspect of division of fractions is typically difficult for students and teachers?
- What possible errors and/or omissions typically occur in the solutions? Why?

Learning Mathematics for Teaching – A Framework for Professional Learning

If we were only interested in calculating the numerical answer, then calculating $1\frac{1}{4} \div \frac{1}{3}$? might appear to be an insignificant contribution to the goal of learning mathematics for teaching. However, the experience of solving this division problem is intriguing because the problem requires the development of multiple solutions (i.e., mathematical and story models), thus expanding the diverse possibilities for mathematical thinking and doing. Yet, the problem is sufficiently constrained with problem details (e.g., $1\frac{1}{4} \div \frac{1}{3}$) to ensure that the mathematical ideas are not too diverse and can be interrelated. When the teacher is aware of the mathematical possibilities in the problems posed to students, he/she can determine whether significant mathematics learning can emerge.

So, what would a professional learning framework look like that focused on learning mathematics for teaching, as described by Ball (2000, 2003, 2005)? What would a professional learning framework look like that was designed using the five key conditions of complex learning systems that Davis & Simmt (2003, 2005) outline: internal diversity, internal redundancy, organized randomness, decentralized control, neighbour interactions? This is the question that we should consider as we participate in and organize professional learning experiences for teachers in our OAME chapters and in our school boards.

Continuing Our Collective OAME Work

Through the individual work of OAME members and the collective practices of the OAME community, our shared goal to improve student achievement through improved instruction is being realized. At our upcoming annual conference, the OAME community will come together as a provincial unity to share our collective knowledge and practices of mathematics.

Come join our mathematics learning community at our 2006 OAME provincial mathematics conference, *Every 1 Counts*. It will be held at Fanshawe College, London, Ontario from May 11 to 13, 2006. This conference will include administrator and teacher workshops that provide practical ideas and strategies for improving mathematics teaching and learning in classrooms. As well, OAME's latest professional development resource, *Growing Up Mathematically*, will be presented. I hope to meet you there!

KKZ

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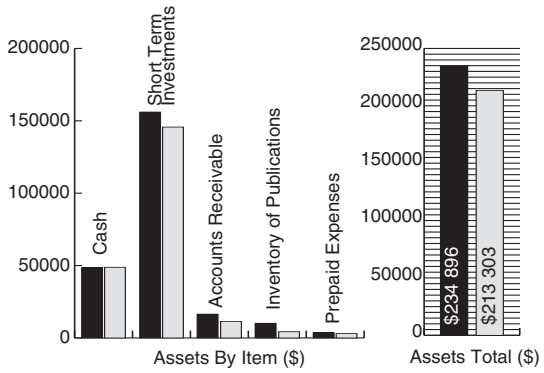
Notice to Readers

We have compiled the Balance Sheet of the Ontario Association for Mathematics Education (Association Pour L'Enseignement Des Mathematiques) as at August 31, 2005 and the Statement of Operations and Operating Fund Balance for the year then ended, from information provided by management. We have not audited, reviewed or otherwise attempted to verify the accuracy or completeness of such information. Readers are cautioned that these statements may not be appropriate for their purposes.

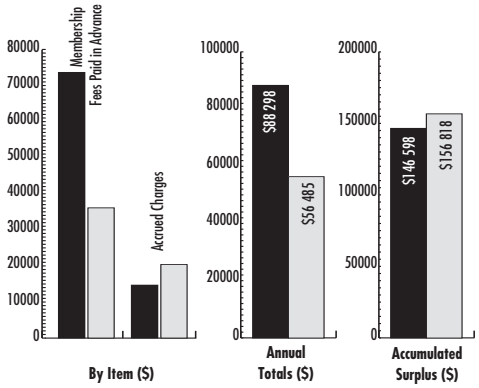
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2005/2004

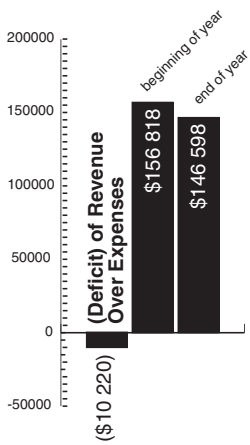
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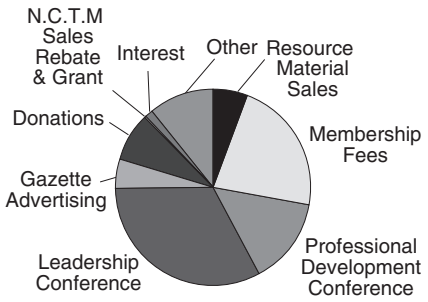
Liabilities and Fund Balance



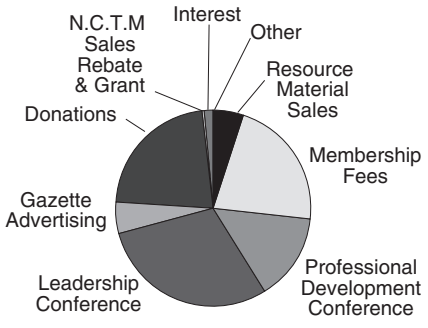
Operating Fund Balance



Revenue

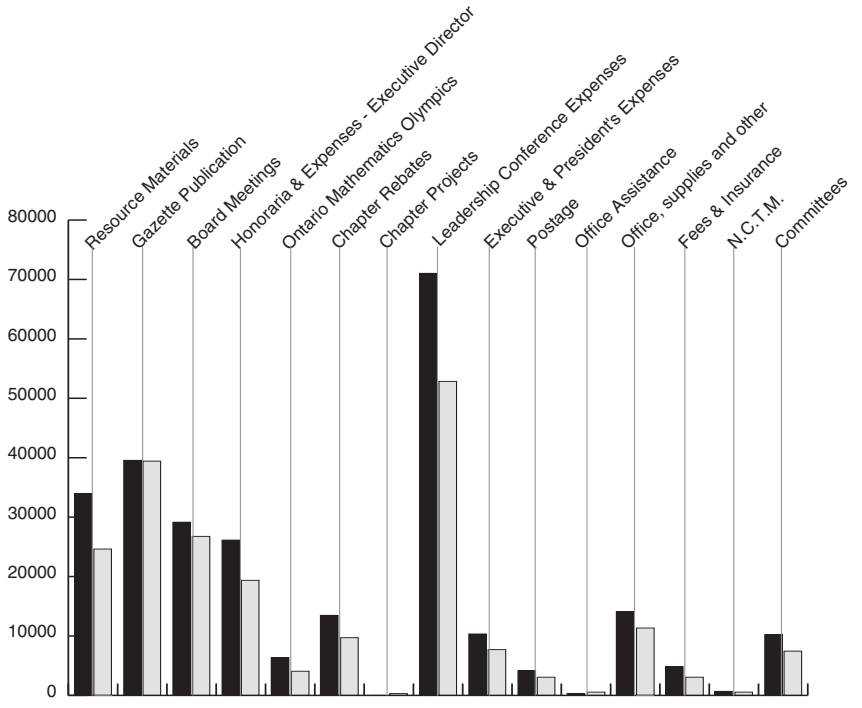


2005 ($253 080)



2004 ($226 564)

Expenditures



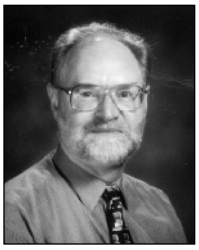
▲ Technology Corner: Walk the Function – Rates of Change and Functions using the CBR

MARY BOURASSA



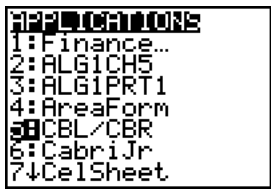
Mary Bourassa teaches mathematics at Lisgar Collegiate Institute in Ottawa. She is a strong advocate for the appropriate use of technology in the classroom. She is also an OAME director, president of COMA, gives workshops around the world and is a National Instructor for Texas Instruments.

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Fred Ferneyhough is former head of mathematics at Harold M. Brathwaite SS in Brampton. He remains a teacher there as well as an avid user of and advocate for the use of technology in the mathematics classroom. He is also an author and tech consultant for several books and a National Instructor for Texas Instruments.

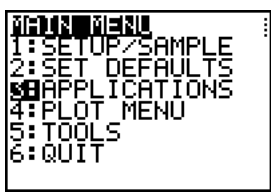
One attachment that does not get enough use is the CBR or calculator based ranger. My students have always enjoyed activities using this device. The standard application that most people use is the "Distance Match" (sometimes called "Walk This Way") activity and the "Ball Bounce".



To access the software needed to run the attachment, press the APPS key and scroll down to the choice labeled CBL/CBR and press ENTER Press ENTER again to move past the title screen. Scroll down to the third option "3: RANGER" and press ENTER. As with all menu options, you can also just press the number to the left of the option to access that feature.



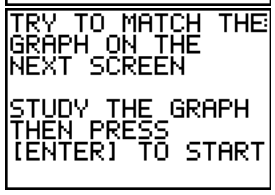
You will see another announcement screen. Press ENTER to get past this screen. The main menu for the Ranger will appear. For the "Walk This Way" activity and the "Ball Bounce" activities, press 3 for applications. When the option presents itself, choose METERS for the distance unit.



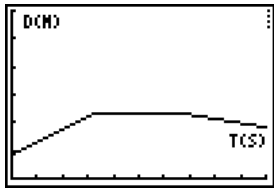
We will return to the Ball Bounce later. For now, press 1 for the DIST(ANCE) MATCH option.



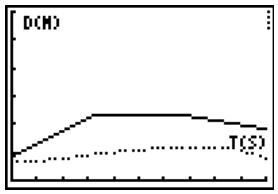
In this activity, a graph of distance vs. time will be presented. The student is required to walk in front of the device so that his/her distance matches the graph presented. Press ENTER to move past this screen.



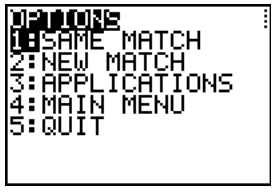
A graph will appear on the screen. There are several stored in memory and the user has no control over which one appears. At this point, the participating student will need to decide where to begin and how fast to walk. The units are seconds on the horizontal axis and metres on the vertical axis. Press ENTER when the student is ready to walk. I have found that having students work in pairs is best. One walks while the other controls the device. Students have had more success when the second student counts down "3, 2, 1, Go" before pressing ENTER to give the walker some warning as to when to begin.



In this mode, a scatterplot representing the student's path will be superimposed on the graph. Select a very confident student as the first walker as the first attempt may be disastrous – as shown. However, the analysis that students go through to correct their errors is worth the momentary discomfort. Press ENTER when the walk is completed. At this point, the student has several options as shown.

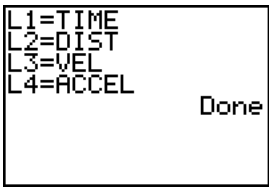


Most students elect to repeat the walk until they get it correct. You can have several students participate in the activity and then allow them to do some walks with a partner. When finished, press 5 to access the QUIT option.

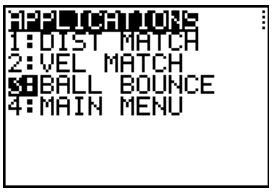


The data from the activity is stored in the lists of the

calculator. I have found that the Distance vs. Time data is (almost) always good but the data for Velocity vs. Time or Acceleration vs. Time are sometimes questionable.



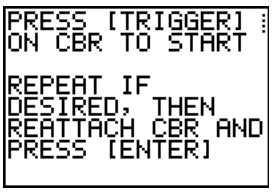
The ball bounce is a great activity for classes who are studying quadratic functions. Return to the CBL/CBR application and go through the options until you get to the applications screen. This time, select option 3 for BALL BOUNCE.



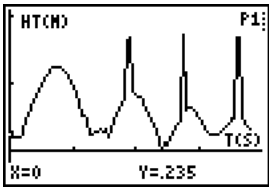
You may get an instruction that you can disconnect the CBR from the calculator. If having the cable in the way is a problem, you may wish to try removing the cable. Notice that the closest that you can hold the ball is half a metre away. I have seen teachers clamp the CBR to the underside of door frames for this activity in order to hold it in position.

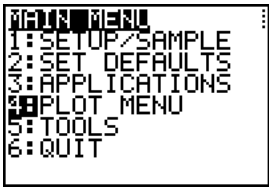


When ready, one student should drop the ball just after a second student presses the TRIGGER button on the CBR. A well inflated basketball works very well for this activity – if you pry one away from your phys ed department!

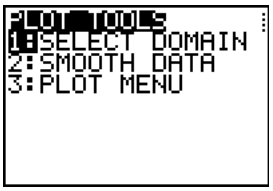


When you are finished, reconnect the cable to the calculator and press [ENTER]. The data will be transferred back to the memory of the calculator. On a good day, you will get a great set of data with several inverted parabolas. The screen shown here is very common. Note that the "parabolas" are upside down. The device measures the distance from the object to the sensor, so the ball is the greatest distance away when it hits the floor.

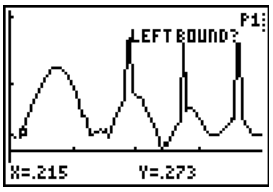




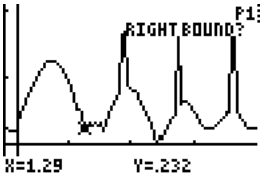
Press [ENTER]. The device will switch over to a PLOT MENU. Select the option 4: PLOT TOOLS followed by the SELECT DOMAIN option in the next menu.



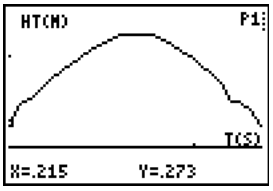
The device will show the screen with the command LEFT BOUND stamped on the screen. Move your cursor to the beginning of an interval where a good parabola begins. Press [ENTER] to set the left bound.



Repeat this for the right bound by moving to the end of the interval. Press [ENTER] . The screen will refresh with just the data that you have selected. The rest of the data is discarded by the calculator.

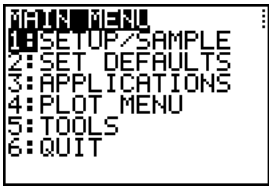


Now, quit the application and in the home screen, the data in list 1 and list 2 can be used for a quadratic regression. If the drop was accurate, you might even be able to get the constant -9.8 for gravity.



Function Walks

Another way to use the CBR is to select the SETUP/SAMPLE option from the main RANGER menu.



Change the settings as shown. For REALTIME, press [ENTER]. to toggle the option from YES to NO. For TIME(S), simply type in the length of time that you want. When you are finished, move your cursor up to the option "START NOW" at the top right of the screen. Press [ENTER] when ready.



You will get an instruction on the next screen advising you on how to handle the hardware and where to push buttons. The idea here is that your students will walk in front of the CBR in such as way as to create a curve that models the functions that you are studying in your class.



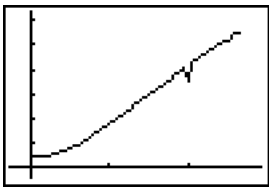
The following are examples of walks that my students have done in class. This year, I had the students in my Advanced Functions and Introductory Calculus class produce all of these functions as an activity for the functions strand. In the future we intend to break them up as shown. Refer to the December 2001 article for instructions on saving data for future purposes.

When our students perform these walks, we have the diagnostics turned on and their mark is the value of R^2 or r^2 depending on the type of graph.

Grade Nine – linear walks. We are planning to have our grade nine students walk to produce four linear graphs:

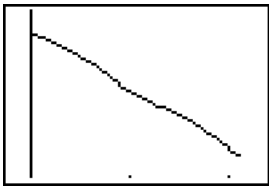
Linear with positive slope less than 1

Linear with positive slope greater than 1

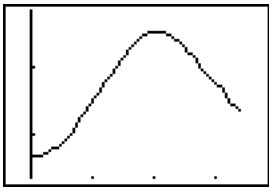


Linear with negative slope between 0 and -1

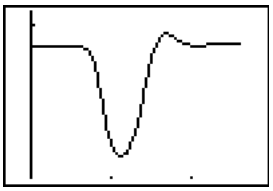
Linear with negative slope less than -1



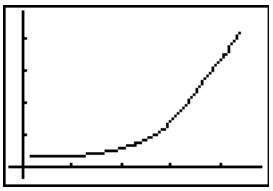
For grade ten, the plans are to have students produce two graphs - a parabola that opens up and one that opens down.



For this graph, the student did not need the full amount of time to get the graph that he wanted. There is a lot of extraneous data in his lists so we trimmed out the excess by going to [2nd], [STAT], move over to OPS and choose option "8: Select". This will allow you to trim the graph in the same way as the PLOT TOOLS menu did in the CBR app. The excess data is discarded by the calculator.

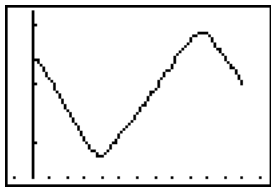


For grade eleven, the focus will be on exponential and trig functions. For the exponential functions, a lot of students fooled us and just clipped part of another walk for a fraction of a second. In the future, we will have them walk for at least four seconds so that they have to speed up.

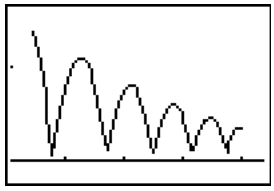


Trig regressions do not produce a value for R^2, so we told the students that this activity would be marked on a rubric with the level equivalent to the number of cycles produced and then looking at the fit. I can see three full cycles on this graph, so that might work out to a level three. Then I consider how well the curve fits the data to adjust up or down the a level 3^- or 3^+.

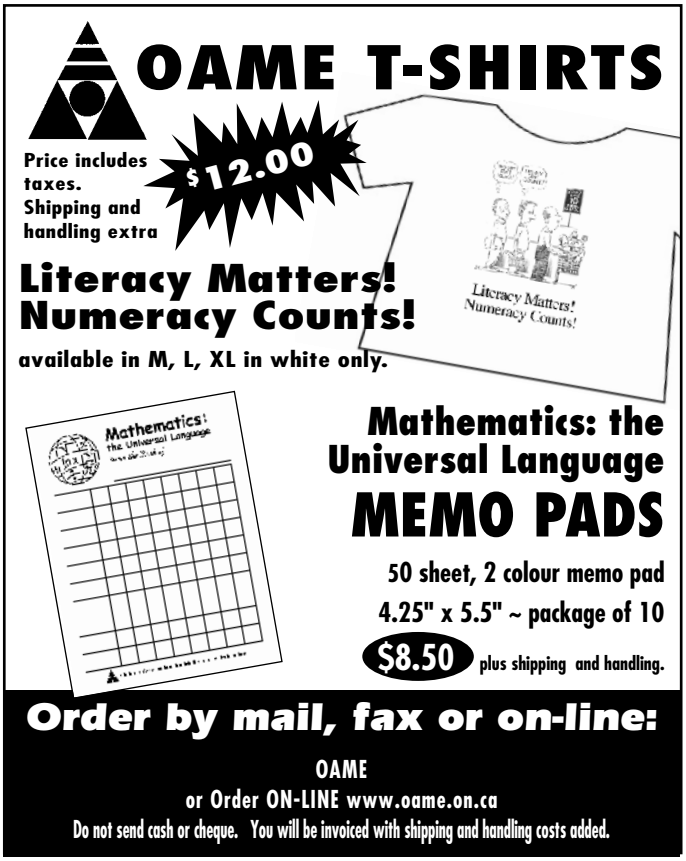
For grade 12, students were asked to produce a cubic and quartic function. The graph shown was actually done by a parent during a parents' night with one of my grade twelve students coaching him. I used this set of data for the final exam where the students were to model the data with the appropriate regression and then analyze the function using calculus techniques. One has to wonder if our future students will ever get the opportunity to do activities of this nature if/when calculus is removed from the high school curriculum.



Finally, I used the SETUP/SAMPLE approach for the Ball Bounce activity. My students found that this gave them better data. The one shown is a sample that I "borrowed" from one class. I could then have each group of students find the equation of one parabola and compare what they got for the force of gravity. The results were great.



If you are about to purchase new equipment, consider buying the newest CBR and getting EasyData to add to your collection of toys. Either way, using the CBR opens up a wide number of activities that fit into our curriculum. A bit of time spent preparing activities for this approach is well worth it. ▲



▲ Hey It's Elementary: Everything Old May be New Again, but It Isn't Good Enough



LYNDA COLGAN

In Ontario, to obtain a Bachelor of Laws degree, a student must minimally complete 4 years in a specialized professional school after completing 2 years of university. To become a physician, one must minimally complete a 4 year M.D. program–after at least 3 years of undergraduate study. To become a dentist, one must complete a minimum of 4 years of study in a professional school after at least 2 years of pre-professional study at the post-secondary level. To become a veterinarian, one must study minimally for 4 years, after 2 years of undergraduate study in highly specialized fields. To become an optometrist, one must study for at least 4 years after pre-professional study. To become a primary/junior or secondary school teacher in Ontario, one must attend classes at a Faculty of Education for approximately 15 weeks and one must complete a field placement of about 11 weeks.

In spite of the rigours of preparation and education for other professions, Ontario is one of a handful of provinces in Canada with a one-year, consecutive B.Ed. program[1]. In other words, in Ontario, the holder of a 3-year or 4-year B.A. or B.Sc. gains entrance to a Faculty of Education. Since the Ministry of Education and the College of Teachers legislate the number of days of practicum during which teacher candidates (a.k.a. student teachers) are situated in classroom settings under the aegis of an associate teacher (usually about 11 weeks), the Faculties of Education are left with the 'other weeks' of the one-year (September 1st to April 30th) teacher education program (minus 2-week Christmas holidays, March Break and Reading Week).

At Queen's University, where I am a professor, our teacher candidates attend classes at the Faculty for 4 weeks in September, 3 weeks in November, 5 weeks during January and February and 3 weeks in April. During each week of on-campus time, I see my elementary mathematics curriculum classes once for 2.5 hours (minus 10 minutes for class change). Over the course of the B.Ed. 'year', I am expected to address all issues related to the content, instruction and assessment of mathematics from Kindergarten to Grade 6 as well as inform teacher candidates about how to use manipulatives effectively in all strands at all grade levels, share research about children's mathematical development, provide tools for diagnosing mathematics disabilities, communicating with parents, and integrating mathematics with other disciplines, to name but a few topics. Other Ontario universities' Faculties of Education may vary by a few hours here and there, but the reality is that teacher preparation, especially for a complex and expansive subject like elementary mathematics is woefully inadequate to meet the challenges of today's demanding classrooms or address the ever-expanding knowledge about how young children learn mathematics.

Merely extending the pre-service program to two years would not necessarily produce better teachers, but isn't a two year post-degree program a good starting point for discussion when the literature also suggests (in at least 60 substantive empirical studies) that the single best predictor of student achievement in schools was the length of the time of teacher education? A number of studies have shown that graduates of the five year concurrent teacher education programs are rated by principals and colleagues as much more effective than graduates of concurrent four year programs, (Darling-Hammond, 1998). According to Darling-Hammond many recent studies show that graduates of the longer programs are more satisfied with their teacher education, are viewed by colleagues and principals as better prepared, are as effective as more experienced teachers and are more likely to enter and remain in teaching than graduates from four year programs (Darling-Hammond, 1997, 321). This is good news for concurrent education programs–those in which post-secondary education is shared between the faculty of education and departments like arts, science, mathematics, geography and psychology.

In Ontario we have recently spent millions of dollars on *The Early Math Strategy*, *The Junior Math Strategy*, the *Literacy and Numeracy Secretariat*, the Ministry of Education *Turn-Around Teams* and a plethora of local initiatives aimed at intensive professional development

[1] Five provinces (including Ontario) currently offer a one-year pre-service program option, five have a two-year program, and three offer four-year, stand-alone B.Ed programs. In addition to both one- and two year options, New Brunswick offers a one-and-a-half-year program.

and targeted training to raise student achievement levels in basic subjects like language and mathematics. I have to wonder if we might be overlooking the obvious. If students are expected to know more and be able to apply their knowledge skillfully, then teachers must be models of such learning. The demands for in-service teacher education may be extraordinary because pre-service teacher education, in its current incarnation, has not adequately prepared front-line teachers for the complexities of teaching reform-based mathematics in filled-to-capacity, multilingual classrooms that house large numbers of IEP students with highly individualized special needs yet lack the human and material resources to fulfill the requirements of textbooks (e.g., "Use your MIRA to do questions 1–8") let alone the basic tenets of Maslow's hierarchy. It may be time to recognize that we may not be able to deepen a teacher candidate's subject matter knowledge and strengthen her ability to teach the subject to a variety of students without a fundamental change to both the length and structure of our teacher preparation programs in Ontario.

One of the more explicit calls for change to pre-service education in Ontario was the highly publicized recommendation for a two-year Bachelor of Education program in the release of *For the love of learning*, the Royal Commission on Learning (1995).

> *68. That the consecutive program for teacher education be extended to two years, and that one year be added to the concurrent program, and that the Bachelor of Education degree be awarded on successful completion of the two-year program or, in the case of the concurrent program, on completion of the equivalent of the two-year education program;*

The Ministry of Education under Premier Dalton McGuinty first appeared to be in favour of actualizing this recommendation by promising to legislate a two-year post-degree education degree program; however, projections of huge numbers of retirements (about 32% of the current teaching population over the next 10 years) coupled with concerns over early career teachers leaving the profession within their first three years, raised red flags about teacher supply. As an alternative to a two-year pre-service program, the Ministry is now committed to supporting a more formalized learning component in the first year of practice via a first-year induction program, believing that it will form a natural area for collaboration between faculties of education and school systems and most importantly a more confident entry for new teachers.

I am a strong supporter of mentoring. But the research on formal mentoring programs suggests that they require intensive training for mentors, release time for mentors and mentees, structured curricula, strong communities of trust and time, time, time. Since each of these criteria is in short supply in today's fast-paced, vortex-like educational environments, high-quality mentoring may be difficult to implement and sustain.

Thus my personal vote would be for a longer consecutive (e.g., post-degree) teacher education program, with teacher candidates placed only in exceptional schools–where master teachers are orchestrating the kind of classroom that the NCTM vision statement describes so passionately, (e.g., *Imagine a classroom, a school, or a school district where all students have access to high-quality, engaging mathematics instruction. There are ambitious expectations for all, with accommodations for those who need them and challenges for those who stand to benefit from them. Knowledgeable teachers have adequate resources to support their work and are continually growing as professionals. The curriculum is mathematically rich, offering students opportunities to learn important mathematical concepts and procedures with understanding. Technology is an essential component of the environment. Students confidently engage in complex mathematical tasks chosen carefully by teachers. They draw on knowledge from a wide variety of mathematical topics, sometimes approaching the same problem from different mathematical perspectives or representing the mathematics in different ways until they find methods that enable them to make progress. Teachers help students make, refine, and explore conjectures on the basis of evidence and use a variety of reasoning and proof techniques to confirm or disprove those conjectures. Students are flexible and resourceful problem solvers. Alone or in groups and with access to technology, they work productively and reflectively, with the skilled guidance of their teachers. Orally and in writing, students communicate their ideas and results effectively. They value mathematics and engage actively in learning it*). This vision requires not only more time than my current mathematics curriculum course; it demands a dramatically different type of course than my current 36-hour survey course about mathematics and its teaching and learning.

There is certain to be a multitude of other opinions about the nature of appropriate models and new configurations for pre-service education. But before the

cacophony of dissenting views, all of which need to be heard and weighed in light of the literature, I think it is important to examine how teacher education in Ontario evolved over the past century, because as Russell Hoban said in 1925: "*If the past cannot teach the present and the father cannot teach the son, then history need not have bothered to go on, and the world has wasted a great deal of time".*

The Rise of Normal Schools

Teacher preparation in Canada is about 175 years old. In fact, under Egerton Ryerson's supervision, a parcel of semi-rural land known as St. James Square was purchased in 1850 in Toronto for the site of Canada's first Normal School, the first training facility for teachers in Canada (the property on which Ryerson University now sits).

Before that time, little theoretical or practical attention was given to preparing teachers. Since children were not expected to go to school, the provision of schooling was a local option, often dependent on the availability of a teacher. Usually, school was held for only a few months in winter, and the curriculum was limited to the Bible, reading and writing, and some arithmetic because time, money and personnel were not available to teach more than the essentials of literacy.

Until the 1860s, most teachers were men for whom teaching was most often a part-time job and seldom pursued as a career. In fact, men typically used it as a stepping stone–usually to the ministry, while women used it as employment between schooling and marriage. By the turn of the century, however, 50% of elementary school teachers in Ontario were women.

Before the first Normal School, most Ontario elementary school teachers had little education beyond their own six or eight years in elementary school. High school teachers were better educated, some being graduates of Latin grammar schools or academies, but it was a rare occurrence to find a teacher who had taken a course or received any instruction in teaching as a discipline.

By 1830, in Prussia and France, teacher-training institutions were developing, many built on the educational philosophies of Swiss educator, Johann Heinrich Pestalozzi. Pestalozzi believed that teaching should heed a child's instincts, not impose learning on them. He thought teaching and learning should be oriented to what a child could see, hear and touch in his or her immediate environment. For teaching to do that, Pestalozzi asserted, teachers needed special training in the nature of the child; therefore, special teacher training institutions emerged. The French dubbed such an institution as "ecole normale" – "ecole" meaning school – "normale", coming from the Latin "norma", literally a carpenter's square, but figuratively meaning a model or principle. To the French, this was a school in which the rules or principles of teaching were taught. North Americans translated the term to "normal school". (The name "normal school" persisted until the 1950s when such institutions became teacher's colleges. The designation "Faculty of Education" was given in the late 1970s when teacher education fell under the auspices of the university.)

The earliest normal schools offered a few weeks to one year of study. Later, two years and then three years became the rule. Prospective teachers studied the subjects that they would teach (at first, the Bible, orthography, reading), how to teach them and general pedagogy. They also practiced teaching in model (or laboratory) schools.

Normal schools trained elementary school teachers. Initially, students were admitted directly from elementary school. Gradually, schooling beyond the 8th grade became a requirement, and by 1894 high school graduation was an entrance standard in normal schools.

Two other Europeans, whose ideas had a substantial effect on normal school training were Johann Friedrich Herbart, a German philosopher and psychologist and Friedrich Froebel, a German educator. Herbart's contribution was teaching methods. His belief in the importance of association in learning led him to formulate a five-step process of learning and teaching: preparation (orientation), presentation, association, generalization and application. Central to his vision of professionalizing education was the notion of the 'lesson plan'. Froebel's contribution was kindergarten education to foster the "mental, moral and expressive powers" of young children before they entered elementary school. In 1883, the first Kindergarten in Ontario was opened in the Louisa Street School in Toronto. Ada Marean was the teacher of the class of 80 children. She had seven teachers-in-training assisting her.

Normal School Candidates

In 1850, when Ontario first adopted official standards for qualifying teachers, the requirements were minimal: candidates were expected to read, spell, write, and to have some knowledge of geography and the basic rules

of grammar. To be considered for acceptance into the Normal School program, candidates were required to pass a medical examination by a medical officer, appointed by the Minister of Education. The application for admission to the Normal School had to be accompanied by a satisfactory certificate of good character obtained within three months of the time of making the application. By 1920, the minimum academic standing for admission to the Normal School was *the Entrance to Normal Certificate*, which required that, in addition to Junior Matriculation requirements in English, history, and mathematics, the candidate must have completed the Grade XI course in one foreign language, one science, and in geography.

The Normal School Program and Sample Curricula

Around 1930, typically, teacher candidates attended seven forty-five minute class periods per day from mid-September to mid-June. A sample of the minimum and maximum number of class periods to be devoted to the various subjects of instruction for a full Normal School session from British Columbia's first Normal School is detailed below:

SUBJECT	PERIODS
School Administration	50 to 60
Educational Psychology	20 to 25
Measurements, Graphics, and Statistics	20 to 25
Educational Movements and Sociology	30 to 35
Arithmetic	50 to 60
Geography	50 to 60
History and Civics	50 to 60
Nature-study and Agriculture	50 to 60
Primary Grade and Manual Arts	50 to 60
Grammar	25 to 30
Writing	25 to 30
Reading	20 to 25
Composition and Spelling	30 to 35
Drawing and Art	60 to 70
Music and Voice-training	60 to 70
Home Economics	60 to 70
Health Education	30 to 35
Physical Education	60 to 70

A summary of several course descriptions from the British Columbia Normal School curriculum overview for 1928-29 follows:

The School and the Child

- The teacher's responsibility in knowing the physical, mental, social, and moral status of the child in school.
- Factors determining grading and promotion of school-children; the value of standardized intelligence and achievement tests as aids in determining such grading.
- The special care and management of the problem child – the gifted child, the subnormal child, those abnormal physically and temperamentally, those defective in speech, hearing, eyesight, training and social privilege.
- The problem of discipline – a positive attitude on the part of both teacher and pupil resulting in right conduct and added social responsibility.
- Interest and motivation; rewards and punishments.
- Routine class-room management – assembling, dismissing, giving of signals and commands, punctuality and regularity of attendance.
- School Law of Ontario relating to duties of pupils and parents.

Measurement, Statistics and Graphics

- Purposes and methods of educational measurement.
- Construction of sample tests; study of typical standardized tests; individual and group intelligence tests – appropriate use of each; standardized achievement tests; mental age; intelligence quotient.
- Classification and tabulation of quantitative data; graphic representation of frequency distributions; how to obtain the mean, median, percentiles, quartile and standard deviations in a frequency distribution; simple correlation; meaning and characteristics of the normal curve.

Reference Books

Monroe, DeVoss & Kelly, *Educational Tests and Measurements* (Revised Edition). Hines, *A Guide to Educational Measurements*. Russell, *Classroom Tests*. Ruch, *Improvements of the Written Examination*. Paterson, *Preparation and Use of the New-Type Examination*. Thurstone, *The Fundamentals of Statistics*. Rugg, *A Primer of Graphics and Statistics*. Williams, *Graphic Methods in Education*.

Arithmetic

- Changing concepts and modern requirements in arithmetic – emphasis on number facts and operations in actual daily use and that bear close relationship to existing human needs.

- An introduction to the official programme of studies in arithmetic by grades up to and including Grade IX.
- An appreciation of the progressive increase in the difficulty and complexity of the operations involved in the course with each advancing grade.
- Appropriateness of the assignments in arithmetic to the present knowledge and ability of the pupils, grade by grade, as well as to their future needs.
- A more critical review of the course, with detailed treatment of selected topics from the work of each grade.
- The place of arithmetic in correlation with other subjects.
- Importance of realism in the presentation of all numerical situations.
- Equipment and special devices to facilitate worth-while review of arithmetic operations and as aids in the maintaining of interest.
- The use of standardized tests and of practice material in arithmetic.

Reference Books

Leunes, *The teaching of Arithmetic*. Overman, *A Course in Arithmetic for Teachers*. Overman, *Principles and Methods of Teaching Arithmetic*. Osburn, *A Socialized Study of Corrective Arithmetic*. Thorndike, *The New Methods in Arithmetic*. Newcomb, *Modern Methods of Teaching Arithmetic*. Stone, *The Teaching of Arithmetic*.

So What?

As I read these course outlines and look at the time allocations and admission requirements, I am struck by the similarities to today's programs in teacher education for elementary teachers. Only highly qualified candidates need apply. Whether in 1928 or 2006, prospective teachers need to have support from their community (Girl Guides, Hockey Coaches, Assisted Living Environments) and be well-educated. The "Normal Schools" introduced the fundamental areas that impacted schooling: sociology, psychology and philosophy. There is a balance of theory and practice. There is a balance between classroom management and organizational/administration skills and pedagogical practices. There is equal attention to all curriculum areas. This would closely parallel what happens in many contemporary faculties, with time allocated to the foundations of education (its history, psychological and philosophical roots), curriculum, skills and issues (such as diversity).

While there are similarities, there are also differences, the most obvious of which is that a one-year program in 1928 was longer than today's one-year program. In 1928, teacher candidates got about 45 hours of instruction in the teaching and learning of arithmetic alone. In 2006, we have five strands in the mathematics curriculum, and less time devoted to all five strands than was provided to one strand in 1928. In 1928, all teacher candidates studied assessment and evaluation as part of their basic teacher preparation. That is not the reality in 2006, at least at Queen's.

We know that our September to June school year has its roots in our once farming-based society. Children could not attend school in the summer because they were needed to harvest crops at the height of the season. Though we have fewer rural schools and a decidedly non-agrarian society, for over one century we have continued to use an obsolete model. There are research-based models that suggest highly workable models to better reflect current needs, yet these have not been widely implemented.

In the earliest colonial years in Ontario, teachers learned their practice through serving as apprentices to other "school masters" who, after a period of time, declared the apprentices to be qualified. Formal course work was added to the field placement experience with the advent of the Normal School a century and a-half ago. It seems that in spite of the change in name from "Normal School" [to "Teacher's College"] to "Faculty of Education" not much on the surface has changed either, from lecture hall/classroom experience to duration of program to content of courses in spite of the fact that the realities of the classroom and the theories about learning that exist today bear little resemblance to what was known at the earliest stages of teacher education.

Change is not easy. No one knows that more than the mathematics education community. Maybe it is time for the mathematics community to tackle a new challenge. Teaching is a profession, and as we see from our peers in law, medicine, occupational therapy, veterinary science, dentistry and optometry (to name a few), the preparation of professionals demands rigour and experience over time with the best tools, the most current strategies and leading-edge clinical mentors.

In 1990, prolific American researcher and author, John Goodlad, stated that teacher education was "one of our nation's neglected enterprises". It is time to end that

neglect. And that can only be done by beginning at the beginning. Just as we know that a child's earliest years are the most important in shaping her future success, we must recognize that a prospective teacher's earliest years are fundamental in building the teaching community our children need. In-service education is important. But pre-service education should overshadow it in its import and urgency for attention. As Plato said, "the beginning is the most important part of the work".

Certificate of Qualification-Normal School, for Ontario

This is to Certify, that _____ having attended the Normal School during the _____Session, 18__, and having been carefully examined in the several branches named in the margin, is hereby recommended to the Chief Superintendent of Education, as eligible to receive a First (or Second) Class Certificate of Qualification, as a Common School Teacher in Ontario, according to the "Programme of the Examination and Classification of Common School Teachers," revised by the Council of Public Instruction, on the 17th day of December, 1858.

_____ Head Master.

_____ Second Master.

In Accordance with the forgoing recommendation, and under the authority vested in the Chief Superintendent of Education by the 107th section of the Upper Canada Consolidated Common School Act (22nd Victoria, chapter 64),

STANDING

In The Different Branches – (No. 1 being the highest

Spelling _____	Education _____	Geometry _____
Reading _____	Writing _____	Mensuration _____
Grammar _____	Drawing _____	Natural Philosophy __
Composition _____	Music _____	Chemical Physics ___
English Literature ___	Book-Keeping _____	Chemistry _____
History _____	Arithmetic _____	Aptitude to Teach ___
Georgraphy _____	Algebra _____	Conduct _____

I do hereby grant to_____a First (or Second) Class Certificate of Qualification, as a Common School Teacher, of the grade and standing above indicated, which Certificate shall be valid in any part of Ontario, until revoked by this Department (or for one year, as in the case of Second Class Certificates, Grade C).

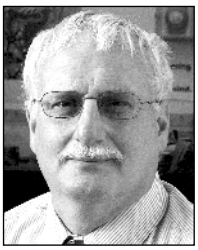
Dated at the Education Office, Toronto, this
fifteenth day of one thousand eight hundred and sixty

_____
Chief Superintendent of Education for Ontario.

Recorded in Certificated Register A of
the Department, Number _____Registrar.

In Ontario teaching certificates were divided into classes Grade A, (B or C,) of the First (or Second) Class. Here is a sample certificate from 1867. ▲

▲ OAME/NCTM March 2005 Report



JOHN KERSLEY

NCTM's theme for 2005-2006 is entitled "Assessing to Learn and Learning to Assess"

In brief, the focus is assessment. See **www.nctm.org/focus** for more information. NCTM policy, as indicated in its publication, Standards, advocates learning mathematics with understanding, rather than simply learning rote mathematical procedures. I would think that all mathematics teachers are in agreement with this and place much emphasis of it in one's mathematics teaching. The processes of problem solving, reasoning, making connections, proof and communication are essential in the development of students' conceptual understanding of mathematics. Thus, it is important that students have the opportunity to develop these processes in their assigned homework, class work, and self-assignment activities. These processes should, therefore, also be reflected in evaluations. This month, continuing its theme of assessment, NCTM suggests that teachers look at their recent assessments and evaluations to see if these processes reflect what one believes and values in the learning of mathematics.

NCTM publications relating to assessment include:

The Mathematics Assessment Series

- *A Practical Handbook for Grades K-2*, Stock #12359
- *A Practical Handbook for Grades 3-5*, Stock #12050
- *A Practical Handbook for Grades 6-8*, Stock #721
- *A Practical Handbook for Grades 9-12*, Stock #720
- *Mathematics Assessment: Cases and Discussion Questions for Grades K-5*, Stock #12051
- *Mathematics Assessment: Cases and Discussion Questions for Grades 6-12*, Stock #722
- *Mathematics Assessment Sampler, Grades 3-5,* Stock #12937

- *Exploring Classroom Assessment in Mathematics: A Guide for Professional Development*, Stock #672
- *Assessment Standards for School Mathematics,* Stock #593

Contact me for details regarding the ordering of these and other NCTM publications or visit **www.nctm.org/catalog**

In addition to the over 200 books for sale, NCTM publishes several journals specifically geared to different levels of mathematics education. The following are samples of articles in recent issues:

From Simple Questions to Powerful Connections: A Two-Year Conversation about Negative Numbers The article describes the experiences of a group of primary-grade students and their teacher as they explore negative numbers over the course of two years. It is just one example of how a problem-solving environment contributes to discussion and understanding in mathematics.

Math Roots: Serving Up Sierpinski! The article is an exploration of the origins of the Sierpinski triangle, its foundation for fractals, and related student activities.

Paper Moon: Simulating a Total Solar Eclipse This article describes a classroom activity in which a solar eclipse is simulated and a mathematical model is developed to explain the data. Students use manipulative devices and graphing calculators to carry out the experiment and then compare their results to those collected in Koolymilka, Australia, during the 2002 eclipse.

If you are not already a member of NCTM, visit **www.nctm.org/membership/application** and click on member benefits.

I mentioned in my last column (*Ontario Mathematics Gazette*, December 2005) that NCTM is in partnership with the Paramount Network Television Series, *NUMB3RS*. This venture is designed to support teachers in providing interesting classroom activities. For each new *NUMB3RS* episode, a short, ready-to-use mathematics activity will be available on the program's website **www.cbs.com/primetime/numb3rs/ti/activities.shtml** each Saturday before it airs. Activities are based on the math presented in the episode and take 5–15 minutes to do. The math used in each episode of *NUMB3RS* is based on real FBI cases. Worth a look.

Websites of interest to mathematics as suggested by NCTM

Math Matters

www.mathmattersonline.com
Free sample—math challenges for grades 2 – 4 emphasis on problem solving

Just Us Teachers

www.justusteachers.com/Math_Fonts.html
For making one's own materials with 1,2,3 Math Fonts software
Designed for the elementary school mathematics
Free samples available

SAT Math Pro

www.SATMathPro.com
Interactive math problems and videos to help students prepare for the math component of the PSAT, SAT and ACT exams

Homeroom Teacher

www.homeroomteacher.com
offers links to free educational clip art, lesson plans, etc for the classroom teacher

NCTM Conferences 2006

www.nctm.org/meetings

NCTM Annual Meeting

St. Louis "Asking Questions-Generating Solutions"
April 26-29, 2006

NCTM Regionals

Chicago September 20 -22, 2006
Phoenix October 5 – 7, 2006
Atlantic City October 19 – 21, 2006 ▲

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▲ Friday Special!

JACK WEINER



Fridays at the University of Guelph, five minutes before the end of class, I say, "Pens down, books closed, it's "Friday Special" time!" Then I show on screen an article or cartoon or letter or…something that has to do with math, the "real world" and has absolutely nothing to do with class, assignments, or tests. It is math for fun. Often, it is some flagrant example of how the media abuse math. I hope you use some of these. Make them "Monday Morning" specials or "We need a break!" specials. If one falls flat, blame me. If it works, you take the credit.

Here is a recurring Friday Special theme:

When the media does math, more often than not, the media gets it wrong!

Please indulge me as the column allows another subject to make an appearance as a guest Friday Special. It seems that…

When the media does geography…

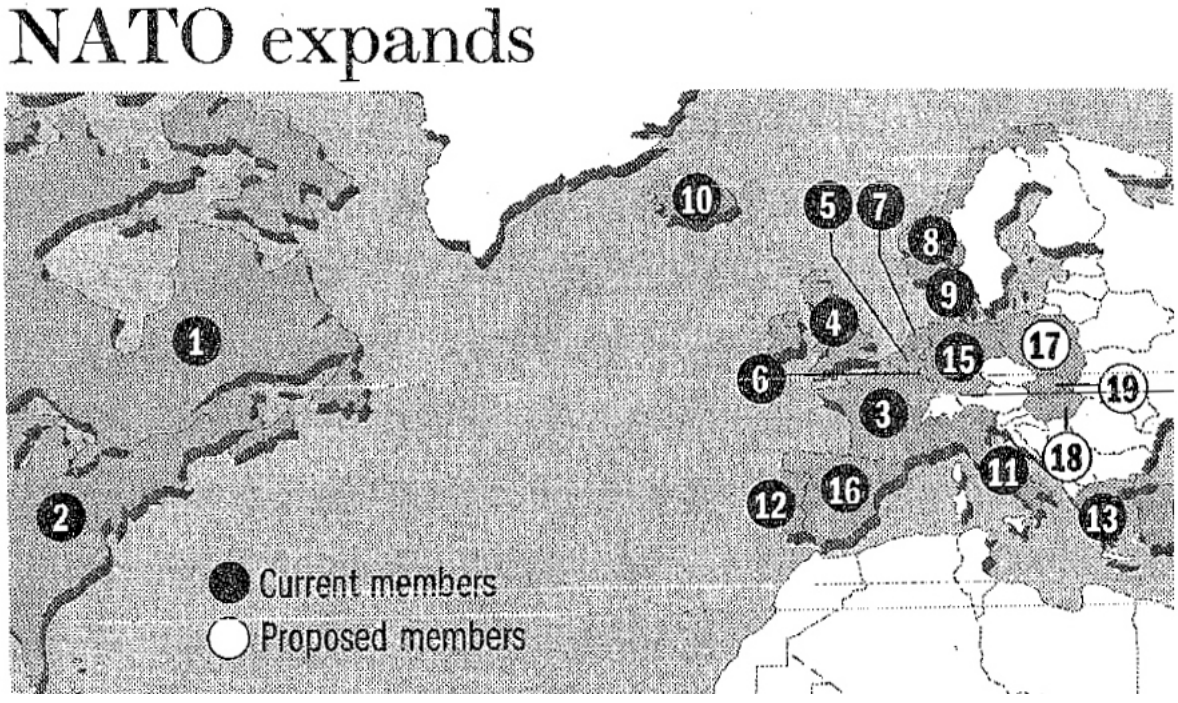
After the collapse of the Soviet Union in 1989, many countries in Eastern Europe attained autonomy for the first time in decades, a few for the first time period. The Warsaw Pact dissolved. Its western counterpart, NATO, did not. In fact, many former Warsaw Pact countries decided that membership in NATO would be to their advantage and initiated efforts to join.

Reporting on this phenomenon, the *Toronto Star* commissioned the accompanying graphic. It shows, at the time of the article, current and proposed membership in NATO. Aware of the possibility for error in identifying the small, closely neighbouring countries in Europe, great pains were likely taken to ensure the European labels were correct. As far as I can tell, the *Toronto Star* did a good job. That is, across the pond.

Take a five minute diversion to give your students a little history/geography lesson on this topic. Have them check out Canada and the United States on the map. OUCH! And remember, this graphic was commissioned for and published by the *Toronto Star*.

When the media does geography…

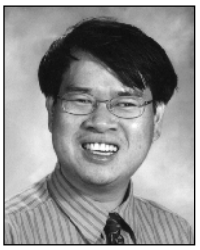
Best wishes, Jack ▲



1. United States
2. Canada
3. France
4. Britain
5. Belgium
6. Luxembourg
7. Netherlands
8. Norway
9. Denmark
10. Iceland
11. Italy
12. Portugal
13. Greece
14. Turkey
15. Germany
16. Spain
17. Poland
18. Hungary
19. Czech Republic

▲ Get Interactive!

Louis Lim



Louis Lim is a part-time mathematics teacher at Unionville HS and a PhD student at York University. He is currently completing a 3-year term as an editorial panel member of the NCTM's Mathematics Teacher and is a former editor of the OAME Gazette*. In the spring 2005, he was the recipient of OAME's "Exceptional and Creative Teaching in Secondary Mathematics" award.*

In this edition of *Get Interactive!*, I feature 2 electronic columns written by Ivars Peterson, a keynote speaker at the OAME 2000 annual conference in Ottawa. Peterson is author of numerous books, including *Fragments of Infinity: A Kaleidoscope of Math and Art* and *The Mathematical Tourist: Snapshots of Modern Mathematics*. He has also written *Math Trek: Adventures in the Math Zone* and *Math Trek 2: A Mathematical Space Odyssey*, geared towards elementary students. Each column is short and concise and seeks to convey the importance and elegance of (often contemporary) mathematics. Get Interactive! ends with links to celebrate π day on March 14.

1. Ivars Peterson's *Math Trek*

http://www.maa.org/news/mathtrek.html

Peterson writes a weekly electronic column for the Mathematical Association for America (MAA), called *Math Trek*. Entries in the year **2005** include whether to "park and walk" or "cruise the parking lot" to locate a parking spot at a busy shopping mall (December 12); a variation of the birthday problem (50% chance at least 2 people in a room of 23 people will share the same birthday) to how many students does a teacher need to call on before there is a birthday match? (April 25); Mersenne primes, with 250 000 computers in the world searching for the next such prime number (March 7) (see **http://www.mersenne.org/** for the 43rd Mersenne prime discovered December 15); a Möbius-shaped snow sculpture (February 7) with photographs of its 5-day formation (see **http://stanwagon.com/snow/breck2005/**); an applet, **http://www-stat.stanford.edu/~susan/surprise/Polya.html**, to explore why 1 restaurant is packed with customers while neighbouring restaurants are almost empty (January 10).

2. Ivars Peterson's *MatheMUSEments*

http://www.sciencenewsforkids.org/pages/puzzlezone/math.asp

Ivars Peterson also writes a monthly electronic column in *Science News for Kids* (aged 9 to 13). Included are: Sudoku puzzles (see **http://www.activityvillage.co.uk/sudoku_for_kids.htm**, suitable for junior students) (October 2005); how a high school student set a world record by folding a piece of paper in half 12 times (July/August 2004); a dog uses a minimum path to run and swim to retrieve a ball thrown at a beach (students can revisit the problem when they take calculus down the road – no pun! (January 2004); mathematical analysis of *Monopoly* (January 2003); why you wait a long time only to find several transit buses arrive together (December 2001); the mathematics of juggling (February 2000).

3. Celebrating ∏ Day

With March 14 being π day, please plan to celebrate this special day with your students. Unfortunately, π day is during the March Break this year so an early or belated celebration is suggested. Books written about this fascinating irrational number include *Sir Cumference* and the *Dragon of Pi: A Math Adventure* and *The Joy of* π . Further, π has been calculated to 1.24 trillion decimal places using a supercomputer and has been recited to 83 431 decimal places by a 59 year old Japanese health counselor[1]. Here are some wonderful websites to help celebrate π:

- **http://www.mathwithmrherte.com/pi_day.htm** for a collection of activities suitable for elementary and high school students to celebrate π day.
- **http://home.gwu.edu/%7Eottmanl/ottmanpresent/frame0001.html** for photographs of *Sliding Pi* at the Downsview Subway Station in Toronto. The coloured tiles are based on the digits of π.
- **http://www.avoision.com/experiments/pi10k/pi10k.html** for a musical sequence using the first 10 000 digits of π. You are able to choose from C, A, G, and F major scales or select a randomly generated scale.
- **http://www.123greetings.com/events/pi_day/** to send a free electronic π greeting card. ▲

[1] *Source: http://news.bbc.co.uk/1/hi/world/asia-pacific/4644103.stm*

▲ Photo Math - A New Way of Picturing Math

RON LANCASTER
INDEPENDENT MATHEMATICS CONSULTANT



Ron Lancaster is a Lecturer in Mathematics Education at the Ontario Institute for Studies in Education at the University of Toronto. He is also an independent mathematics consultant and works with teachers, students and educational organizations in North America, Asia and Israel.

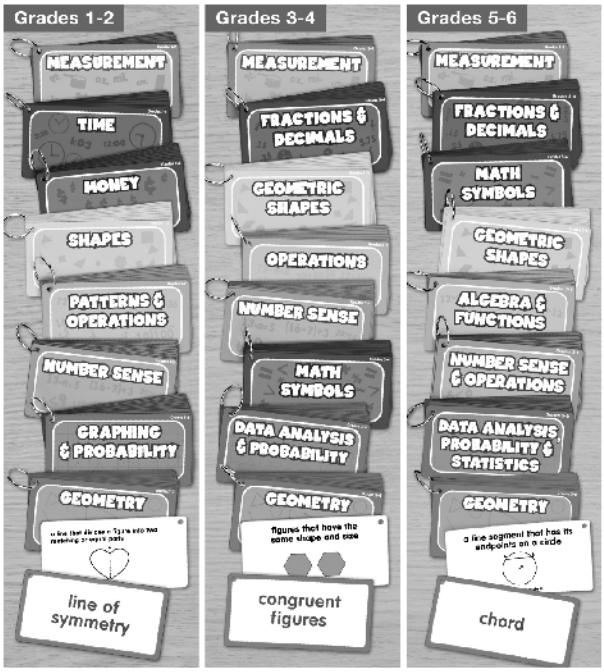
"A picture is worth a thousand words" is an expression that is often used to convey the importance of using images to make a point. The point of this column is to go beyond this notion and promote the idea that in fact "A picture is worth a thousand numbers". Photos with Math is what readers can expect to find in every Photo Math column and the emphasis will be on seeing and doing mathematics everywhere. Teachers may want to assign these questions to their students as part of an overall effort to make connections between the curriculum and the world around us. Establishing these connections is at the heart of the new Ontario curriculum as well as the new NCTM document, *Principles and Standards for School Mathematics*. It is hoped that these questions will inspire students to be more creative and playful and that in the end, students will develop an ability to see the world from a different perspective.

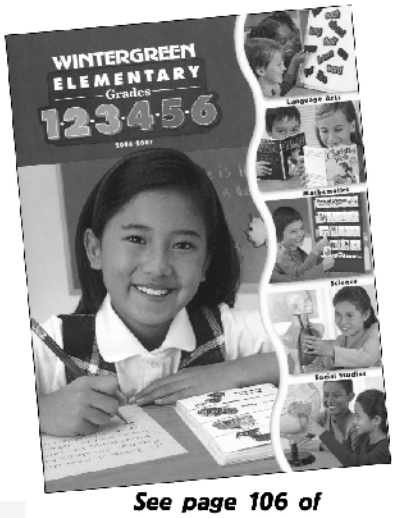
Teachers and students are encouraged to pose mathematical questions related to their own encounters and to submit these problems along with photographs to the author for possible publication in future columns. Photos can be sent via e-mail or by regular mail to the author of this column.

Introductory Comments

In order for you to get ready to celebrate π Day on March 14, the column for this month contains photos of π. I have not included any questions to go along with these photos since there is no shortage of material posted on-line for teachers to use on π Day.

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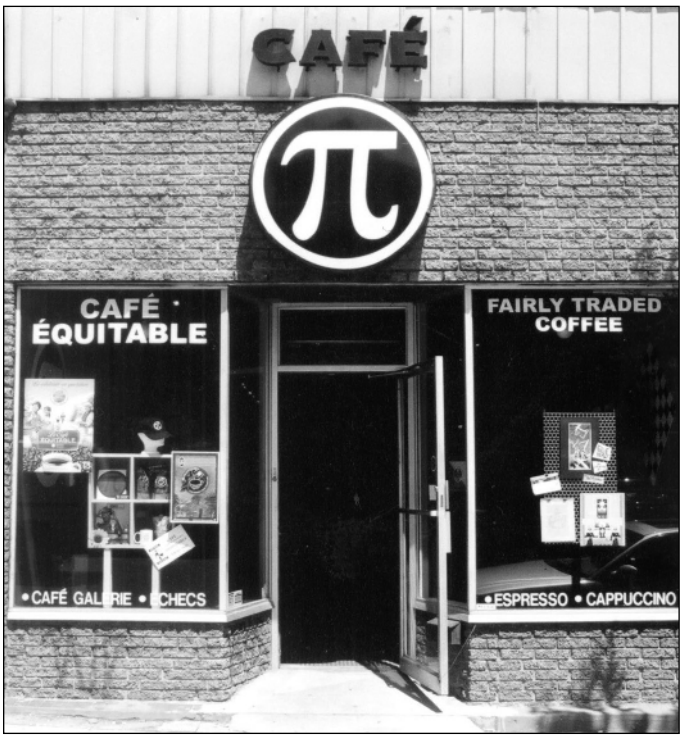
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The first two photos were taken by myself in Montreal in front of the π Cafe located at 4127 Boul. St. Laurent. The owner of this cafe loves math and he sells π t-shirts and mugs. People play chess while they dine and it is fun to either play or just watch a game. The phone number of the cafe is 514-286-4828.





The next photo was taken in Seattle by Ann Coiner, a friend of mine who has taught mathematics in the US and internationally for many years. Ann also worked for Schoolkit.com and is now employed by Sylvan Learning. The beautiful sculpture of π that Ann photographed was created by Micajah Bienvenu and is on display at the Harbor Stairs in downtown Seattle. Bienvenu's sculptures are highly engaging and very playful.



For more information about his work, go to **http://www.artmb.com/** Follow the link to New Sculpture.

Additional photos of Bienvenu's work along with other photos can be found at the following websites.

- I have encountered pi: **http://pc40s.blogspot.com/2005/02/i-have-encountered-pi.html**
- Mark and Meg's Photo Gallery: **http://www.markandmeg.com/gallery/Potlatch2005/IMG_0916**
- Pi Squared by Mavrik: **http://www.dpchallenge.com/image.php?IMAGE_ID=17512** ▲

▲ Assessment Corner: Your Feedback to Students Matters!

CHRIS SUURTAMM



Chris Suurtamm is an Assistant Professor of Mathematics Education at the University of Ottawa. She is an experienced mathematics teacher who is committed to helping teachers with the implementation of the new curriculum and assessment practices.

This article focuses on feedback to students and the important role that a teacher's feedback plays in the engagement or disengagement of students. I recently heard a talk about a research project that looked at the factors contributing to students leaving secondary school before graduation (Ferguson, 2006). Although the factors that influence student disengagement from school are complex, the key findings indicate that suggestions for the development of policies and programs to retain youth fall under three principles: "be more understanding, be more flexible, and be more proactive in reaching out to youth, families and communities" (p. 6). Ferguson also emphasized the important role that a teacher plays in engaging students in school. He summed it up by saying that teachers need to show that they care.

The discussion of the important role that teachers play connected to my own research with prospective elementary teachers and in particular, to how teachers can help to interest or disinterest students in mathematics. My colleague, Barbara Graves and I are working with prospective elementary teachers in a week-long summer math program to enhance their understanding of mathematics. We gather data through questionnaires and focus groups, before, during and after their experiences in the summer program. In fact, we follow some of them as they begin their first few years of teaching. Many of the participants attend the summer program (a.k.a. math camp) because they are uncomfortable with mathematics, have math anxiety, or are concerned that they don't know enough mathematics to be able to teach it. There are a few others who attend math camp because they love doing math and want more exposure to it, or want to review the math they once knew. In the first questionnaire which is given the night before math camp starts, we have the participants describe their relationship with math with reference to their previous math experiences. In many cases, we hear of teachers who strongly helped or hindered their understanding and confidence with mathematics.

There are some who talk about the important positive role that particular teachers played in helping them understand mathematics or made the experience enjoyable. Here, two participants talk about teachers whose creativity or enthusiasm made math fun.

> *My most memorable experiences with math were with great teachers in grades 7 and 9. Teachers who LOVED math and wanted to share it.*

> *My memory of math begins around grade 9. I had awesome teachers in math who made learning it fun, such as opening the windows in winter for a "polar coordinates" lesson, and giving ample opportunity for extra help and math contests.*

Another shares the idea that the teacher provided opportunities to work together and discuss problems and to use diagrams and visuals to help to solve problems which provided an expanded view of mathematics.

> *The most fun I've ever had with mathematics was when I was in grade 4 in Mr. Smith's [pseudonym] class. Everyday, he would write a new word problem on the board and the class would have to work to solve it. We were allowed to discuss the problems in groups, so we got to share our ideas. Mr. Smith also encouraged us to illustrate the problems, which I enjoyed, since I'm more highly visual. I've always enjoyed mathematics, but I'll admit that some of the concepts aren't always easy for me to grasp.*

In contrast to an open-ended problem solving approach, some were most comfortable when there was a certainty to the mathematical approach or the use of an applied set of rules.

> *I used to be very comfortable with math in elementary school. I guess I was always comfortable with rules and applications that were repetitive, because all you needed was practice and memory to do well. After getting to high school, competition from other students could be intimidating, along with some teachers and some difficult concepts.*

However, others did not appreciate the message that there was only one way to do a question.

> *I have always been told "you just do it that way". I never experienced a teacher growing up that was excited about teaching math or made math fun. My lessons always included a demonstration question done by the*

teacher on the chalkboard and then the class did similar problems individually afterwards.

Although a student may have had some positive experiences, there are frequently comments about a particular teacher who turned them away from mathematics.

My grade 12 math teacher simply assigned pages from a text to read and complete. The following day, students were given a sample of the questions to do on the board and two of the male students would correct and explain them.

Some students felt intimidated by the teacher's opinion of their math ability. Some were told that they would never be able to do math.

I always felt comfortable with math until grade 8 when I asked the teacher a question and she told me that I would never be a math person!

Math is a great source of anxiety for me, which is one of the reasons I have signed up for this math camp. I have had very negative experiences with math, most notably in grade 8 where I could not complete a problem and the teacher made me sit at the back of the room and called me stupid.

As we see above in many cases, students can often pinpoint the exact grade or topic that created the stumbling block. Often the student sees this as the end of their career in math. For some, it is learning the multiplication tables.

In grade 3, I had a whole lot of substitute teachers. That was the year we started multiplication. I started to lose ground in math that year. I feel I never got my feet back under me for math again. I was trying, but the world of math and my confidence in it just got smaller and smaller.

I did not learn my multiplication tables until grade 5 when my teacher finally noticed. She made me play the multiplication rap to learn.

There are several instances where students report being given strong impressions that mathematics was for boys and not for girls.

I used to like math. However, in grade 11 I had a math teacher who scared me. I was afraid to ask questions and the class was (or seemed to be) more for boys. I ended up failing grade 11 and took it in summer school. After that, I never took math again.

In grade 12 I had a particularly boring teacher and just squeaked through. His explanation was that girls usually reach their potential at this level. I went on to complete 2 first year university math courses with honours just to prove him wrong. The teacher makes the difference.

My experience with math is fairly stereotypical. Girls were bad at math and boys are good with math.

Most of the stories tell of ups and downs with math and the students connect these roller coaster rides with the teachers who taught the classes.

During junior high I recall feeling very interested in math as a result of the excitement of the teacher. Throughout grades 9 – 10, my excitement and confidence dropped and I detested math all together as I averaged 55-60%. During grades 11 and 12, I was fortunate enough to have a more enthusiastic teacher and my experience was more positive averaging higher grades and enjoying the learning. So, reflecting back I can attribute the approaches that were taken by teachers as huge factors in my mathematics learning curve.

The most exciting stories are those where a teacher has been able to turn around a student's negative attitude towards math.

I can remember several bouts of math anxiety throughout my life. However, in grade 9 I had a teacher who took the time to make math make sense in my world. I, to this day, owe him so much! In high school I went on to love math and even helped others with math in the peer help centre. In fact, I thought of teaching high school math when I left high school – that's how much I loved math!!

I remember learning my multiplication tables and the teacher who taught them to me. I don't know what it was that makes that aspect memorable, but I can still remember sitting in her classroom in grade 2/3. I also enjoyed OAC Algebra & Geometry and I owe that to the wonderful teacher I had. That was my favourite course in high school!

I share these stories to remind us that what teachers say and do in a classroom is crucial to how a student views mathematics and how the student views him or herself as a mathematics learner. I would suggest that our goal in mathematics education is to increase the number of positive stories through connecting with mathematics and with students in ways that engage each student in mathematics and that value each student as a mathematics learner.

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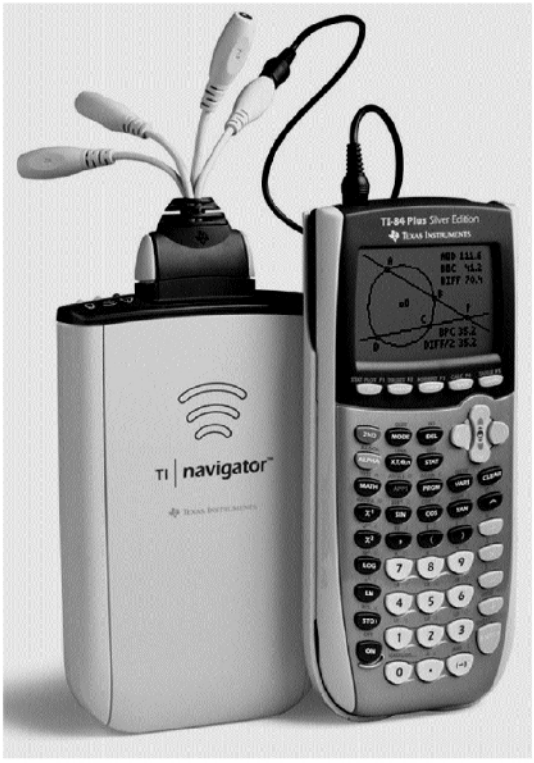
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▲ In Memorium

A good friend, Ray Nowak, passed away on November 10 after a lengthy battle with cancer. I was surprised to find out that he was 59 years old. He just never seemed to be that old.

Prior to retirement in 2002, Ray had been the Head of Mathematics at Bramalea SS in Brampton, Ontario for 15 years and a consultant for gifted education for mathematics for the Peel Board of Education for several years before that. Ray was well known outside of just Peel thanks to the many workshops he conducted at annual OAME and NCTM conferences and various local math association PD events. He presented often on his own, but was a wonderful mentor and co-presented with other speakers such as Most math teachers outside of Peel might have enjoyed sessions that Ray conducted at annual OAME conferences, often by himself and frequently with speakers such as Kevin Spry and James Harris who worked with Ray at Bramalea. In addition to workshops Ray wrote articles for the OAME *Gazette* and was an author of a book entitled *Mathematical Peepshows* published by Brendan Kelly.

His department was always a leader in the use of technology in the mathematics classrooms and everything that I do with graphing calculators started during the four years that I enjoyed his leadership. Ray had a very different way of looking at mathematics and often combined numerical approaches to topics in calculus long before the calculus reform movement indicated that we should be doing this.

Ray had two passions outside of teaching. He was an exceptional keyboard player and had joined a number of bands in the Toronto area. His contacts within the music community were numerous and he was friends with a number of Canadian musical icons from the sixties and seventies. His musical interests found theire way into his classrooms where he taught a unit on music and mathematics, using sine waves produced by software to generate musical tones. This lead to another book entitled *Sin and SynthMathematical Peepshows*.

His other passion was his family. Ray married Haiyan after leaving teaching and is survived by Haiyan and a son Jacob. He lost part of a leg to bone cancer in 1995 and came through that recovery with the most amazing positive attitude possible. However, cancer caught up to him shortly after his son was born. When I spoke to him last spring, he knew the end was coming and looked at each day as a gift.

Those of us who knew him well appreciated the gift of knowing someone who truly cared about friends and inspired a number of us to be much better teachers.

Donations in memory of Ray can be made to St. Michael's Hospital Pallative Care Unit. ▲

▲ Math Monsters: A New Adventure in Math, Art and Procrastination

MARIA CASASOLA

Maria Casasola is a grade eight math and art teacher at Claude E. Garton School in Thunder Bay, ON.

A few years ago a student teacher gave me a plaque with the phrase, "Leap and the net will appear". I guess she had been paying attention when I said that we all needed to take chances with our teaching. Sometimes we need to take on projects even if we aren't exactly sure how they are going to turn out. Once you leap you have to figure it out before you splatter on the pavement below. There's nothing like looming disaster to promote creative problem solving.

That's where these math monsters come in. A few years ago my local chapter put on a math conference and I had been given the task of creating math centerpieces with my grade eight students. It was a bit last minute and I was pleasantly surprised when it all turned out. This time around, I had two years notice. I wanted to do something a little different this time. Two years is a long time to mull things over. Perhaps, it was too much time to generate, dismiss ideas and dare I say, procrastinate. What was I going to do? Time was running out.

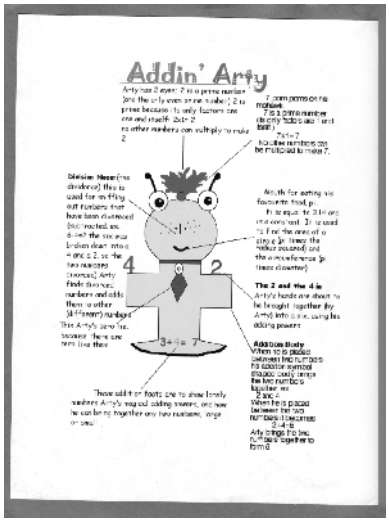
As I walked down the hallway in the primary wing I saw a drawing of a monster. A little idea started to form in my head. From previous experience I knew that I could have students combine art and math. Could they combine monsters and math and make them into centrepieces? Would they stand up on the tables or fall into the soup bowls? Would the students be able to pull enough mathematical ideas out of their monsters to satisfy the demanding math teacher in me?

It was time to leap and have faith that we would figure it out together before we crashed into our deadline. The student response was enthusiastic although many needed a lot of encouraging and threatening to elaborate in writing about the math powers their monster possessed. Staff and students at our school were curious about what we were doing. They wanted to come and meet the monsters and I am not referring to the grade eights. I loved watching my intermediate classes

take the time to explain to the primary students about the math in their monsters. It was satisfying to share the positive response from the conference participants with the students. My faith was not misplaced.

Mathematical Monster Mathzilla

Mathzilla was hatched in the brain of a very disturbed math teacher in the fall of 2005. She spent her earliest months as a sketch. She finally was realized in the flesh (paper mache) in the fall of 2005. Her favourite past times are prime factorization, logic problems and chess. Her future goals include being the first math monster to the moon and taking over cities in Northwestern Ontario. Her favourite math quote is from Aristotle, who said, "Numbers rule the universe".



Your class has been commissioned to create mathematical centrepieces for an upcoming math conference. You and a partner need to create a mathematical monster as a centerpiece for the table. It must please your eyes, as well as your mathematical mind.



1 Monsters Addin' Arty and James Isaac Mewtan and with the students who brought them to life. 2 Two thumbs up for Pi Fighter. 3 This monster eats numbers and poops out the prime factors. Only intermediate boys could so artfully combine bathroom humour and math. 4 This monster divides by prime numbers to find the greatest common factor. 5 This is Error. He is part calculator and all monster. 6 These students triumphed over many technical difficulties to put Chico together. 7 Prime Kitty is under construction. 8 Hanging out with the boys. 9 The math monsters at the conference. 10 The Oddosaurus and its creators chat with their curious fans.

You will be making an armature (body) out of a balloon, newspaper, tape and whatever else will work. You may even use some paper pulp to model (sculpt) some interesting details. Found objects are also acceptable. As this is sculptural, ensure that your final product looks good from all viewpoints.

To accompany your monster there will be a written explanation including illustrations about all the mathematical powers your monster has.

Expectations

- communicate mathematical thinking orally, visually, and in writing, using mathematical vocabulary and a variety of appropriate representations, and observing mathematical conventions
- can produce two- and three-dimensional works of art that communicate a variety of ideas (thoughts, feelings, experiences) for specific purposes and to specific audiences,
- can describe, in a plan for a work of art, the main idea to be communicated and the artistic decisions made to support that message

Steps to Success

1. Find a partner and brainstorm ideas about math that your centrepiece will communicate. Look at the art materials and the math materials that your teacher has provided.
2. Sketch out some of your ideas. Try a number of different approaches.

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3. Create the body of your monster. Balloons, paper mache and paper pulp work well.
4. Use paint and any other materials (foam, feathers and pom-poms) to bring your monstrous math ideas to life.
5. Create a shutter book (look at the sample your teacher has created) explaining all of the mathematical powers your monster has. You will need to have a brief biography, labeled diagram, name plate and some action scenes (think comic strip).
6. Submit centrepiece and shutter book. ▲

MATH COMMUNICATION The conveying of meaning through various forms			
LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
- expresses and organizes mathematical thinking with limited effectiveness - uses conventions (spelling, grammar, symbols, terms), vocabulary and terminology with limited effectiveness	- expresses and organizes mathematical thinking with some effectiveness - uses conventions (spelling, grammar, symbols, terms), vocabulary and terminology with some effectiveness	- expresses and organizes mathematical thinking with considerable effectiveness - uses conventions (spelling, grammar, symbols, terms), vocabulary and terminology with considerable effectiveness	- expresses and organizes mathematical thinking with high degree of effectiveness- uses conventions (spelling, grammar, symbols, terms), vocabulary and terminology with high degree of effectiveness
ART			
LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
- applies few of the skills, concepts and techniques taught (assemblage, paper mache, painting, modeling) - communicates math ideas in limited and incomplete ways - centerpiece is only visually appealing from a single view through the limited use of design principles and details.	- applies some of the skills, concepts and techniques taught (assemblage, paper mache, painting, modeling) - communicates math ideas in complete but simple ways - centerpiece is visually appealing from some views through a partial use of design principles and details	applies most of the skills, concepts and techniques taught (assemblage, paper mache, painting, modeling) - communicates math ideas in complete ways with increasing sophistication - centerpiece is visually appealing up close and from a distance through the use of design principles and details	applies all (or almost all) of the skills, concepts and techniques taught (assemblage, paper mache, painting, modeling) - communicates math ideas in complex and well-developed ways - centerpiece is visually appealing up close and from a distance through the complex use of design principles and details

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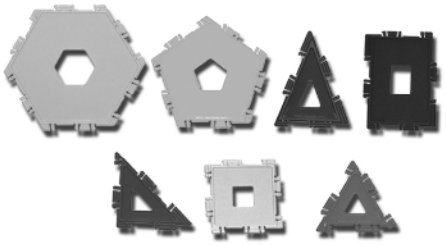
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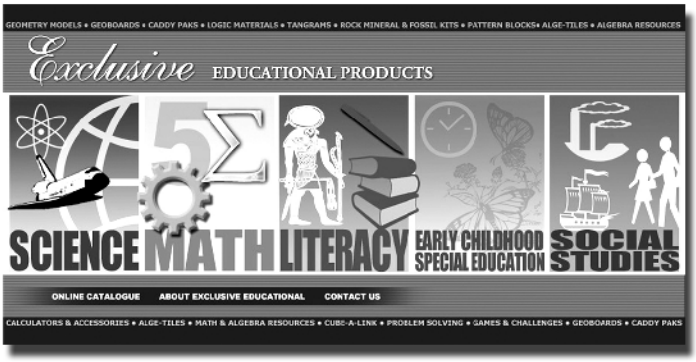
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▲ The Impotence of Being Ernest: Deskside Reflections of a Mathematics Student at Risk

Daniel H. Jarvis



Dan Jarvis is a mathematics and visual arts educator. As a doctoral candidate at the University of Western Ontario, he is presently focusing his research on curriculum negotiation and professional development models for mathematics educators.

Ernest: I hate math. I don't much like school in general, but I sure hate math—especially with Mr. Moribund[1]. Nothing makes sense—nothing he does or says makes the least bit of sense to me. Boring.

Recognizing and Understanding the 'At-Risk' Mathematics Learner

Ernest is a fictitious compilation of many actual "at-risk" student voices which the author has had the privilege of hearing while teaching mathematics at the secondary level. As such, Ernest represents one of the many students within the educational system who struggles with academics, and particularly with the subject of mathematics. He has been labelled, as have thousands of others like him, as a student "at risk of failure". A brief survey of the research and literature will provide us with a better understanding of some frequent characteristics of at-risk learners, how student and teacher perceptions affect achievement and various teaching and learning strategies that can be effective in dealing with this student population.

Frequent Characteristics

While a profile of the at-risk learner can vary among research reports and related texts, certain characteristics are frequently described. Vatter (1992) summarizes these as follows: "poor self-concept; poor academic performance, high absenteeism and discipline problems; low aspirations and parents or guardians with low expectations; low family socioeconomic level; non-traditional family life, often with a single or foster parent or with a stepparent; inadequate goals and lack of future orientation" (p. 292).

With specific reference to the discipline of mathematics, researchers Haylock and D'Eon (1999) list six factors related to low achievement in this discipline: (i) reading and language problems; (ii) perceptual problems; (iii) attention deficit disorder; (iv) social problems; (v) learned disability; and (vi) mathematics anxiety (pp. 3-7). Regardless of which factors are more predominant, or their specific origins, the fact remains that these characteristics often lead to a vicious, downward spiral of failure for the at-risk learner.

Perception and Realities

Vatter (1992) indicates that low motivation among low-achieving students causes them to form very negative perceptions of school. He notes that "once caught up in a cycle of perceived failure, the at-risk student has difficulty breaking out of it", highlighting the ironic reality that "In fact, many of these students are so accustomed to failure that they don't believe their success, even when it has been pointed out to them" (p. 292). Student perceptions and resulting actions are inextricably tied to teacher perceptions and consequent teacher behaviour in classrooms. Dunn (2004) notes that much of at-risk students' difficulty in mathematics actually derives from how they are taught mathematics, which is commonly a function of corresponding low expectations of teachers for these students. She explains how "learners labelled as less capable than their peers are taught less mathematics and are presented with skill-oriented, direct instruction and practice rather than conceptually focused instruction promoting problem solving and understanding" (p. 47). Such instruction often fails because it reinforces learners' negative self-perceptions and deprives them of challenging mathematical learning; low teacher expectations are merely fulfilled.

As we have seen, the at-risk learner is a complex amalgam of nature, nurture, and nomenclature. While many of his difficulties in achieving success at school may indeed be traceable to conflicts within his home and community, much of his inability to rise above his past and present performance is directly tied to the way in which he is labelled, devalued, and treated accordingly by his instructors. Oddly enough, these well-intentioned teachers, struggling to maintain standards, manage behaviour, and meet curricular expectations, are often unaware of the negative effects they are having on students with these

[1] Moribund and Viveray represent fictional and arguably somewhat extreme characters, whose gender could just as easily be switched, and whose existence in the narrative primarily serves to provide the reader with "traditional" and "reform-oriented" versions, respectively, of classroom mathematics teaching.

particular challenges within the daily classroom experience. Before we discuss specific strategies for increasing the opportunity for success with these students, let's turn to the broader issue of positive school and classroom environments, with a special focus on the teacher-student relationship and the parent connection.

> *Ernest: I asked a question once in math class—I thought Mr. Moribund might at least be pleased with my interest and effort. But he only laughed and made fun of my simple comment. It made me feel so terrible in front of everyone that I swore to myself that I'd never say a word in his class again. He has his classroom favourites, that's for sure. They are always answering his questions, which is actually okay because then he never bothers me in the back. I wonder what school is like when you're smart? I don't remember Mr. Moribund ever saying anything nice to me, not that I'm extra friendly with him. All of my teachers are like that, though. If I can't do what they want me to, I guess I'm just not worth bothering about. We all know I won't finish school anyways, so who cares?*

Building Meaningful Communities for the At-Risk Mathematics Learner

Learning can rarely take place in a school or classroom environment in which the student feels unsafe physically, emotionally, or intellectually. Perhaps the reader is familiar with the well-worn teaching chiasmus[2], "They do not care how much you know, until they know how much you care." Students can easily sense genuine levels of passion (for the subject matter) and compassion (for them); in many cases, a lack of the latter, outside of the school setting, renders this sense of awareness all the more keen and accurate. Students cannot, and will not, progress academically until their affective needs are being met.

Classroom Environment

One of the six key principles listed by the National Council of Teachers of Mathematics (2000) is that of the Teaching Principle, within which the authors expand on the need for teachers to provide challenging and supportive classroom learning environments: "The teacher is responsible for creating an intellectual environment where serious mathematical thinking is the norm. More than just a physical setting with desks, bulletin boards, and posters, the classroom environment communicates subtle messages about what is valued in learning and doing mathematics" (p. 18). This environment takes a great deal of energy, enthusiasm, and patience to establish, particularly when dealing with at-risk learners. For example, these students may think nothing of ignoring routines at the beginning of a new class or school year, perhaps even directly confronting or abusing the teacher verbally. Resources may not be treated with care, homework may be chronically left unattended, and students may tend to balk at opportunities to discuss or communicate their ideas in class.

Teacher-Student Interaction and Caregiver Involvement

It has been well-said that teaching and learning strategies that are effective for at-risk students are indeed "good for all, but necessary for some" (Expert Panel on Student Success in Ontario, 2004, p. 42). I believe that this significant qualifying statement applies equally as well to the classroom environment and teacher-student relationships (reaching them) as it does to the strategies that are required to successfully instruct at-risk learners (teaching them). All students, whether in senior kindergarten or senior secondary, need to know that they are safe to exist, to explore, and to express themselves in the mathematics classroom. The at-risk learner desperately needs this emotional support, and may not function at all, or even attend school and class, without it. The teacher of low-achieving students can and must attempt, first and foremost, to develop a strong, consistent, and trusting bond with each of these children or young adults.

Parents and guardians also play a huge role in a child's education. According to Onslow et al. (2002), "Research has clearly indicated that children's attitudes towards mathematics are strongly influenced by the attitudes of their parents" (p. 6). Therefore, teachers should make every attempt to keep caregivers informed, for example, by newsletters, and to promote their active involvement in the mathematics learning of their son or daughter. Unfortunately, however, many caregivers of students at risk of failure are often unwilling or unable to provide home encouragement regarding daily mathematical practice and assignments. Notwithstanding this lack of participation, Karns (2005, p. 13) cautions against negative teacher responses to at-risk student behaviour, which often include the direct or indirect blaming of caregivers, and which, in turn, increase the cycle of stress and failure for these students and their families.

With a supportive classroom environment established, and with positive school-home connections at least attempted, teachers of at-risk students are now

[2] Chiasmus is a rhetorical figure in which words, grammatical constructions, or concepts are repeated in reverse order, in the same or a modified form.

better-prepared to commence explorations into effective teaching and learning strategies that will potentially yield academic development for each learner.

> *Ernest: At the beginning of every math class, Mr. Moribund walks up to the chalkboard and then starts writing examples and talking at us. I look around, and apart from the few keeners in the front, everyone looks as bored and lost as I am. That makes me feel good, at least. Mr. Moribund tends to mumble and he often gets mixed up—sometimes we'll wait a long time for him to find his place again on his page. He usually goes way too fast, and so even when I try my best to follow along and make some notes, I get lost on the first few steps. After that, what's the use? I pretend that I'm still writing, of course—I don't want him giving me a hassle. Math is really hard—I just don't understand it at all. Besides, when will I ever use this stuff again?! Once he's finished the lesson, he assigns the same predictable list of questions from the textbook. Row after row, page after page—but if you can't do the first two or three easier ones, which I usually can't, you've had it. I refuse to ask him for help, and he certainly doesn't make any effort. He never leaves his desk. Lots of kids talk and pass notes in his class. He ignores most of it, but will sometimes get really hot and mad and then kick us out or give us detentions. As an added bonus, he lists more homework on the board just before the bell because those smart kids have finished everything in class—thanks a lot! It doesn't really matter, though. My books do not go home. I sure hate mathematics.*

Teaching and Learning Strategies for Mathematics Students at Risk

What is it about mathematics that makes it more difficult for the at-risk learner to succeed in, compared to the other core subjects? Haylock and D'Eon (1999) list and explain nine factors that they claim make mathematics, as a discipline, so very hard for students to learn: "(i) characteristics of school mathematics and the way it is taught, (ii) right or wrong, (iii) cumulative effect of failure, (iv) accuracy and concentration, (v) abstractions and symbols, (vi) unstable truths and models, (vii) complex language patterns, (viii) the overuse of the text, and (ix) an over-emphasis on individualized learning" (pp. 25-35). According to Braselton and Decker (1994), mathematics is the most difficult content area material to read because "there are more concepts per word, per sentence, and per paragraph than in any other subject," and because "the mixture of words, numerals, letters, symbols, and graphics require the reader to shift from one type of vocabulary to another" (p. 276). So again, whereas all students may find mathematics challenging due to the nature of this dense text and the high level of literacy required to understand and solve problems, the at-risk learner can become all that much more frustrated given these particular challenges.

Many and varied are the teaching and learning strategies regarding the needs of the at-risk learner (Expert Panel on Student Success in Ontario, 2004; Smith & Geller, 2004). To simplify this wealth of information, the following four categories of factors will be discussed throughout the remainder of this article: (i) communication and good questioning; (ii) adequate challenge and scaffolding; (iii) active learning and extended projects; and (iv) formative and varied assessment.

Communication and Good Questioning

Much of the at-risk students' lack of progress centers on the infrequency of their mental and verbal participation in the learning. Teachers are largely responsible for this latter problem, in that they control and direct the quantity and quality of the verbal exchanges made during an average classroom experience. Reinhart (2000) summarized the most important things that he has found to work successfully in his classroom practice, in terms of increasing the amount and effectiveness of classroom communication and appropriate questioning. His five rules of thumb, or guiding principles, are these: (i) never say anything a kid can say!; (ii) ask good questions; (iii) use more process questions than product questions; (iv) replace lectures with sets of questions; and (v) be patient—wait time is very important. Perhaps the most powerful statement made by this math teacher was his profound confession, "I am convinced that children learn in more ways than I know how to teach" (p. 483).

Likewise, Craven (2000) strongly emphasizes the importance of good mathematical communication, providing ideas for the recording and sharing of students' learning (e.g., journal entry/learning log, report, poster, letter, story, three-dimensional model, sketch/drawing with explanation, oral presentation). He challenges all mathematics teachers by asserting that, "Children must be empowered to take risks and encouraged to explain their thinking. Teachers must construct tasks that will generate discussion and provide an opportunity for students to explain their understanding of mathematical concepts through pictures, words, and numbers" (p. 27).

Not only must mathematics teachers challenge their students with appropriately-crafted and timed questions, they must also consider how to orchestrate the entire

learning experience in such a way as to provide adequate and significant levels of challenge[3] for all at-risk learners, in most classroom activities.

Adequate Challenge and Scaffolding

Despite the fact that the at-risk mathematics student finds learning difficult, he/she must still be adequately challenged in day-to-day activities. It is only in this way that students will be able to grapple with, what Piaget referred to as, "disequilibrium" or "cognitive dissonance," and in so doing, reinforce existing neural connections and also develop new connections and deeper mathematical understanding. Martinez and Martinez (2003, pp. 29-30) likewise discuss the recognition, and powerful potential, of "eustress" (good stress)—as opposed to "distress"—in helping children learn mathematics. Chatterley and Peck (1995) describe how even the most well-intentioned teacher can rob students of mathematical learning: "If we understand the process necessary to provide the referents within the minds of our students, we will cease to mentally cripple them by being overly kind and sympathetic and by helping too much and often far too soon" (p. 436). Notwithstanding the need for challenge, teachers must also take pains to not overly swamp the at-risk student with learning tasks that are too far above, or ahead of them (Turner & Meyer, 2004, p. 312). Tomlinson (2001) notes that "when a student continues to work on understandings and skills already mastered, little if any new learning takes place. On the other hand, if tasks are far ahead of a student's current point of mastery, frustration results and learning does not" (p. 8). Both extremes are obviously to be avoided—the secret lies in finding the right combination of applied mystery and mastery.

The Russian psychologist, Lev Vygotsky (1930/1978), developed an insightful educational theory which he referred to as the Zone of Proximal Development (ZDP)—the difference between the learner's capacity to solve problems on his/her own, and his/her capacity to solve them with external assistance. According to this theory, the teacher's role is to provide appropriate instructional scaffolding and non-intrusive, relational support in order to maximize student achievement within his/her ZDP. For the at-risk student, this scaffolding may involve carefully-prepared worksheets that provide a framework for new learning; formative assessment of student skills and comprehension; or simply positive, consistent verbal coaching that reinforces the bond between student and teacher. Adequate and appropriate scaffolding allows the teacher to extend and maximize the degree of challenge for each low-achieving student.

Thus far, we have noted that the at-risk learner must be encouraged to communicate via good teacher questioning and listening, and that he/she must be adequately challenged and provided with appropriate scaffolding. Next, we must consider the learner's need to move around, to explore math via investigations, and to personalize projects that are at once meaningful and in keeping with the curriculum.

Active Learning and Extended Projects

Active learning allows students to actively take part in the learning process by manipulating concrete materials, using calculators and other technology software, moving around the room or school during investigations, and working in groups. While all of these activities possess great potential for student engagement and learning, teachers must carefully prepare students for the inherent freedom involved in these assignments. In other words, rich and meaningful cooperative learning does not just magically happen by rearranging desks and bodies (Expert Panel on Student Success in Ontario, 2004). Furthermore, active learning is truly only successful insofar as it leads students from tactile, physical representations to more abstract mathematical ideas. While free play with manipulatives at the start of a lesson, for example, is valuable as part of an introduction to learning, structured play, or guided exploration, with the assistance of a well-informed and organized teacher, is essential for students to acquire and construct deeper mathematical understanding during active learning experiences.

Mathematics assignments and projects should also be meaningful, authentic (e.g., tied to real-world contexts), and challenging (National Council of Teachers of Mathematics, 2000, pp. 18-19; Ontario Ministry of Education and Training, 1999, p. 4). One very interesting teacher journey is that of Robert (2002), who tells her story of moving from a high-achieving school, in which her extended classroom projects were welcomed and enthusiastically participated in, to another school of predominantly at-risk students, in which these assignments were not originally well-received. However, through exploration, observation, student feedback, and teaching modifications, she managed to successfully challenge and support her group of low-achieving students. Based on her experiences, she warns fellow teachers that, "Once we say that some children are not capable thinkers or problem solvers, we have all but

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[3] *See, for example,* Tomlinson's How to Differentiate Instruction in Mixed-Ability Classrooms *(2001), or visit OME's* Leading Math Success *(2006) website* ***http://www.curriculum.org/lms/index.html*** *for strategies used in challenging all learners.*

guaranteed that they will not be so," but then adds, with enthusiasm, that "if, instead, we recognize that students gain confidence in themselves through experience with problem solving, we will be surprised by what our 'low achievers' accomplish" (p. 294). Similarly, at the secondary school level, Vatter (1992) found that by using a completely project-based approach, involving student choice, hands-on learning, and authentic, relevant topics, his low-achieving mathematics students covered the same curricular expectations yet were much more engaged in their learning.

We have seen that if the at-risk learner feels safe and encouraged to communicate and to participate in meaningful, challenging, and varied assignments, the opportunity for genuine and incremental learning is greatly increased. Now let us consider how that instruction and assessment must also be consistently linked.

Formative and Varied Assessment

Much has been written about the significant difference between "assessment of learning" as contrasted with "assessment for learning" (see for example Consortium of Ontario School Boards, 2003, pp. 21-25). Although difficult for many teachers to understand and thereby implement, assessment can and should be used on a regular basis to provide meaningful and timely feedback to students and parents, and to guide teachers as they modify curricular strategies and assignments. In this sense, assessment does not, and should not, always involve an attached mark or grade. However, this interpretation of assessment is often dismissed by teachers who feel that time spent on assessment that does not render a usable mark/grade, is indeed time wasted; likewise, for students, if the assignment is not "worth marks," they are often not interested in completing it with equal effort. Nonetheless, diagnostic, formative, and summative assessment practices should all be employed by educators in a combined effort to improve student learning.

Not only do mathematics students at risk of failure learn differently, they also often have different needs when it comes to the area of assessment. Multiple strategies should therefore be employed, allowing students to demonstrate what they have learned to the teacher in a variety of ways. Telese (1998) describes how, "High standards associated with the use of equitable practices both in teaching and assessment benefit all students and raise expectations, at the same time, communicate to students how important mathematics is and what are important ways to learn mathematics" (p. 40). Assessment accommodations might include more time to complete tasks, oral assessment, or anecdotal observations during instruction. In all cases, "assessment accommodations are not a 'watering down' of the process but an opportunity for students to show what they know and can do in a way other than originally planned" (Expert Panel on Student Success in Ontario, 2004, p. 39). Linking varied assessment to balanced instructional practices is essential.

Reaching and teaching the low-achieving student represents a complex and difficult task. We have now looked together at four areas which, when explored by informed and energetic educators, may lead to significant affective and academic gains for students at risk of failure. By creating an environment wherein valuation, communication, exploration, and modification are part-and-parcel of the everyday mathematics learning experience, these low-achieving students may indeed become higher-achieving. Courageous and patient teachers must actually court risk in order to prevent these students from succumbing to it.

Ernest: Mr. Moribund was eventually transferred to another school. We had another teacher after that. Her name was Ms. Viveray, and math class was never quite the same. When she talked at the front—which she actually didn't do much—you could hear and even understand what she was saying. I finally got up the nerve to ask a question again one day. She didn't answer it directly though, which I found strange, but



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instead asked me more and more questions until I ended up actually answering the original question myself! Ms. Viveray's classroom was highly unpredictable, but in a good way though. One day we'd be working in groups, the next day we'd be in pairs, and then by ourselves in rows—some days we even did all three. We used all kinds of stuff in class—boxes, egg cartons, construction paper, sticks, stones and other weird props. We were allowed to use graphing calculators in class and we explored neat graphs of different kinds of lines. We even went across to the computer lab a couple of times and tried this shapes program where everything you drew could be moved around, and you could see the angles and lengths changing on the screen as you did it. We often worked on big projects, and even got to choose topics that we liked from her list, or that we made up on our own. The smart kids still did great in math, but everyone else also seemed to eventually "get it". For the most difficult lessons, she would hand out these sheets which helped guide you through the activity—it was still hard and challenging, but you felt like you had just enough clues to get you started. We still wrote tests, but she let us use any of the "objects" we had learned the math with in class, we were given more time if needed, and some kids were even able to explain their answers to her, if they just couldn't figure out how to write their thinking down. Oh, and one other thing, Ms. "V" actually phoned my house one night, and as I handed the phone to my mom, I remember trying so hard to recall what I had done wrong in math class, or at school that day. But I guess she just wanted to talk to her and let her know that I was doing real well—in math class, of all places. I like Ms. Viveray—a lot. I wish more of my teachers were like her. School isn't so bad—maybe I'll stick it out.

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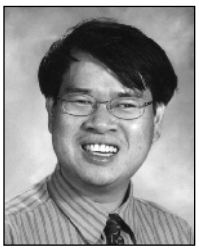
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▲ A Grade 10 Applied Mathematics Summative Performance Task at the Ontario Science Centre

Louis Lim



Louis Lim is a part-time mathematics teacher at Unionville HS and a PhD student at York University. He is currently completing a 3-year term as an editorial panel member of the NCTM's Mathematics Teacher *and is a former editor of the OAME* Gazette*. In the spring 2005, he was the recipient of OAME's "Exceptional and Creative Teaching in Secondary Mathematics" award.*

Introduction

During the first semester of the 2005/06 school year, I[1] taught a grade 10 language intensive applied mathematics course with the Special Education department. My self-contained class consisted of 6 students, each identified with a communication exceptionality. A major aim is to develop effective oral and written skills, and I emphasized the relationship between mathematics and communication: "they communicate to learn mathematics and they learn to communicate mathematically" (NCTM, 2000, p. 60). During the first half of the course, oral communication was highlighted. Students explained their solutions to the rest of the class, making use of the chalkboard or overhead projector. The importance of a learning community was emphasized in the first class to ensure that all ideas and thoughts would be respected and valued. During the second half of the course, writing was emphasized. Students first explained their thinking orally (either to the class or to a partner) and then wrote. Although they found writing difficult, this skill improved with continual practice and with descriptive feedback from me.

The incorporation of alternative assessments, including performance tasks, is particularly important for applied students in order to provide "more opportunities to experience hands-on applications of the concepts and theories" (Ontario Ministry of Education and Training, 2005, p. 6). Connections is 1 of 7 mathematical processes in the revised Ontario mathematics curriculum (2005) and 1 of 10 standards of the National Council of Teachers of Mathematics (2000). Math trails are a marvelous way to connect mathematics with the real-world, which have been presented at recent OAME conferences by Ron Lancaster and published in several journal articles (see references section). Ron also has a regular column, Photo Math, in the OAME *Gazette*, making use of photographs to create mathematical questions.

For the 30% final evaluation in this course, I opted for a performance task at the Ontario Science Centre (10%); hand-in application-type questions (5%); and a final examination (15%). With the first semester ending in late January, the performance task occurred in the second week of December since field trips could not take place after the second week of January. To prepare, I visited the Ontario Science Centre on four occasions and found their website, **http://www.ontariosciencecentre.ca/**, helpful. Fortunately, teacher preparation or pre-visits are free with identification of the College of Teachers record card. Booking the trip was done on-line **http://www.ontariosciencecentre.ca/school/book/default.asp** with a fax confirmation received shortly afterwards. Student admission is $5.00 for the self-guided exhibit hall visit (excluding the Imax films and *Body Worlds 2*, a special exhibit occurring at the time) and teacher admission is free.

The students were informed that the trip would count towards their 30% final evaluation. They were also told the trip would be structured, by completing a workbook, with visits to certain displays in five exhibit halls: Living Earth, Communication, Human Body, Sports, and the Science Arcade. To alleviate anxiety of not remembering the material (e.g., learned at the beginning of the course), my role as teacher would be supportive, through the use of gentle prompts (e.g., "Remember…" or "Remind me…").

The Field Work

Since the Ontario Science Centre opens daily at 10:00 a.m., we arrived 45 minutes earlier to determine the height of the building using right-angled trigonometry; we used the steel pinhole cameras outside the main entrance to help find the height of a tree using similar triangles and solved a system of equations to select between two options to transport the class via a taxi-van. Since the outside weather was -12ºC, we alternated between obtaining data outside and performing the calculations inside.

[1] *In this article, "I", "my", and "me" refer to the author, a classroom teacher.*



Figure 1: Students calculate the height of the Ontario Science Centre after measuring the angle of elevation with a clinometer.

Once indoors, we visited the Living Earth exhibit hall. Students applied their number sense skills using percents and ratios. First, they visited the Treating Water Right station to taste-test the water at three drinking fountains. They inputted their preference (A, B, or C) into a computer. After determining what percentage of the 471 544 people surveyed prefer tap, bottled, and filtered water, they calculated how many of these people prefer tap water.



Figure 2: Michael inputs his selection, Mark tests the water in fountain A, and Kim waits to use the computer.

Next, students found their water volume by standing on a computerized scale at the Human Sponge exhibit. They were astonished that males are made up of 70% water and females are made up of 60% water. Since 1 L of water equals 1 kg of water, students converted their water volume to mass in kilograms. Reading a display nearby that 74.5% of a 15-year old's brain is water, they calculated their brain's weight based on water, using a reference from the *Grolier Multimedia Encyclopedia* (1995): "the average human brain weighs 390 g; its average maximum weight, reached at age 15 is 1315 g."

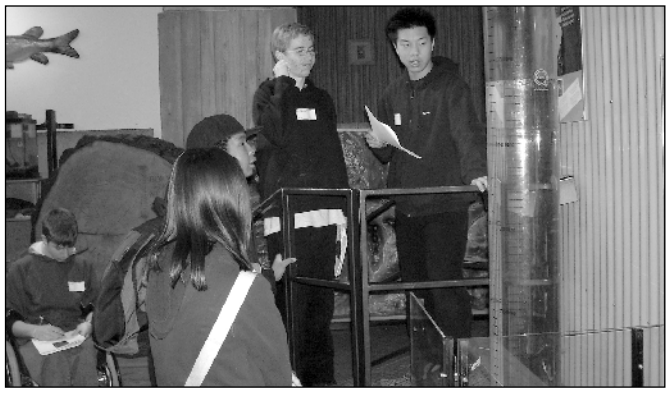


Figure 3: Jacky stands on the water scale as Kim, Mark, and Matthew look on.

In the Communication exhibit hall, students were assessed on their oral communication skills at the Pattern Talk Table (please see assessment section of this article for rubric). In pairs, they sat at opposite ends of the table, separated by a barrier in the middle. They took turns making a pattern using five coloured tiles and then described their pattern to their partner for replication. Using "zero feedback", the guesser could not say anything or even look at their partner.

Students had further opportunity to apply their number sense skills at the Whodunnit Video display. After witnessing a theft at the Ontario Science Centre, students are asked to identify the suspect from a line-up. The class was surprised that none of them nor their teacher could select the correct suspect! In actuality, as many as 80% of eyewitnesses choose the wrong person and we talked about the consequences to the justice system. They then calculated how many students at our school would have selected the correct suspect.

Before lunch, students visited the Human Body exhibit hall to apply their ratio and percent skills one further time. They wrote a ratio to compare the mass of an elephant's heart to its entire mass and then determined what percentage of an elephant's entire mass is due to its heart.

I believe a trip to the Ontario Science Centre would not be complete without a visit to the "Amazing Aging Machine" located in the Human Body exhibit hall. Even though this exhibit was not formally part of the trip and the line-up about 20 minutes (this popular machine takes about 3 minutes to predict one's facial appearance 50 years from now), my students felt this was well-worth having a reduced lunch period. Each student received a slip of paper with a password to retrieve 5 free photographs from the Ontario Science Centre website.

To make this more memorable, I videotaped and downloaded the aging process for each student onto a personalized CD.

During the afternoon, students visited the Science Arcade exhibit hall and applied their understanding of equation solving with the Law of Levers exhibit. Students determined their weight using the Law of Levers, $w_1 \times A = w_2 \times B$, where w_1 is one's weight (in lbs) to be found; w_2 = 150 lbs, the weight of the wooden lever; A is the position where the lever balances (in feet); and B = 2 feet (given):

Our final destination was the Sports exhibit hall. Michael, a student in the class who is the recipient of 2 medals at the 2005 Canada Summer Games in Regina, challenged us to a wheelchair race. Only a couple of students and I took up his offer and Michael won by a landslide. We used the access ramp beside the wheelchair race to verify, using slope, if a regulation of the Americans with Disabilities Act holds: for every 12 inches of run, there must be less than 1 inch of rise.

We then connected slope to the tangent ratio, which our textbook states, "The tangent ratio is called slope when it is used to describe the steepness of a hill" (McGraw Hill Ryerson, 2000, p. 258).

The final activity was the Through Thick and Thin display. Students explored the impact of dropping a weight on two mats of different textures. The focus of this question was on written communication with descriptors "describe your observations" and "explain".



Figure 4: William, Michael, Mark, and Kim communicate their understanding of the impact of equal weights on two mats of different textures.

Assessment

The field work at the Ontario Science Centre allowed for application of course concepts and consolidation of skills. I only evaluated students' responses to questions that addressed the specific expectations of the grade 10 applied mathematics course. Knowledge and application-type questions were evaluated using a traditional marking scheme, while communication (at the Pattern Talk display) was determined using the following rubric:

Level 1	Level 2	Level 3	Level 4
The student's description is limited in details and clarity. The replicated pattern is far from the original pattern. The student requires frequent assistance from the teacher.	The student's description is somewhat detailed and clear. The replicated pattern contains several minor errors due to the student's description. The student may require some assistance from the teacher.	The student's description of the pattern is detailed and clear. The student requires no assistance from the teacher. The replicated pattern contains a minor error due to the student's description.	The student's description of the pattern is detailed and clear. The student requires no assistance from the teacher. The guesser successfully replicated the pattern.

In addition to assessing students' academic achievement, ample opportunities existed throughout the day to assess learning skills, in particular, teamwork and independent work. I wrote brief anecdotal notes that assisted me with completing the learning skills component on the report card.

Final Remarks

The summative performance task at the Ontario Science Centre was a success as noted by students' on-task behaviour and work ethic. Their English teacher approached me the next day to share that one of the students rated the trip as "10 out of 10". When my vice principal asked how the trip went, I replied, "You would have been very proud of the students. They were great ambassadors for the school!"

Students in applied classes require hands-on learning experiences and this field trip allowed them to consolidate their learning with course concepts and with learning from earlier grades. I must mention that not all the overall and specific expectations were addressed in this trip. Since the trip occurred in early December, the quadratic relationships strand was yet to be taught. There were instances when I could not create questions to meet the overall and specific expectations of the course. The Ministry of Education requires that all overall expectations be assessed in the final evaluation and the use of multiple assessments (performance task, take-home assignments, final examination) addressed that issue.

An added bonus of the field work was the opportunity to spend an entire day with a group of students. Several days later, I provided each student with a personalized

CD which contains photos of them doing mathematics as well as a video of their aging process as a keepsake. Readers of the *Ontario Mathematics Gazette* interested in receiving an electronic copy of the handout can contact me at louis.lim1@gmail.com. I look forward to organizing a grade 9 applied mathematics version for my language intensive class in semester 2.

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