How Much Math Could a Math Teacher Teach

One does not have to search long to find people with strong opinions about the state of math education in British Columbia's K-12 system. The general public must wonder if they have a hearing problem when told on the one hand of all the things wrong with the present math curriculum and how it's failing our kids, and then be reminded on the other hand by the Minister of Education that B.C. students are among the world's best in reading, math and science. Such contradictory claims are confusing, but the general public knows that all is not well and if something is not done soon the situation will just get worse.

Canada's system of math education is ill. And it's ill in many other areas of the world as well, especially in the United States. Yes, it's true that the Canadian K-12 educational system is generating some students who are highly gifted in mathematics. And yes, it's true that TIMSS (Third International Mathematics and Science Study) found that Canadian, and in particular British Columbian, students rate near the top in mathematics at the Grade 4 and Grade 8 level compared to forty-one other nations studied. However, since these countries face the same problems in the teaching of mathematics as Canada, the TIMSS finding could be viewed as comparing the temperature of two sick children. Sure, the Canadian child's temperature is better overall, but the child is still ill. Interestingly, the TIMSS data shows that by Grade 12 Canada and B.C. had slipped in the standings, which is reason for alarm considering that many of the Asian nations that topped the rankings in the Grade 4 and Grade 8 level studies did not participate at the Grade 12 level. Perhaps we should take pride that American students fared worse, but at least in the U.S. there's been a lot of talk of late about addressing the problem.

The universities, even though they select the highest performers from the province's secondary school system, freely speak of a growing gap between what students are expected to know and what they really do know heading into first-year university calculus. This gap is even more obvious in most colleges, where there are larger numbers and percentages of students entering with grades ranging in the C's and low B's.

So what must to be done to make the patient well? To decide on the treatment, we first need to uncover the cause of ailment. Many post-secondary mathematics instructors would agree that math instruction has suffered greatly of late in the K-12 school system, and would be fairly unanimous in pinpointing five main problems.

1. The over-reliance on calculators. The lead story in the June 5, 2005 edition of **Macleans** talks of growing evidence that too much cyber-time dumbs down our children. The too frequent and too early use of calculators in the teaching and learning of math can do the same. Students soon learn to systematically click on particular features of the calculator to obtain a numeric

result. In essence, they memorize the functions of the calculator to achieve a result, rather than learn or understand how to do the math. Because they have absolute trust in the answer the calculator provides, they don't even bother to check to see if the answer makes any sense. For them, math is more an exercise of pushing buttons than of problem solving or making quantitative judgments. When their calculator is removed, they are at total loss as to how to proceed, even for simple additions or multiplications. For example, they are unable to readily compute 13 x 25, because they lack the ability to conceptualize the problem and are hence unable to break this product down as (10 x 25 = 250) + (3 x 25 = 75), for a total of 325. This discomfort with simple calculations and excessive trust in calculators has now infected many people's daily lives. When taxes are to be computed on a purchase and change given, they place full trust on a sales clerk who is likely equally inept with simple calculations. Case in point comes from an SFU student who recently wrote a letter to the editor of the *Vancouver Sun* stating, "I scored 97 per cent on my Math 12 provincial exam three years ago and considered myself to be quite comfortable with my grasp of the topics we learned. It was when I began my first year at Simon Fraser University that I realized the true weakness in my understanding. I was shocked when I took my first calculus course to learn that we were permitted no calculators at all. No longer was I rewarded for my use of technology. Instead, I had to fully understand the fundamentals of the subject in order to succeed. Without understanding the mechanics and theory behind the numbers, we [while in high school] were doing nothing but playing graphing and statistics games on a glorified version of a Game Boy." It is important to note that the mathematics department at SFU has adopted the no calculator rule specifically because it believes that high school students have become overly reliant on calculators and are not adequately learning the mathematics.

2. <u>The proliferation of topics at all levels.</u> A March 4, 2005 **Vancouver Sun** article entitled "*Things That Don't Add Up in B.C. Math Classes*" describes the "spiral" math curriculum used in the teaching of B.C. math as crippling learning, especially among disadvantaged students. The spiral model offers a surface-level mix of math topics each year, with the idea that the student picks up a bit more with each passing. As noted in the article, the U.S. National Research Centre for TIMSS concluded that there were too many topics that were introduced too early, repeated too often, and covered too superficially. Opponents of the spiral model say that it isn't working, and students are worse off for it. They suggest that fewer topics should be covered each year, but at greater depth. And because this model fails to provide the necessary foundation at the elementary level, it leaves many otherwise capable students completely unprepared when faced with the realities of high school algebra. High school teachers faced with this shortfall of learning are unable to correct deficiencies generated in the lower levels, and success in math tumbles as a result. The difficulties that students face lead to math anxiety, to a lack of confidence that they can do it, and ultimately to the question of whether they really want to do it. Many students give up out of frustration. This is most unfortunate, because a

2004 Statistics Canada report, "*Student Achievement in Mathematics – the Roles of Attitudes, Perceptions and Family Background*" shows that in their early years Canadian youth appear to be well motivated to learn mathematics. While they were just as interested in mathematics and enjoyed it as much as students in other countries as a whole, they believed more strongly in its usefulness to their future employment and education. By the time they leave school, this interest has waned drastically.

3. The de-emphasis of fractions in the elementary curriculum. Because the use of calculators to produce decimal answers is seen as so important, competence with fractions is viewed with less importance than it once was. Fractions have generally been slotted towards the end of the school year, around the time school field trips are scheduled. Students then move through the K-12 system with, at best, a very superficial grasp of fractions. It is not uncommon to face students in a postsecondary math class who cannot comprehend that 5/4 (five quarters) of a portion is greater than one full portion (four quarters). This lack of a solid understanding with fractions hurts students in their secondary and post-secondary mathematics education. Though on the TIMMS study B.C. Grade 8 students may have faired better over-all than the international average, this study did identify fractions as an area in which they performed poorly by comparison. Other areas in which they performed poorly include signed (negative/positive) arithmetic, geometry, algebra, multi-step problems, and word problems. These are not minor topics, and left uncorrected these deficiencies become ever more evident and problematic as students move from one grade to the next. The outcome is failure to learn, math anxiety, and inevitably math illiteracy.

4. The perception of math as too hard. While this seems to be a growing universal perception by society at large, it is reinforced far too frequently within the walls of the K-12 system, especially at the secondary level. Many counselors (and sometimes teachers) reinforce the notion that math is too hard. Perhaps this is partly due to their own discomfort with mathematics, but these are the very people who should be encouraging students that they can do math if they work at it and helping them explore ways to succeed at math. Instead, they suggest easier pathways for students, or avoidance of math beyond the bare minimum required for high school completion. And students believe them – after all, it's what many students want to hear by that stage anyway. Is this wrong? Most counselors probably agree, at least quietly if not openly, that this approach is not a proper solution to the problem. A common error is to counsel students to take the wrong pathway despite their anticipated academic plans. B.C.'s *Principles* pathway in mathematics is tailored for students who plan to go to university or to further their mathematics in university. Post-secondary institutions expect that students who have completed Principles of Math 12, and are starting calculus, will have a good grasp of the algebra, functions, geometry, trigonometry, and most importantly how to do basic arithmetic without the use of a calculator. While

the content of this Grade 12 course may not be a perfect match for all the above, it is nevertheless critical that students have strong math competencies. But the main thing is that it is **not** a hard pathway. The *Applications* pathway is designed for students entering technical or trades programs, or who do not plan to take further math and simply wish examples of math applications they will experience in their daily lives or need as job-entry skill requirements. It is as demanding a pathway as the *Principles* route, but it does not cover as many topics and delves deeper on what it does cover – along with greater illustration through relevant problem sets. The *Essentials* pathway is a much lower-level exposure to mathematics, and does not deserve a great deal of further attention from a post-secondary perspective. Sadly, because school officials perceive the *Principles* pathway as the more difficult, students with a weaker grasp of math are often directed to take either the *Applications* or *Essentials* pathway, when, in fact, they really require the *Principles* courses for their educational aspirations. What's commonly heard about the *Principles* courses, starting at Grade 10, is that they are too hard. But what defines a course as too hard? Surely not failure rates alone. Besides, the term "too" is subjective - and what's wrong with a course being hard? Aren't students expected to be challenged and to work hard in their senior years of high school? Certainly that's what society, the workforce and the post-secondary institutions expect and demand. Most of the students counseled to take the easier streams **can** succeed and do well in *Principles* if they try. To guide them into easier pathways cheats them of the learning experience that may be most appropriate for them. It does not prepare them adequately for university math courses. It provides an illusion of preparedness that does not exist.

5. <u>The lack of a mathematics background of many teachers.</u> This is undoubtedly **the** number one problem with the teaching of mathematics in the K-12 system. Many elementary teachers are themselves uncomfortable with mathematics, yet they are assigned to teach it. Likewise, many secondary teachers of mathematics lack appropriate backgrounds in mathematics, and yet are assigned to these courses. A June 1999 Ministry of Education "*Report of the Mathematics Task Force*" found that students pursuing an elementary teacher preparation program in B.C. receive different levels of mathematical preparation. There is no provincial standard. What they do receive may involve, at most, one or two mathematics content courses beyond what they obtained in their K-12 schooling, and to that may be added only one mathematics education (how to teach math) course. Sadly, the vast majority of elementary teachers do not have a mathematical or scientific background to supplement this skeletal exposure to mathematics in their teacher-training program. And for many of these teachers, their entire math schooling may have been undertaken with trepidation and apprehension. Would you ask a person who barely spoke French to teach a French class? I doubt that anyone would seriously suggest that this is reasonable and worthy. Then why would one suggest that a person without a sufficient background in math, and possibly even a discomfort with the subject, would be competent teaching introductory foundational mathematics that becomes the building blocks for further comprehension in arithmetic, geometry, trigonometry,

algebra, calculus and numerical logic in general? Sadly, it doesn't get a lot better at the secondary level. A May 2004 BC College of Teachers Report, "*Results of the Survey of Recent Graduates*" claims that 46.2% of secondary school math classes were taught by "out-of-field" teachers, defined as teachers without a major or minor in mathematics (or science, likely, for that matter). A November 1999 report by the British Columbia Provincial Committee for Teacher Supply and Demand describes out-of-field teaching as highly problematic for student learning. Yet nothing appears to have been done about it. The 1990 "*Project 2061: Science for All Americans*" report from the American Academy for the Advancement of Science comments, "Few elementary school teachers have even a rudimentary education in science or mathematics, and many junior and senior high school teachers of science and mathematics do not meet reasonable standards of preparation in those fields. Unfortunately, such deficiencies have long been tolerated by the institutions that prepare teachers, the bodies that license them, the schools that hire them and give them their assignments, and by the teaching profession itself." Indeed, studies have reported that nearly 70% of US middle school students are assigned to teachers who have neither a major nor certification in mathematics. Some corrective action has been implemented in the U.S. (for example, improved teacher training opportunities in some States), although much more remains to be done. While we wait for changes here in B.C., should we fault the teachers for the dilution of mathematical standards in the K-12 system? In some ways one has to as they are the easiest target, but it would be grossly unfair to load the entire blame on them. There are a number of teachers in every school district with appropriate math background that are doing a stellar job. Most students know who they are. Unfortunately, they are usually at the senior level and cannot possibly be expected to right all previous wrongs. Likewise there are some without a math or science background who over-rate their ability to teach mathematics. But the majority, particularly those at the elementary level, are doing the best they can under the circumstances. Out of this rises a decline in mathematical skills, and worse, a perception of mathematics as inaccessible to all but the highly gifted few. As a result, the post-secondary system turns out even fewer qualified secondary math teachers, and elementary teachers become increasingly math phobic.

An unavoidable consequence of these problems in the K-12 system is an erosion of standards and the progression of students inadequately prepared for advancement. Most educators recognize that an A grade in mathematics probably does not mean what it used to, and anything at the C or C- level means very little other than that the student took the course. This relaxation of grading standards misrepresents student achievement and masks systemic problems with mathematics education in the school system. So too does allowing students to advance in a subject area where their performance would suggest otherwise. It almost assures problems at the higher levels, and especially at the post-secondary level. If allowed to continue, we could enter a mathematical "dark age" at a time when mathematical skills are more than ever in demand. Surely Canada can and must do better if it wishes to retain its economic standing in the

world order. It is, after all, a prosperous nation that claims to value public education as the very foundation of its strength. And two of the most critical cornerstones of this educational foundation are a literate and numerate society – a society composed of people who can think, analyze and deduce logically and mathematically, and who can communicate those thoughts and findings clearly and concisely. It is a society that deliberately stakes its future state of well being on its competence and ability to lead in quantitative and qualitative reasoning – in essence, on its strength in science, mathematics and technology.

So what has Kwantlen University College planned to do to help rectify matters? Four things, actually.

First, there are a reasonable number of highly gifted math students in the secondary schools who have completed Principles of Mathematics 12 and Calculus 12 with exemplary grades before entering Grade 12. There are no further math courses available to them in the secondary system, so they cannot pursue a subject area they enjoy. Kwantlen University College will guarantee seats in its Calculus and Linear Algebra courses for such students in its region, while they are completing high school.

Second, effective September 2007, Kwantlen University College offers a minor in Mathematics within its Bachelor of Arts degree. This option is designed for students wishing to pursue a secondary school teaching career with an interest in teaching mathematics. The Mathematics minor blends nicely with existing minors in English and History, as these are all teachable subjects in the secondary system. There already exists a serious shortage of math teachers in the secondary system, and it is further estimated that at the current production rate of high school teachers in B.C., the impending surge of retirements will generate a shortfall between 6000 to 8000 teachers overall by 2010. To assist teachers already in the system who lack a math (or science) background, there have been discussions to mount a professional development diploma in mathematics.

Third, Kwantlen's Learning Centres provide free out-of-class assistance in mathematics by qualified tutors and faculty.

Fourth, it is hoped that Mathematics Labs will be funded in the near future at Kwantlen to provide both compulsory and voluntary problem solving assistance to all students taking courses in mathematics – starting as a pilot project at the MATH 1112 level.

Kwantlen University College knows that other post-secondary institutions in B.C. similarly trying to address math deficiencies in various ways. However, there is general agreement that there can be no adequate solution to these problems without a radical change in perception and policies within the K-12 system itself.