Spinning Threads between Students, Teachers, Life and Mathematics
Coarse or Silken Threads?

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Spinning and weaving are regarded as some of the most ancient of arts. Yet the threads of knowledge between students, teachers, life and mathematics leading up to the Twenty First Century have often lead to a coarse and rough cloth, rather than a potentially rich cloth of mathematical knowledge. The contemporary cloth of knowledge and mathematical learning does not reflect the potential silken paradigm of ancient times.

This paper will examine the weaving of the four threads of teacher, student, mathematics and contemporary society. What has happened to the role of the teacher? What of the relationship between teacher and student? Whatever level of communication is developed between teacher and student, how is this affected by the mathematics curriculum and the society of an increasingly technological world in which each has to operate? The content of the curriculum can turn many students away from mathematics before they really begin. And the pace of change and availability of technology in society can dramatically affect the role and relationship of the educational partners. Can these threads be spun more smoothly and woven to produce a rich silken mathematical cloth suitable for wear in the twenty-first Century?

A world without mathematics would be a world without understanding; a world full of confusion and chaos. When, however, mathematics is applied to the world and thought of as a way to explain the world in which we live situations and occurrences can become visible to the human way of thinking. Discoveries and knowledge through the ages have used mathematics to add meaning and truth to our world. In the technological world of today, mathematics has been actively used to bring satellites and spacecraft into orbit around our world. The new "Principles and Standards for School Mathematics" issued by the National Council of the Teachers of Mathematics (NCTM) in April 2000 succinctly states the position of mathematics education in today's world. "The need to understand and be able to use mathematics in everyday life and in the workplace has never been greater".[i]

Our world, at the dawn of the twenty-first century, is one in which technology has shrunk distance. Distance and gaps are now of little concern, almost any place is reachable by many people. However, for the student of mathematics in a global society the potential and promise of the latter twentieth century has not yet been realized, why? The view and interpretation of mathematics that will be used throughout this paper will be that of mathematics as a way of thinking; a language that helps us interpret the world in which we live. The themes and discussion developed throughout will be ubiquitous with examples provided to illustrate themes.

That technological development has helped bring advances to many individuals throughout the world is without debate. Within individual communities and countries people are able to communicate to a greater degree and much more frequently with the aid of the information technology of the World Wide Web (WWW). Globalization, although first appearing in the economic sphere, applies to most aspects of societal interaction today. The global arena described in the influential report of UNESCO's International Commission on Education for the Twenty-first Century, judiciously points out that all is not necessarily bright in

a global world. Differences can and have been created between have and have-not countries and cultures within countries, such that divisions are created that have given rise to tension and to conflict. Education, in more than just mathematics, has given access to knowledge. Although the knowledge might have been misplaced at best, or at worst misused, education still provides the hook of hope to the future.

Mathematics as one topic of education, is a subject is brought to students through curriculum. While the emphasis on curriculum components has changed over the last 50 years, the curriculum content itself has not been through such a dramatic transformation. Alterations in emphasis have been more of a cyclical nature, often seen as reacting to events in the world. The cyclical rotations seem to move between a "basics" computational nature to a more broad understanding of mathematics with some innovation and a touch of abstraction. The last quarter of a century has seen the latest rotation from a back-to-the-basics trend to one where more innovative curriculum materials have been produced for mathematics students.

Students of mathematics today in many western nations are indeed expected to have a broader range of mathematical understanding. It is now quite accepted that students will be expected to acquire skills that will likely change over a period of time and that they may find themselves changing occupations more than once in their lifetimes. The breadth of mathematics curriculum that students are expected to know has therefore increased.

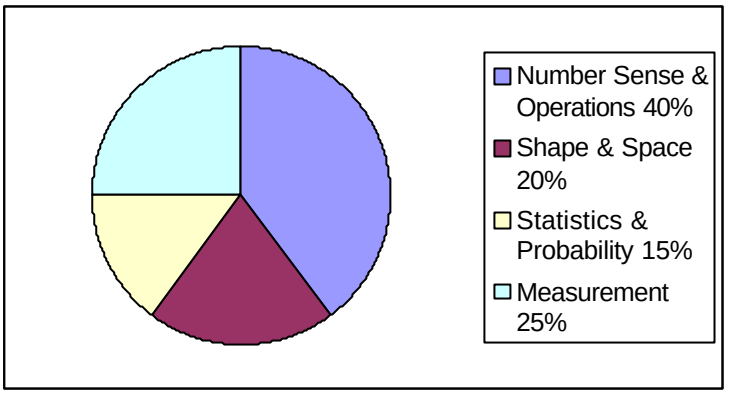
There are no major differences between the strands or topics of the school mathematics curriculum in Canada, Great Britain or the United States of America (USA). Each curriculum provides a framework for activities introduced at age-appropriate stages in students schooling through the Kindergarten to G12 grades and carefully developed along cognitively developmental lines. While the strands are organized in a clear and coherent manner this does not at all preclude cross-strand connections or indeed cross-curricular use of topics. In fact this is encouraged to occur as much as possible.

The provincial Ministries of Education mandates the curriculum for the provinces and territories in Canada. In British Columbia (BC) all grade levels in K – 12 schools have the same basic division of the mathematics curriculum into four strands, as detailed in the chart below. The current curriculum was last changed in 1997 to bring into closer alignment with the Western Canadian Protocol (WCP) framework. By the nature of the WCP, curriculums between the western Canadian provinces of BC, Alberta, Manitoba and Saskatchewan are being brought into closer alignment. The benefits of this commonality include greater ease of mobility for students, and the production of resources that are more sound and reflect a wider perspective of Canadian societal needs and interests.

The BC Kindergarten to Grade 7 Mathematics Integrated Resource Package divides the curriculum into four strands of Number Sense and Operations, Measurement, Shape and Space and Statistics and Probability. The strands are divided according to the chart below.

Educators are "required" and expected to connect the content of the strands of the curriculum to the world of the students. Students are expected to be able to relate activities to their own world. Mathematics is a living, breathing subject, which can add significant meaning to the world of students. The curriculum has a significant opportunity, and responsibility, therefore to "equip" students with the tools to operate in the world. For reasons of brevity,

unfortunately, the "student" is, and will need to continue to be, regarded as a school student somewhere between the ages of four and 18.



Through this mathematical content students are expected to develop skills which are very clearly detailed for students whose educational organizations follow the five process Standards of the NCTM, Problem Solving, Communication, Connection, Representation and Reasoning and Proof. These skills and processes are by no means exclusive to the mathematical curriculum, but it is considered that students have the greatest opportunity to develop these critical skills. The general pedagogical base of the process Standards allow for the key component of evaluation of student's progress and assessment of the curriculum itself. The NCTM does not intend for the refined Standards contained in their new document to be prescriptive, rather that they serve as a catalyst for ongoing educational dialogue and discussion between the various partner groups of the educational community.

It is encouraging that the NCTM have added a fourth grade level band to their new Principles and Standards document which focuses on the Pre-K – 2 student. It has been known for some time pedagogically that these early years of children are a time of profound change. Indeed the document states "At no other time in schooling is cognitive growth so remarkable".[ii] Yet the emphasis and the larger share of resources continues to be placed with students who are soon to leave school, to graduate from high schools in many western countries, and join the economic workforce.

Students come to school, or educational environments, with varying degrees of readiness to learn. The psychological and emotional "baggage" that a child brings to school with them needs to be actively considered on a daily basis to maximize the students' ability and opportunities to learn. It is a sad indictment of the western world and of parts of Canada, that it is not only in Third World Countries that the day at school has to start with a breakfast program before or while the formal education is taking place! Federal studies are indeed underway in Canada to try and measure the young child's readiness to learn formal education as they enter kindergarten. It is hoped that in part this study will enable the available resources to be placed where the greatest needs emerge.

Factors that have had significant impact on a students readiness to learn must include the impact of societal messages on students principally transmitted through media, whether this be through magazine, radio, entertainment or the all-powerful television. Many students spend

more time in front of a television than they do in school, and therefore have become accustomed to casual and instant gratification. How ready to make an effort are these students in school?

At the close of twentieth century many students are also coming to school from homes where the traditional two-parent family is no longer a reality and stability at home is not consistent. Although the United Nations' Declaration of Human rights has clearly stated education as a human right, throughout the world the degree with which children are able to become students for any length of time is immense. Although there are these global variations in the availability of education, the influential TIMSS are some reassurance that much is possible from students in mathematics education. Students around the world have taken part in the tests and studies, and in turn provided information beyond simple data, which is, and should continue to be, used for educational improvement.

There is however, no such age restriction or implication to that of the *learner*. Just how essential is it that the mathematics curricula are given solely in schools, between the approximate ages of four and 18? The UNESCO report cited earlier proposes a plan; not entirely new, but still somewhat radical to many, that learning is a lifelong process. Education is described as being at,

"…the heart of both personal and community development; its mission is to enable each of us, without exception, to develop all our talents to the full and to realize our creative potential, including responsibility for our own lives and achievement of our person aims. "[iii]

The Commission saw this as an essential contribution to a search for a more just and better world in which to live; a more humanitarian world. Should the focus therefore of school curricula be one more attune to the skills of learning and not so focused to the content of learning? Where resources are stretched thinly, if a student could learn throughout life rather than in one stage of life, and life-long learning was truly valued by the global society, would we not come closer to our true potential?

The twenty-first century provides a society more complex than at any previous time. While technology can bring many benefits to many people, including students of mathematics, it can and has created greater disparity between the have and have-not segments of society. Not only are communities affected by the phenomenon of globalization, but many find themselves to have become alarmingly interdependent; unable to respond to the unique needs of their community. One manifestation of this communal discontinuity has often been seen throughout history in the migration of segments of populations. This can cause severe economic and societal pressures putting ever more strain on educational services.

In the globalized world of the twenty-first century it is not so much change that causes such difficulty, in particular for the have-not segments of society, but the pace of the change. Innovations in the era of the Industrial Revolution often took decades to affect the average citizen, now unfortunately innovations in the Information Age make new equipment obsolete within two years. Maurice Burke aptly describes the effects of technological change as having had an explosive affect on most aspects of twentieth-century society.[iv] While this seems a melancholy beginning for the new millennium, if technology is harnessed in a carefully planned and thoughtful manner, particularly within education, significant gains are easily attainable.

It is foolish to deny that the technology of ever-complex calculators and computers does bring incredible learning opportunities and mathematics to students. The potential gains for student learning are astounding. The development of computer software has in particular brought aspects of geometry to the forefront of many students' mathematical experiences. Laborious calculations do not now have to be endured once a concept is introduced in mathematics classes. Necessary practice activities, often referred to as drill, can now become "drill and thrill" exercises rather than "drill and kill". Indeed the influential NCTM has a separate Technology Principle in its' new Principles document, and states that "Technology is essential in teaching learning mathematics…". [v] While it is acknowledged that the vision of the NCTM is a vision to take mathematics educators into the new millennium, just how essential is the use of technology for students?

Research has long shown that high ideals and expectations do have a positive effect on learning and these are usually set with careful planning at all levels and often research studies. Certainly increased resources can also make learning easier for students and technological tools can certainly be counted among these resources. However, as discussed earlier if Burke regards the effects of technological change as having had an explosive effect, who would place such "explosives" in the hands of students without very serious care and attention, considering every aspect of its' use? Who is to provide the supervision and guidance?

The debate of what is appropriate use of calculators and technology is growing. These electronic tools need to be handled judiciously with prudence and thorough planning. Innovation need not be feared, but one does not have to be at the forefront of technological innovation and change to reap rich rewards. The potential promise of technology in the fields of education has not, unfortunately, been maximized as much as it might have been even in many of the so-called advanced countries. Planning has not always been as complete as it might have been.

The growing technology debate has a large component that is assessing the effects of technological integration. All too often it is being discovered that although society's values towards technology are growing; that students are increasingly becoming familiar with technology; that mathematics curriculums very often have a component specifically relating to the use of technology; but that teachers are insufficiently trained in the instructional use of technology. A significant study by the American Council on Education stated as one of its' key findings that "Teachers are inadequately prepared to understand and apply technology to teaching"[vi], and that only one in five teachers felt that they were very well prepared to integrate technology in teaching. This crucial finding is not exclusively American by any means.

Many countries have had goals set by educational authorities to connecting schools to the World Wide Web by a target date and to increase the numbers of computers available to students. In 1998 the US had a declared ratio of one instructional computer to every six students in public schools.[vii] In BC, Canada, the provincial Ministry of Education established the Provincial Learning Network (PLN) to which public schools in BC are to be connected by the end of 2000. Individual school districts are required to submit plans to the Ministry which specify the progress towards making this available to students, following which some provincial funding is released to school districts to fund technology. How many of the goals have included significant on-going teacher training and support?

The inadequacy felt by teachers towards the instructional use of technology brings a vital partner to the forefront of this discussion on the richness of mathematics education, the teacher. The role of a teacher is perhaps more crucial now than it has ever been, especially a teacher of the young leaner. Teachers today have to do far more than impart information to their students. In this respect a teacher imparts attitudes towards many aspects of life to their students; they are a role model. It is certainly no exception that the teacher is still the key player in the development of an attitude towards learning.

In the learning situation today, a teacher's role all to frequently has to include dealing with the problems of the social environment that students bring to school with them. For too many students the teacher is expected to deal with life problems where families have failed. If families and society are barely coping with the pace of change, as already discussed, how can young students be expected to handle change? Changes are occurring on more than just a local level. Globalization has affected most populations to even a small degree, and therefore it is appropriate that a teacher also include in their portfolio of roles, themselves as agents of change.

The UNESCO Commission's report cited earlier resolutely emphasizes the role of the teacher as being vital, particularly at the beginning of basic education. It states,

"It is at an early stage of basic education that the principal attitudes towards learning as well as the self-image of the learner are formed. The role of the teacher at this stage is crucial."[viii]

Improvements would not be sort for any field so urgently if that environment were producing a quality product. Change-for-change sake is counterproductive even to the globalized economies of the world. Education however, is increasingly coming under a microscope as it strives to produce citizens capable of functioning and reaching their potential in a world entering the Twenty-first century. The teacher as a key player in the process of education is not excluded from the evaluative process, and is the target of much recent examination.

Ample research exists to state that a teacher has a singularly powerful influence on the learning and academic performance of student's. The latter assertion being a powerful factor in effective education to many. Just as with any profession, some teacher's are more effective of others. It is largely the responsibility of the classroom teacher to create a "climate of support" inclusive of mutual respect, where each student is supported and encouraged to work towards their potential. It is within this climate of support that effective teaching and meaningful learning takes place.

What then makes an effective teacher? The UNESCO Commission's report simply but elegantly lays a foundation for effective teachers,

> "Teachers' great strength lies in the example they set, of curiosity, open-mindedness, willingness to put their assumptions to the test and to acknowledge mistakes; most of all, they must transmit a love of learning."[ix]

Although the debate has existed since at least the time of Plato and his dialogue "Meno" as to whether excellence can be taught, studies have been done which identified key factors and

characteristics of effective teachers. Importantly this has included what teachers themselves believe to be key factors. In Jackson and Leroy's study entitled "Eminent Teachers views on Teacher Education and Development"[x] teachers' attributed much of their success to personal characteristics developed throughout their lives. Other factors identified have been neatly summarized under the heading of competent pedagogical practice.

It would be surprising if subject matter knowledge, in this case mathematics education, was not identified as a key factor; the more qualification and training for teachers in their subject specialty the more effective the teaching, and student learning. It is interesting to note that some studies have identified differences between the academic capacity for prospective elementary school teachers and prospective secondary teachers, with the former purportedly having below average capacity.[xi]

Countless studies have concurred that sound teacher training programs are critical components to the preparation of teachers. It attests to importance of this finding that nearly every author in the NCTM's 2000 Yearbook "Learning Mathematics for a New Century" speak of the crucial importance of teacher preparation. Although there is slight variation in the agreed factors that make an effective teacher training program these have generally included the following:-

a) The program is supported by the central administration.
b) Applicants are admitted through a thoughtfully designed process of matriculation.
c) Graduates of the programs are carefully guided into and supported in a community of teachers and learners, not just left to their own devises.
d) Program elements, especially subject matter learning and clinical training are tightly articulated, with practice coupled to theory.
e) Program quality and outcomes are carefully, independently and continuously assessed, and
f) Arts, education and science faculty have developed an effective way to combine their contributions.

With the factor identified earlier of a young students capacity for cognitive growth in the pre-kindergarten to G2 school years, and the supposedly below average academic capacity of prospective elementary teachers, it is startlingly odd that more emphasis and resources are not directed towards this critical time of learning. This would include teacher training programs, the mathematical curriculum and overall resources including the lauded technology. Technology, whether it be calculators or computers or other innovative devices cannot ever replace the teacher. Education is always short of resources relative to the circumstance of each community, but more can be done with what is already available as funding.

If the society would accept, as research has found, that effective teachers make THE difference in student learning and this is combined with an adjusted focus towards early elementary education for the student, prospective teacher and current teachers, together with the UNESCO Commissions call for lifelong learning the future as we enter the twenty-first century could be much brighter for many. The future would not only be brighter but it would be a more humanitarian future, one that focuses on, "Hetangata, hetangata, hetangata" (People, people, people).[xii]

Education has long been identified as a key to the future. It is therefore suggested that mathematics education can provide a living golden key or hook of hope to the future to indeed weave the four threads of teacher, student, mathematics and contemporary society into a potentially magnificent and silken cloth suitable for wear in the twenty first century.

[xiii] References

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Endnotes

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[vi] American Council on Education., *To Touch the Future -Transforming the Way Teachers are Taught,* Washington, D.C., 2000, no. 5.

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