



Mathematical Literacy... an idea to talk about

'Mathematics is a common human activity, increasing in importance in a rapidly advancing, technological society. A greater proficiency in using mathematics increases the opportunities available to individuals. Students need to become mathematically literate in order to explore problem-solving situations, accommodate changing conditions, and actively create new knowledge in striving for self-fulfillment'. (p. 2 Alberta Program of Studies, 1996)

What does it mean to be literate in mathematics? This was the question the executive of the Mathematics Council of the Alberta Teachers' Association (MCATA) took up in the fall of 2001 in response to an increasing demand from teachers and districts for direction in this area. In Alberta, directed education funding addressing early reading/writing literacy, has provided projects that result in widespread satisfaction with learning and teaching results in this area. Now educators and the public are asking "What does it look like for our students to be literate in mathematics? How would we begin this work in our schools?" MCATA developed this referent paper and brochure, to help teachers, schools, and districts begin to develop a deeper understanding of mathematical literacy and appreciate its potential importance for our students. It is becoming more common to speak of multiple forms of literacies, such as media literacy, visual literacy, technological literacy, family literacy, and environmental literacy. Elliot Eisner (p. 353, 1997) suggests the following view of literacy. It is inclusive and honours the many ways we come to understand and live in our world. *'In order to be read, a poem, an equation, a painting, a dance, a novel, or a contract each requires a distinctive form of literacy, when literacy means, as I intend it to mean, a way of conveying meaning through and recovering meaning from the form of representation in which it appears.'* We believe that mathematical literacy is as important and as necessary as the dominant literacies of reading and writing.

The Alberta Curriculum is clear that students require more than basic skills and procedures to be mathematically literate. It lays out the mathematics standards we need to address at each grade level and provides a solid base for mathematical literacy.

Much of the current literature uses the British term numeracy to describe this work. We choose not to use this term because when we asked people what they thought it meant the most frequent answer was "...something about number and computation." We decided that using the term mathematical literacy gives a bigger and more accurate context to the work.

Alberta's definition of Mathematical Literacy springs from those that have gone before and asks that everyone join in on the conversation.

Mathematical Literacy is:

- **Connecting mathematics to the real world**
- **Using mathematics appropriately in a variety of contexts**
- **Communicating using the richness of the language of mathematics**
- **Synthesizing, analyzing, and evaluating the mathematical thinking of others**
- **Appreciating the utility and the elegance of mathematics**
- **Understanding and being conscious of what has been learned mathematically**

Proceedings of MCATA Spring Symposium 2002

Mathematical Literacy is...

An aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication abilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work

International Life Skills Survey (ILSS, 2000) .

An individual's capacity to identify and to understand the role that mathematics plays in the world, to make well-founded mathematical judgments and to engage in mathematics in ways that meet the needs of that individual's current and future life as a constructive, concerned, and reflective citizen.

Program for International Student Assessment (PISA, 2000)

Quantitative literacy is not the same as statistics. Neither is it the same as mathematics...Quantitative literacy is more a habit of mind, an approach to problems that

employs and enhances both statistics and mathematics...Numeracy is often about the logic of certainty...Numeracy is often anchored in data derived from and attached to the empirical world.

The Case for Qualitative Literacy (NCTM, 2001)

Quantitative literacy – sometimes called numeracy – comprises a reasonable sense of number, including the ability to estimate orders of magnitude within a certain range, the ability to read a chart or a graph, and the ability to follow an argument based on numerical or statistical evidence.

“Why Numbers Count: Quantitative Literacy for Tomorrow’s America”(Steen, 1997)

Quantitative literacy is about the democratization of mathematics.

“Quantitative Literacy: Why Numeracy Matters for Schools and Colleges” (Steen, 2002)

What does this Mean for Alberta Students?

For Alberta students a focus on mathematical literacy will require re examining what constitutes “basic skills”. Mathematics will move beyond computation and an emphasis on manipulation and symbolic logic. Students will be looking at deeper meanings and understandings of mathematics. They will have more opportunity to work in problem-solving contexts and to search for relationships and meanings themselves. The problems that they solve as applications of their learning will, to the extent possible, be based on real world contexts. No longer will they routinely be asking the question: “what are we doing this for?”

Classroom activities will include the opportunity for reflection on topics as students search for meaning in the work that they are doing and formulate their own conclusions which they can share verbally, and in writing with their colleagues. These conclusions will use the language of mathematics and will be critiqued by other students and then defended and modified through discussion with other students and with their teachers. This process will facilitate the development of an appreciation for mathematics as a body of knowledge created through dialogue. This dialogue can occur throughout the day as all teachers in all disciplines become keepers of good mathematical thought and model this in their work. Students will see mathematics as important in all disciplines and to all people and therefore worthy of their attention.

Students will have the opportunity to engage in a wider range of activities and to work with a wider range of resources. Their creativity will be challenged as they look for the meaning of concepts and grapple with ways to represent this meaning so that others (colleagues, teachers and others) will understand it. They will defend their conclusions, sometimes by explaining their reasoning in more than one way. They will also have the opportunity of relating to the explanation of others and giving them feedback on their work. This will allow them the opportunity to revisit their own understandings and apply them to those of others and thereby develop critical thinking skills. . The *NCTM Professional Teaching Standards* address the role of the teacher, student, mathematical task and the teaching environment. These standards, if implemented would provide strong support to the development of mathematical literacy. And how will students react to this change? They will love it! Students usually like math in the early grades. As we move away from exploration activities and into more algorithmic learning, the interest of the majority of students wanes and is replaced with disdain for the discipline. Students will gain insight into mathematics and its applications to the world in which they live, and they will do it in a way that will pique their interest and allow them to own the knowledge.

Action Plan

In order for mathematical literacy to become a reality in Alberta, a concerted effort will be required from all stakeholders. Parents, teachers, schools, school systems, Alberta Learning, the government, and indeed society as a whole must agree on the importance of mathematical literacy, and genuinely collaborate in order that Albertans truly achieve mathematical literacy.

Producing new courses, or registering students in more of our existing math courses will not achieve mathematical literacy. Achieving mathematical literacy will require more collaboration between teachers. A more unified approach to literacy is called for, so that the efforts of elementary school teachers are understood and built upon as students enter junior high, and then again as those students enter high school.

MCATA

The Mathematics Council of the Alberta Teachers Association should take a leadership role in championing the cause of mathematical literacy. MCATA is the natural body to communicate

with teachers as they work with parents, students and school systems in achieving universal mathematical literacy.

MCATA has begun the process by studying mathematical literacy over the course of the 2001-2002 year, and received input from dozens of teachers and supervisors of mathematics on the subject of mathematical literacy. MCATA's first responsibility will be to disseminate knowledge of mathematical literacy. This paper is a first step. As well, MCATA will publish a brochure for a wide audience, summarizing its findings and recommendations. The paper and brochure will be published on the website and in Delta-K. The paper will be submitted to other journals for publication. The theme of the Fall Math Leaders' Symposium and 2002 MCATA Annual Conference will be mathematical literacy, as a continuation of this work, and a follow up to the Spring 2002 Math Leaders' Symposium.

The council will develop workshops for a variety of audiences on the topic. For instance, at future conferences, parents will have the opportunity to attend a workshop geared specifically to them, at no cost. MCATA will make the workshop available to schools and/or school councils so that parents, teachers, board members, and interested members of the public will have the opportunity to learn about mathematical literacy and their role in advancing it.

Alberta Learning

Alberta Learning must take leadership if mathematical literacy is to become a reality for citizens of Alberta. The program of studies for Alberta already contains many of the elements that contribute to mathematical literacy. Alberta Learning is not by any means being asked to revise the existing curriculum. It would be advantageous, however, if the expectations and standards in the program of studies could be refined or highlighted so that an emphasis on mathematical literacy is communicated. Alberta students are already expected to connect mathematics to real life by the curriculum, but these connections need to be even stronger.

One key element of mathematical literacy is to understand the pervasiveness of mathematics in contemporary society. To help students in this regard, Alberta Learning could cross-reference all school curricula, to point out to all teachers the need for mathematical literacy in places other than math classes. For instance, in The Grade 5 Science unit on Weather, measure, record and analyse weather data over time. In Social Studies 10 students study economic growth and development. This is clearly a topic requiring careful analysis of quantitative data, and likely a

fruitful place for mathematics and social studies teachers to collaborate. Such collaboration would be accelerated if Alberta Learning would make explicit this and other such curricular connections.

While achieving mathematical literacy primarily requires a retooling of current practice, it is not likely to be obtained without investment of some additional resources. Alberta Learning and the provincial government must also address three issues consistently raised by teachers in discussion of mathematical literacy.

- English as a Second Language students will need more support to achieve mathematical literacy.
- Smaller classes enhance communication.
- The projects and activities that most advance mathematical literacy are much more likely to occur and be effective in classes smaller than the current average in Alberta.

Schools and School Systems

The principal requirement of schools and systems is that they provide support to teachers as they focus on developing mathematical literacy in all students.

Teachers need time for collaboration. Where programs and approaches already exist to develop mathematical literacy, the authors and users of the programs need time and opportunity to help other teachers incorporate them. Where schools perceive specific needs, teachers must be given time and resources to meet those needs. Given that opportunities for integrating mathematical literacy in other content areas will arise, teachers need time to work together to construct meaningful and relevant lessons and projects to facilitate the integration.

Teachers have suggested a number of activities that will help achieve the goal of mathematical literacy. None of the ideas are very expensive, but most require one very precious commodity—teacher time. Some of the promising activities are:

- Inform parents of the concepts, vocabulary and ideas so that they can partner with teachers in striving for mathematical literacy.
- Work in teams to develop units, projects and performance assessments that promote mathematical literacy and have real world connections.
- Allow teacher teams to collaborate to build activities that integrate multiple subject areas, or multiple ages and grade levels of students.

- Promote vocabulary and reading comprehension skills in math classes.
- Stress effective use of journaling math class.
- Assign preparation time so that math teachers have preps in common during which collaboration is possible.
- Provide time, funding and opportunity for teachers to improve their own mathematical background and confidence. For example teachers could participate in programs currently offered at the University of Alberta and Mount Royal College.

As parental support for achieving mathematical literacy is critical, schools should also utilize school councils in communicating to parents the importance of literacy, and in particular the school's plan for achieving it.

Other Stakeholders

Many other groups have programs in place, or could adapt existing programs, to further the cause of mathematical literacy.

The Pacific Institute for the Mathematical Sciences has partnered with the Galileo Educational Network, for example, to help schools present math fairs. Math fair is a showcase for student problem solving and an opportunity for students to communicate mathematically with others. Clearly, by itself math fair, or any other program or event, will not achieve mathematical literacy. However, each such project can be an important component in achieving our goal.

The Regional Professional Development Consortia could be instrumental in facilitating inservice and collaboration for teachers. With established reputations, programs and contacts with schools, the consortia could play a significant role in helping schools and systems focus on mathematical literacy. Also, the consortia already have a website that teachers can use to share information, resources and projects.

The Calgary Mathematical Association is currently collecting and presenting teachers' stories about all aspects of teaching and learning. By acknowledging the importance of these stories, and aiding in disseminating them, the CMA can advance the cause of mathematical literacy. This is but one example of how grassroots efforts can be part of the effort to increase mathematical literacy in Alberta.

Alberta Initiatives for School Improvement (AISI) Projects

There are many Alberta Initiatives for School Improvement (AISI) projects directed towards mathematics. These may or may not be addressing mathematical literacy. This directed funding could provide powerful support for teachers and students as they work towards a goal of becoming literate in mathematics. As the projects work through the third year districts may want to shift some resources from reading /writing literacy to developing an understanding of mathematics as a literacy.

We invite you to take up this conversation and plan some action to help Alberta Students not only do well on their tests but more importantly, use mathematics confidently and effectively in their daily encounters in the world. We hope you find our “*What should be considered as we develop students’ mathematical literacy?*” (see Appendix) helpful in your thinking and planning. If you would like to get this idea going in your district and require like someone from the math council of the Alberta Teachers’ Association to get you started, please contact us through our website at www.mathteachers.ab.ca. This paper and the brochure are available on our website as well.

Make a difference!

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Appendix

What should be considered as we develop students' mathematical literacy?

An effective math program provides time to grapple with significant ideas and worthwhile mathematical tasks, using space and materials in ways that facilitate students' learning of mathematics. It provides opportunities for teachers to provoke students to think mathematically, reason together and challenge each other's ideas as members of a mathematical community.

When we speak of worthwhile mathematical tasks we use the NCTM definition from the *Professional Standards Teaching Mathematics 1991*.

Worthwhile tasks “promote the development of students understanding concepts and procedures in a way that also fosters their ability to solve problems and to reason and communicate mathematically. Good tasks are ones that do not separate mathematical thinking from mathematical concepts or skills that capture students' curiosity and that invite them to speculate and pursue their hunches. Many such tasks can be approached in more than one interesting and legitimate way; some have more than one reasonable solution. These tasks, consequently, facilitate significant classroom discourse, for they require that students reason about different strategies and outcomes, weigh the pros and cons of alternatives, and pursue particular paths.”

Creating and sustaining a powerful mathematical community involves ongoing questioning by those involved. Below are some questions for teachers, students and parents to help them to determine whether their mathematics program is one that fosters those aspects most important in developing math literacy. School and district leaders should use all of these perspectives when assessing math programs for their school or district.

Aspects of a program to develop mathematical literacy. Does it...	Do the textbooks and other resources...	Student	Teacher	Parent
Give opportunity for students to justify processes and answers?	Require the justification of answers and processes?	Can I show how I know this is the answer? Can I justify choosing this strategy?	Do I ask, “How do you know that? What worked well with the strategy you chose?”	Can your child explain his/her thinking and justify his/her strategy choice?
Encourage flexible thinking and strategy selection?	Model multiple solution paths for both students and teachers?	Can I think about a problem in more than one way? Can I think of more than one way to solve it?	Do my students know how to approach a problem in more than one way?	Does your child know how to approach a problem in more than one way?
Focus on developing conceptual understanding?	Use models and demonstrations that support conceptual thinking?	Do I understand why I'm doing what I'm doing? Do I ask questions to clarify thinking rather than clarifying steps to be followed?	Can the student explain why he/she is doing what he/she is doing? Does he/she and do I ask questions to clarify thinking rather than clarifying steps to be followed?	Can your child explain why he/she is doing what he/she is doing? Does he/she ask questions to clarify thinking rather than clarifying steps to be followed?

Assess student understanding, and not just procedures and skills?	Require students to understand concepts and explain their thinking in order to do well on assessment tasks?	Do I have to understand concepts and explain my thinking in order to do well on assessment tasks?	Do students have to understand concepts and explain their thinking in order to do well on assessment tasks? Are there opportunities for multiple solution paths?	Does my child have to understand concepts and explain his/her thinking in order to do well on tests and other assessments?
Incorporate the important processes of mathematics: <ul style="list-style-type: none"> • mathematical reasoning • communicating in multiple ways • problem solving 	Suggest ways to have students share their reasoning, communicate their work in different ways, and work on problems that are interesting to them?	Do I get opportunities to share my reasoning, communicate my work in different ways, and work on problems that are interesting to me?	Do I give students the opportunity to share their reasoning, communicate their work in different ways and work on problems that are interesting to them?	Does my child get to share his or her reasoning; communicate his/her work in different ways and work on problems that are interesting?
Contain worthwhile mathematical tasks? <i>(NCTM Professional Standards for Teaching Mathematics 1991 p. 25)</i>	Provide tasks based on the diverse range of ways that students learn mathematics? Are they based on sound and significant mathematics?	Do the tasks help me to understand and learn mathematics?	Are the tasks based on students' understandings, interests and abilities? Do they engage students intellectually?	Do the math tasks engage my child intellectually?
Use technology to explore mathematical ideas and enhance concept development?	Use technology in ways that expand what the student is able to understand and do?	Does technology help me to do and understand more challenging mathematical ideas?	Is technology used in a way that lets students explore and come to understand mathematical ideas in a way that pencil and paper or manipulative wouldn't?	Does technology help my child do and understand more challenging mathematical ideas?
Provide opportunities for students to gain confidence in mathematical ability?	Suggest explicit ways for teachers to build students' confidence in their mathematical ability?	Do I feel confident that I can learn new things in mathematics?	Do my students feel confident that they can successfully understand new math concepts and solve new kinds of problems?	Does your child feel that he/she can successfully understand new math concepts and solve new kinds of problems?
Incorporate meaningful practice of basic operations and procedures?	Provide practice in context such as investigating significant problems, exploring mathematical patterns or developing game strategies?	Is my practice of operations and procedures interesting and does it help me to think better mathematically?	Do my students practice in ways that are meaningful and that help them further their reasoning and understanding of concepts?	Does my child practice in ways that are meaningful and that help them further their reasoning and understanding of concepts?

Connect to other subject areas and disciplines?	Provide explicit suggestions for links to other subject areas?	Can I make mathematical connections to other subjects?	Do I make explicit links to mathematics in other subject areas?	Does my child have the opportunity to use mathematics in other subject areas?
Provide for an appropriate teacher role in discourse?	Provide support for teachers that encourages development of student thinking rather than focussing on procedures or eliciting the right answer?	Does my teacher ask questions that make me think? Does he/she allow me time to think? Does he or she listen to my answers and encourage me to think more deeply?	Do my questions encourage and support student thinking and promote classroom discussion? Do I know “when to provide information, when to clarify and issue, when to model, when to lead and when to let a student struggle with a difficulty”? <i>(Professional Standards for Teaching Mathematics, NCTM 1991 p.35)</i>	Does my child have opportunities to discuss mathematical/ ideas and situations?
Create a positive disposition towards mathematics?	Suggest ways of understanding and addressing student disposition toward mathematics? Are the activities engaging for students?	Do I enjoy math? Do I find math assignments interesting?	Do my students look forward to mathematical activity? Are the activities engaging for students?	Does my child like math? Does he/she find mathematics assignments interesting?
Provide opportunities to critique mathematical information?	Include activities that require the critiquing of real world mathematical information?	Can I decide if math information that others give me makes sense?	Can the student recognize deceptive, inaccurate or skewed mathematical and statistical information?	Does my child notice when mathematical information is misleading or inaccurate?
Connect school mathematics and real life mathematics? Enable and encourage students to recognize mathematics in their world?	Include mathematical situations and tasks that would be encountered in everyday life?	Do I find lots of mathematical situations in my life?	Do children bring real life math situations to school? Can my students create mathematical problems based on real life situations?	Does the child recognize situations in real life that are mathematical?