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Editorial: Special Focus Issue[1] New Mathematical Literacy

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Mathematical literacy

The term 'mathematical literacy' is typically related to notions of mathematical competence that will allow someone to function at some acceptable level in his or her daily and work place life. Before beginning to discuss curriculum change in the context of new mathematical literacy, it may be helpful first to examine briefly the construct of 'mathematical literacy' itself. Mathematical literacy, numeracy (Steen, 1999) and, most recently, proficiency (Kilpatrick, Swafford & Findell, in press) are phrases that have all been used to describe in some way an individual's capacity to function at some competent level in a particular society or culture. This capacity generally is understood to include various facts and skills, processes, and applications essential to daily living and working. The phrases themselves however occasionally cause some confusion. 'Literacy' to many people relates directly to language, perhaps specifically to reading and writing the language to some acceptable level. As such these people prefer not to use the term when applied to mathematics, or any other subject area. Numeracy on the other hand does imply competencies related to mathematics but suffers as a term in that, to most people, numeracy is seen as a quantitative construct and does not include topics such as geometry nor statistics. Whether 'mathematical proficiency' becomes more widely used remains to be seen. Kilpatrick et al. acknowledge that "no term captures completely all aspects of expertise, competence, knowledge, and facility in mathematics".

Regardless of which term we select, we must recognize that the construct is complex involving more than technical competence, and likely must be understood as being specific to time frame, societal and cultural contexts. Literacy must therefore be understood as relating to national and global education issues such as those inherent in our current 'knowledge-based era'.

Within the last number of decades school mathematics curricula have been reexamined for a number of reasons in response, for example, to the Russian

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[1] Significant portions of this editorial were presented and discussed at the *Energising Science, Mathematics and Technical Education for All* conference held at Universiti Brunei Darussalam, May 2001 and is available in different form in the published proceedings of that conference (Clements, Tairab & Wong, Eds.).

'Sputnik' program, to the 'modern mathematics' implementations, and to the back-to-basics movement. Most recently educators have taken advantage of the move into the new millennium to evaluate once again the suitability of our mathematics programs. Hence calls for new literacy's abound (Burton, 1996; Steen, 2001; Lee, (in press).

New literacy's

What then are the new literacy's? Given the 'subject to change' view of mathematical literacy as noted above, it is perhaps more interesting to consider the construct of "new literacy's" in the following manner: "What mathematical teaching and learning (curriculum) changes can we reasonably expect within the next ten to twenty years?" Three articles in this issue of *The Mathematics Educator* highlight components of the discussion on what might constitute "new literacy's". Steen, for example, distinguishes between 'numeracy' and 'mathematics'. Each, in it's own right, is a literacy and each has skills that must be required if one is to thrive in our modern world. Romberg, discusses changes in how we must understand mathematics is to be taught and then comments on the practical classroom and assessment implications that result from that change in thinking and Wong, in his article, presents nine futuristically oriented propositions that engagingly integrates many of the questions we need to address when looking toward the next few decades: some of these are noted above, others are to serve as a catalyst for further discussion.

Analyzing change

With the comments of such authors in mind, and for ease of discussion, ultimately I sorted my reflections into the following set of categories of anticipated changes: content, process, technology, communication, assessment, and teacher education.

Content

Quantitative ability has long been divided into both procedural and conceptual notions of competency. Skemp (1978), for example, described the need for both instrumental and relational understandings. It does seem however that people are clearly stating their curriculum requirements for both kinds of understanding and are basing their arguments on societal needs on the one hand and on relational needs for progress through higher levels of mathematics on the other (Charles & Lobato, 1998). Children need to master their number bonds and have functional mastery with selected algorithms. They need also to understand why these

algorithms work. Authors are also focusing on the role of motivation. Romberg (2000) indicated, for example, that "in classrooms where the emphasis of instruction shifted from mastery of facts and skills to understanding, students became motivated to learn and achievement at all levels increased."

Statistics in some current jurisdictions seems to be defined in terms of 'graphing' and perhaps calculating 'average' (Ministry of Education, Singapore, 2001). In others, statistical applications in primary grades have broader interpretations. Notions of chance and fairness, for example, are now being incorporated into the syllabus and are rationalized in terms of national education and life skills objectives. Further with these new applications, children are able to make connections with other parts of the curriculum (rational numbers), as well as incorporate technology applications (Ministry of Education and Training, Ontario, 1997; Scheaffer, 2000).

Formal proof in geometry has traditionally been left to the secondary grades but nevertheless aspects of 'Euclidean' geometry have been integral to primary level classes. Students using protractors, for example, measure angles of various geometric figures and have been then encouraged to hypothesize about angle relationships. Although these activities will continue, changes seem to be in the direction of including 'transformational geometry' into the curriculum. Notions of congruency, and similarity can more readily be developed using 'flip', slide', and 'turn' transformations rather than relying on side / angle comparisons. Further, some teaching units, those integrating transformational geometry concepts along with tessellations, now incorporate interesting graphics and IT applications. That is, geometry appears to becoming somehow more visual and active in response to perceived pupil interests (NCRMSE, 1994).

A fourth content area that is the center of some focus is algebra. Although 'algebra' still has for many a 'solving equations' interpretation, there is also a considerable shift to understanding algebra as pattern seeking. Children even in primary one classes are being asked to identify and generalize patterns (Ministry of Education and Training, Ontario, 1997; Shaughnessy, 1998).

One article in this issue of *The Mathematics Educator*, by Sharpe, describes a numeracy based study for kindergarten children where she concludes that, to prepare children for the expectations and challenges of a primary one mathematics syllabus, significant change will have to be made. These changes will involve utilizing appropriate teaching resources, altering teaching approaches, and promoting thinking and application situations for these young children. Readers

may find the descriptions of the various intervention tasks interesting and useful.

Process

We have long understood the role of problem solving and ways we can promote its learning (Polya, 1945, 1973). More recently, perhaps to redirect our attention to process components of problem solving, and while the term 'mathematical modeling' has been in use for well over a decade (Kho, 1987), it is clear that authors are now promoting various modeling and representation strategies. Although in Singapore the Ministry of Education (2001) clearly encourages children to use varied strategies to solve problems (p. 18), the use of the model approach continues to be actively promoted (Fong, 1994; Ng & Lim, 2001). Additional illustrations of the active promotion of the use of models are "Telling tales: Models, stories and meanings" (Bissell & Dillon, 2000) and "Representation: An important process for teaching and learning mathematics" (Fennell & Rowan, 2001). Informed educators will undoubtedly have to help children consider various forms of modeling options and how to relate these models to appropriate forms of representations.

In this issue, Ang in his article analyzes the mathematical modeling construct in terms of real world experiences, problem formulation and interpretation, and its solution. Illustrative examples include empirical and analytical approaches to solving a 'maximum volume' problem, as well as another that examines modeling in a population growth context.

Technology

For most educators, technology-based discussion tends to be focused on appropriate calculator and computer uses. Yet technology does include a broader range of resources including manipulative materials, LOGO and its turtle based geometric applications, and other forms of audio-visual media (Clements, 2000). Decisions relating to calculator use in the primary grades will continue to be value-laden ones, often involving input from parent groups, rather than decisions based strictly on research findings (Waits & Demana, 2000). Whether calculators will receive more wide-spread school use, particularly in situations calling for application or investigation, remains to be seen. One interesting development that has started to occur is the role played by graphing calculators in secondary schools. Although not as large, nor as impressive looking as some computer displays, the graphing calculator is showing to be a very powerful instrument for teaching given

its applicability to various strands across the curriculum, its small size and its portability. Readers of this issue may thus be particularly interested in Ball and Stacey's article where they demonstrate how access to computer-algebra-systems (CAS), now available on hand-held calculators, allows for reconsideration of traditional approaches to solving equations.

The classroom role of the computer will undoubtedly continue to soar in ways in which we cannot yet imagine. Further, undoubtedly we will continue to be reminded that many tasks we are expecting to be done now by computers were accomplished just as easily and with less preparation time in pre-computer days. Agreed. But this is not to say that, as we develop and become more sophisticated, we will go beyond using clever PowerPoint presentations to take full advantage of the programs and networking possibilities that continue to be revealed to us.

Communication

As a former primary and secondary school teacher I am not sure how often I would have asked my students to write much more than 'geometric proof' sentences. My recollections of my mathematics teaching all seem to involve students solving equations, drawing diagrams, using base-ten blocks, and so on. Not writing explanations nor discussing project applications! It is perhaps in this area where we will see the biggest changes in the teaching of mathematics within the next few years. Documentation from various studies already illustrates the care Japanese teachers take in selecting problems that promote effective classroom communication (Sawada, 1999; Soh, 1998; Geist, 2000). Soh, for example, concluded that "Japanese teachers were task-driven, better organized, concerned with understanding, and teacher-centered but balanced with sufficient student involvement …where students are constantly kept engaged through meaningful activities and where both verbal and visual presentation prevails." (p. 90)

Justification for increased attention to effective language use in mathematics will likely be centered on the workplace requirements of graduating students. Graduates entering the work force will have to work as part of a group, will have to communicate findings in some convincing manner, and will undoubtedly have to incorporate their mathematics into business and social contexts. Writing journals, keeping portfolios, and completing projects will become understood as normal mathematics activities (Burton, 1996; Sherin, Mendez & Louis, 2000; Whitin & Whitin, 2000).

Assessment

Perhaps questions addressing new literacy's in mathematics relating to assessment and curriculum are somewhat akin to the proverbial chicken and egg conundrum. Which comes first? Does curriculum change drive assessment change? Or vice versa? Most teachers are very wary, for good reason, about making significant changes in classroom practice if assessment through formal examination structures are still maintained. If journals and projects, as noted previously, become part of the mathematics teaching norm we might expect then to see such activities integrated into assessment strategies. Similarly if educational authorities mandate project work as a component of a final grade then clearly curriculum planners will incorporate such work into classroom practices. Where do we start if we wish to effect change?

In a document titled "Measuring Student Knowledge and Skills" the Organisation for Economic Co-operation and Development (OECD) (1999) has developed a new framework for assessment that involved defining mathematical literacy around two major and two minor themes or 'aspects'. The major aspects are 'competencies' and 'big ideas'. The minor aspects are 'curricular strands' and 'situations and contexts'. They further defined classes of competencies that encompass reproduction (class 1), integration (class 2) and generalisation and insight (class 3). A class 1 activity might ask students to solve equations; class 2, find the solution to a word problem. For class 3 activities, however, students might be presented with data or a graph, be asked to predict a result of some sort, then support the prediction with some form of argument. These last type of questions highlight an integrated nature of assessment that incorporates communication, technology and various content component strands. What long-term impact this OECD document has remains to be seen.

Tay, in an article in this issue of *The Mathematics Educator,* addresses language and communication changes in the context of assessment options. He illustrates three different strategies that may help people take a serious look at how we may begin to effect this change process.

Teacher education

Wong, in one of his future-oriented propositions, addresses a number of concerns related to preparing teachers. Usiskin, also in this issue, focuses on one additional aspect of teacher education not discussed by Wong. Teachers, to accommodate the

increasing changing demands of curriculum change, do require more mathematics. But attention must be given to the form this "more mathematics" takes. Usiskin argues that a body of knowledge, called "teacher mathematics", must be defined that enables teachers to formulate mathematical generalizations and to become far more adept at both concept and problem analysis.

Conclusion

Mathematical literacy is a multi-faceted, complex notion that can be analyzed only in relation to its context of time and place. "New literacy" then can only be understood within in this context. The question of 'What is this the new literacy?' (or, 'What are the new literacy's?") seems better considered by asking 'What shifting philosophies, pedagogies, and practices seem to be occurring?' Along with a sub-theme of 'mathematics for all' (Davis, 2000; Kilpatrick et al, in press), it does appear that in general it is still felt that mathematics must be learned with an intent to understand, with a view that it can be used, and that it be seen as a field itself worthy of study .

In particular, with respect to content changes, we may anticipate experiencing in primary mathematics classrooms within the next decade or so that pupils will study more and different "statistics" (fairness and chance), have more of an activity based geometry program that includes transformational geometry and IT applications, and experience an algebra where the focus will be on pattern seeking and prediction behaviours.

It is also reasonable to assume that more attention will be given to language as a communication tool, both oral and written forms. Pupils will also be expected to present reports, write in journals, and complete projects with graphics, text, illustrations and web references. Note that discussion of 'mathematics as a language' and the 'language of mathematics' is quite a distinct and separate issue.

The tension between forms of assessment and curriculum change will necessarily continue. The pressure will be directed toward utilizing alternative forms of assessment. The debate will focus around maintaining current standards of procedural competence yet incorporating and evaluating critical and creative thinking components.

To suggest that the above discussion represents a 'preliminary view' of the state of change might be to miss a critical point. Change is constant. Our notion of literacy, and what constitutes new literacy's, will remain a function of

mathematical, cultural, and socio-political pressures. Some change will be influenced by research, some by our values, and alas, some by administrative expediency. But the debate will be on-going.

It is with the intention of facilitating this debate that we present this issue of *The Mathematics Educator.*

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