

# A SCHOOL BASED APPROACH TO CURRICULUM MANAGEMENT TO PROMOTE MATHEMATICAL LITERACY (*sic* NUMERACY)

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The paper suggests that the term numeracy can no longer adequately define the mathematical competence which individuals should demonstrate. Instead it advocates a reconceptualization of numeracy as mathematical literacy. As a broader concept, mathematical literacy encompasses other dimensions of mathematical skills. This reconceptualization is necessary because technology has created the need for a different set of skills for competent mathematical functioning. The education community must reconfigure curriculum and promote teacher development in order to address related issues. A school based approach to management of the mathematics curriculum is presented in a model which promotes mathematical empowerment through professional development and instructional reform.

## Background

As generally used, the term *numeracy* seeks to distinguish between forms of literacy related to reading and writing--verbal literacy--and forms related to arithmetic or numbers--numeracy. Many readers educated in Trinidad and Tobago and the English-speaking Caribbean will recall that primary mathematics books were arithmetic books (text book series such as *New Capital Arithmetic* aptly exemplify the emphasis on number work and computations). One did algebra and geometry at secondary school; work done in class was referred to as "sums"; mental work was associated with, and focused on, mastery of numbers and computation. In fact, schools subscribed to the three Rs - Reading, (w)Riting, and (a)Rithmetic as the goals for a literate person. In that conceptualization of numeracy, the emphasis was on numbers and the manipulation of numbers. Today, however, many changes have occurred both in mathematical content and in the type and level of mathematics that individuals require for social functioning. The term *arithmetic* is no longer appropriate to describe the mathematical activities in which students engage, since these activities do not exclude geometry and notions of algebra, even at the primary level.

Given the above, any definition of numeracy ought to be broadened to include the wide range of skills needed to cope with the demands for mathematical skills wherever these arise in life. Indeed, it is perhaps unfortunate that, because of its derivation, numeracy is readily associated with *number* and *numerate*. For that reason, it may be useful to think in terms of *mathematical literacy* which will be defined to include not only skills with numbers but also other mathematical skills which are frequently required in daily functioning, for example, spatial sense, interpreting graphs and diagrams, handling information in tables, and using calculating devices. Such a proposition is not untenable as the root concept *literacy* has lately been pluralized to reflect a multiplicity of literacies such as scientific literacy, computer literacy, and visual literacy, to name a few. Whereas verbal literacy specifies those skills which are expressly associated with verbal communication, mathematical literacy encompasses all those skills which are expressly associated with mathematical communication.

### Current Practice

In 1975, the *New Primary School Syllabus* in Trinidad and Tobago first gave serious consideration to several topics other than number. However, tradition was so entrenched that teachers, by and large, continued to teach as they were taught, emphasizing areas where they were confident. At that time, many teachers complained of not being able to implement the new syllabus. Topics such as space and shape, statistics, and probability were given little or no attention. In a teacher survey conducted in schools in Trinidad and Tobago, Byron and Mohan Ram (1991) found that teachers spent at least 65% teaching time on computation; attached, on an average, 94% importance to computation; and expressed 95% confidence in teaching the topic. By comparison, teachers spent between 21% to 40% teaching time on geometry; attached 50% importance to it; and expressed 50% confidence in teaching the topic. This pattern existed throughout the levels and for many other topics.

In the 1986 Draft Revised Mathematics Syllabus (Trinidad and Tobago, 1986), the drafters again reiterated that the heavy emphasis on numbers was inadequate in reflecting goals for mathematics education relevant to the times. Moreover, at that time, the effects of the computer revolution were just being felt within the society. Since then, skills required for



everyday functioning and skills required in the work place have changed considerably as relationships with computer technology have affected patterns of mathematical activities. To provide one example: individuals do not now require the same display of computational skills as previously, since calculators and computers can do complex computations more efficiently. Yet, calculators have been omitted from primary classrooms as if they do not exist. Mathematical literacy should include estimation, and quantitative and analytical skills so that, for example, the results of calculator outputs can be evaluated. This, by no means, suggests the elimination of computation and number work from the mathematics curriculum. Students must be able to recall number facts and must master these. They must, however, know how to make judicious use of these and of the calculator as and when the occasion requires.

Today, the computer revolution worldwide, with the information technologies which have developed in its wake, has exceeded man's wildest imagination. The work place, commerce, industry, and the home have been transformed. The contexts for mathematics have not only broadened; they have changed. Also reflecting change are the students whom schools serve. It is not unusual to have teachers report that students are very different today. Students' interests, needs, and prior understandings are very different, influenced, in no small way, by the technologies which school ignores. On the other hand, the delivery system within schools reflects little change. Content knowledge remains predominantly through textbooks and teacher talk. Instructional strategies remain constrained by earlier theories of how children learn, traditional principles of classroom management, and minimal use of resource materials. Primary education continues to exist within a system designed for the industrial age. This system is being misapplied to educate children in an age in which both the amount of information and the nature of information require different strategies for both teaching and learning.

The Common Entrance examination in Trinidad and Tobago has also contributed to teachers' continued shortsightedness about the purpose and function of the mathematical experiences which students should have. Drill and practice and routine tasks, as measured by the examination, continue to be perceived as viable activities although they only satisfy short-term accountability requirements. Other experiences,

such as integration, student talk, and alternative ways of assessment, which support mathematical literacy are often dismissed as frivolous or time consuming.

### **A Position**

Numeracy as mathematical literacy should have mathematical power as its goal. However, this goal cannot be achieved if student understandings are superficial as can be exemplified in the following scenario. In a problem solving interview with this writer and after reading the problem, a student declared, "I know you have to add, subtract, multiply, or divide. It is always one of these but I don't know which." Then the student, arbitrarily (for that problem, at least), selected two numbers and one of the operations to obtain an answer. When challenged about the size of the answer, the student replied very calmly, "I have to divide now since the answer is too large." In both cases, the computation was correct. If teachers continue to spend long hours emphasizing number facts and algorithms in the abstract, very little will be achieved towards making students develop mathematical sense.

In this writer's view, mathematical literacy must embrace the various facets that support learning and knowledge construction. The bombardment of quantitative and spatial information presented differently in the various media, many of which are predominantly visual, further reiterates the proposition that numeracy as traditionally conceptualized is totally inadequate today. For example, information presented in the news media and routine decision-making situations require, among others, logical reasoning, patterning, spatial skills, and number sense. Furthermore, in the real world, problems occur in contexts and people collaborate to solve problems which do not compartmentalize topics or isolate knowledge. By contrast, in schools, students work problems individually and have, at hand, rules for problems which are assigned immediately after instruction. Connections within mathematics and across all subject areas in holistic learning contexts are under-explored even though those situations are more likely to reflect real life situations. Students' resistance to mathematics and the resultant need for remediation may justly be related to this practice. Moreover, at the primary level, students may be unable to pull together the discrete elements of mathematics in ways that could give them mathematical power. The recent thrust toward whole language learning



provides a precedent for a parallel rethinking of the organization and delivery of the mathematics curriculum.

Interestingly, at the St. Augustine Campus of The University of the West Indies (UWI) from 1985 to 1987, a cadre of teachers was trained to service a numeracy programme. When the course outlines were being developed for the programme, course tutors and this writer emphatically upheld that it was myopic to concentrate numeracy efforts at remediation in number work. It is even more apparent, at the present time, that number work does not equate mathematical literacy. Furthermore, recent literature on mathematics learning (Brown and Palinscar, 1989; Janvier, 1987; Mauer, 1987; Skemp 1987; von Glaserfeld, 1987) challenges the notion that early consistent patterns of failure may be reversed completely in environments which handpick these failures and set them apart as occurring outside the context of the students' experiences. Indeed, attempts to counteract mathematics under-achievement through that approach may aggravate problems or only whitewash fundamental inconsistencies and anomalies which exist in both teaching and learning.

In developing the courses for the programme mentioned above, tutors emphasized the developmental aspects for which remedial work would have meaning. Furthermore, the course tutors agreed that the sets of activities related to developmental concerns and remediation issues were not mutually exclusive and should not be structured as such. The goals for mathematical literacy implied, even at that time, that the mathematics curriculum tap into levels of mathematical thinking to give students ownership of mathematical ideas through meaningful, dynamic experiences in the school setting. Remedial work was not promoted as the strategy to bring about mathematical literacy. In sum, a mathematical literacy thrust should, of necessity, be built into what takes place at all times in the general classroom.

In proposing any reform in mathematics education, it is useful to draw attention to several conditions, attitudes, and beliefs which exist and impact on practice. Firstly, several assumptions appear to control the delivery of the mathematics curriculum. These may be stated as:

- mathematics is a fixed body of facts and procedures;
- to do mathematics is to calculate answers to set problems using a catalogue of well-rehearsed algorithms;

- the delivery system which supports mathematics learning derives mainly or even solely from set text books;
- the subject is best learnt in an environment of competition, with students getting the most out of any problem situation on their own;
- connections outside of the mathematics classrooms are made by students as a matter of course.

Secondly, several major changes have affected the context for mathematical literacy. These can be listed as:

- changes in the need for mathematics - workers in every sector require not just more mathematics but a *different* mathematics;
- changes in the role of technology. Calculators and computers have affected not only what mathematics is important, but also how mathematics is done;
- changes in our understanding of how students learn arising from the theory that learning is a constructive and interactive activity;
- changes in our understanding of the instructional process as a result of the current conceptualization of learning. Specifically, teacher imposition does not ensure learning; teachers can only facilitate the learning process.

New directions in research on learning mathematics, for example, the nature of representational systems (Janvier, 1987); constructivism (von Glaserfeld, 1987); cooperative learning (Brown and Palinscar, 1989) further challenge the assumptions and premises on which traditional mathematics instruction hinge. For students to become mathematically literate, the conceptualization and delivery of the mathematics curriculum need to be reformed. Activities which should characterize student mathematical behaviours ought to be reflected in words such as: examine, explore, represent, communicate, apply, solve, reason, verify, reflect. Teacher instructional behaviours should reflect designs which consider issues such as: student-centred, interactive, divergent, varied learning opportunities, multiple representations, alternative modes of assessment, problem posing, technological applications, reflective practice. The lists have not been exhausted. They merely hint at areas which



ought to receive increased attention in order to make mathematics education challenging, productive, and rewarding.

From the above, the framework for mathematical literacy would be reshaped so that less emphasis is placed on activities that are narrowly linked with number work and remediation. More attention would then be given to promoting rich environments which will make first time learning effective. As The National Research Council (1989) pointed out, "the best time to learn mathematics is when it is first taught; the best way to teach mathematics is to teach it well the first time."

It is also possible that much of what may be wrong in mathematics education, as in other areas of the curriculum, may be associated with the sterile and isolated environments in which teachers operate. Teachers do not have the opportunity to develop professionally through collaboration and sharing of teaching ideas and strategies that work. In early 1994, at the Faculty of Education, St. Augustine, a group of undergraduate students who had completed research projects in primary schools presented their reports at a Colloquium attended by classroom teachers. The reason given for the professional activity was simple. Student teachers go to schools and try out innovations which have many implications for the development of mathematics education but the only persons aware of these are the student teachers, their tutors, and each co-operating teacher.

The response by visiting supervisors, principals, and teachers to the Colloquium was positive. Several projects which were presented reflected an integrated approach to teaching, or focused on learner-centered activities, peer interaction, alternative assessment, or promoted language and communication as critical to the generation of conceptual understanding in mathematics. In fact, when all the presentations were viewed, everyone commented on the wealth of ideas, innovations, and resources which could begin to bring students the mathematical power to which this paper alludes.

### **A Model of Curriculum Management**

Doll (1992) proffered that curriculum improvement results primarily from improving individual persons and organizations. He suggested that staff

development which puts the responsibility for change and growth on the teachers themselves has a high potential for achieving change. According to Doll, inservice education ought to be extended beyond conventional prescriptive workshops and organized so that teachers can actively participate in the change. The inservice activities become more focused and emphasize teachers and their development. The model outlined in this paper proposes such an extension to inservice education through teacher participation, collaboration, and professional writing and speaking. Organized around a programme of staff development, reconceptualization of mathematics content, and instructional monitoring, the model provides the setting for schools to take a pro-active role in redefining numeracy. It is suggested that within such a school-based structure of curriculum management, goals of mathematical literacy can be pursued. The model comprises two components:

1. **Professional Development** which attempts to generate a support system within schools for activities to foster reform in curriculum management practices. It posits that administration must be inducted into a mood for change, and most importantly, teachers must be instrumental in initiating the change process.
2. **Instructional Organization** which highlights the parameters which should inform curriculum inputs within the classroom setting and in the process of achieving mathematical literacy.

#### THE PROFESSIONAL DEVELOPMENT COMPONENT

The professional development component is based on the assumption that people will agree to change if they understand the change. Schubert (1986) noted that the key to curriculum improvement is professional development. He believed that behind every curriculum improvement project was some kind of change in personnel outlook. Targeted at supervisors, principals, and classroom teachers, the component will incorporate several interlocking phases. The phases are important because both principals and teachers must desire to make instruction meaningful and be willing to ruffle the comfort of traditional practice. In sum, all constituents must be receptive to proposals for change if there is to be genuine improvement. Figure 1 presents a diagrammatic



representation of the phases of professional development from an orientation to the change process through to adoption of the change.

Outlined below is an explanation of the phases in **Figure 1** in the thrust towards an ongoing strategy of professional development.

### Phase 1 - AWARENESS

- Supervisors and principals begin a programme of induction to ensure administrative and institutional support for the change process. Their role is significantly related to activities which support the re-education process. Supervisors, principals, teachers of selected classrooms, and master teachers meet and establish needs of a specific school. Master teachers may be selected from current mathematics facilitators, graduates from UWI programmes in Education, and exemplary classroom teachers. This needs assessment provides the basis for the Classroom Action Mathematics Project(s) (CAMP) to be developed.
- The classroom teachers and master teachers collaborate to develop, implement, and evaluate a CAMP. Explicit evaluated data on student performance provide the base to establish levels of mathematical literacy supportive of national literacy goals. The master teachers, as innovators and agents of change, introduce the leadership that is necessary in such a school-based model. As they themselves are immersed in the role of generating learning situations, their displayed expertise will derive from methods which are updated and evaluated. A condition for functioning as a master teacher is continuous re-education through presentations at seminars, professional meetings, and refresher courses.

### Phase 2 - INTEREST

- Supervisors, principals and other teachers view the master teacher and classroom teacher at work in modeled settings. They evaluate the CAMP and re-evaluate their goals as they observe students' responses and performance.

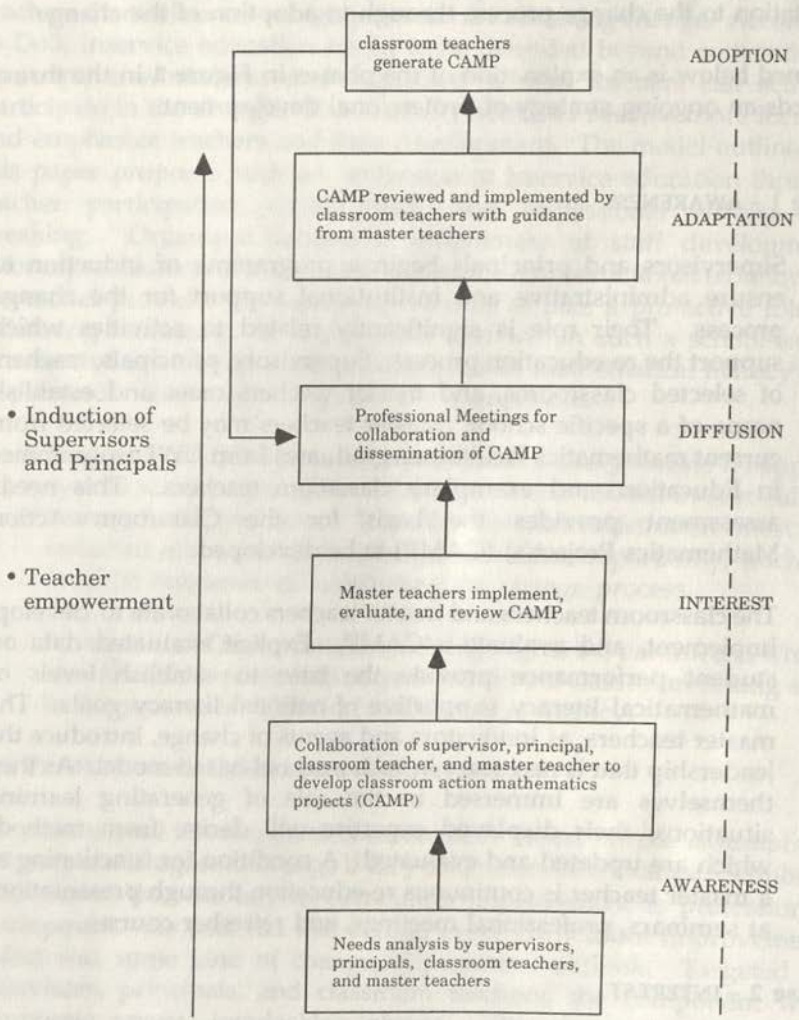


Figure 1. Model of school-based professional development to support mathematical literacy



### Phase 3 - DIFFUSION

- CAMPs are presented and shared at professional meetings held at regional and national levels. These presentations should be structured as professional contributions and used to generate and encourage a culture of professional collaboration among teachers. It is possible that as teachers regain their professional dignity much of the lack of interest and drive to be creative which now exists may be reduced.

### Phase 4 - ADAPTATION

- Principals and teachers express interest in projects which they review, adapt, and implement to meet their specific needs. Because principals understand change, their support is assured. Schools are alive as mathematics classrooms provide opportunities for meaningful experiences and sense making. Support and counsel for these projects will be provided by master teachers.

### Phase 5 - ADOPTION

- Teachers working in teams, or individually, in their respective schools, are challenged to generate their own CAMPs and share these at professional meetings.

The activities in the different phases provide a generative forum for teacher collaboration and the exploration and dissemination of ideas. As needs and interests change and new information from research becomes available, the nature of the professional meetings is reviewed to meet the new demands. A professional organization of teachers of mathematics may well be a useful entity to promote and coordinate these activities.

## THE INSTRUCTIONAL ORGANIZATION COMPONENT

The structure of the instructional component is premised on current conceptions of learning; the types of stimuli that will support the construction of knowledge; and the environments that will challenge sense making. Four major areas are seen as important in facilitating the meaning making process: connections, social interaction, conceptual

orientation, and activity structure. Each component addresses an aspect of instructional organization which requires the teacher's explicit attention. The relation between and among elements which ought to be considered in the reconceptualization process is schematized in Figure 2.

In Figure 2, the four parameters which gird this component of the model emphasize the range and diversity of the experiences to be considered in the design of instruction. In the design, attention ought to be directed at:

- an emphasis on learning rather than performance or instruction;
- making the learner a stakeholder in the enterprise-- students need a sense of ownership through using their own experiences, generating their own questions, and following their own lines of investigation;
- creating settings and experiences which can stimulate and support student interest and levels of motivation;
- information rich environments which provide the catalyst for conceptual change;
- promoting whole learning through connections within mathematics and with other subjects by way of purposeful problem situations;
- variety in experiences that reduce stereotyping and inequity;
- a wide range of presentations using multiple representations;
- multiple levels and forms of communication by which students can negotiate meaning;
- use of the newer technologies to extend the arena of students' experiences;
- ways of students documenting their learning;
- ways of recording student growth by teachers.



# Mathematical Power

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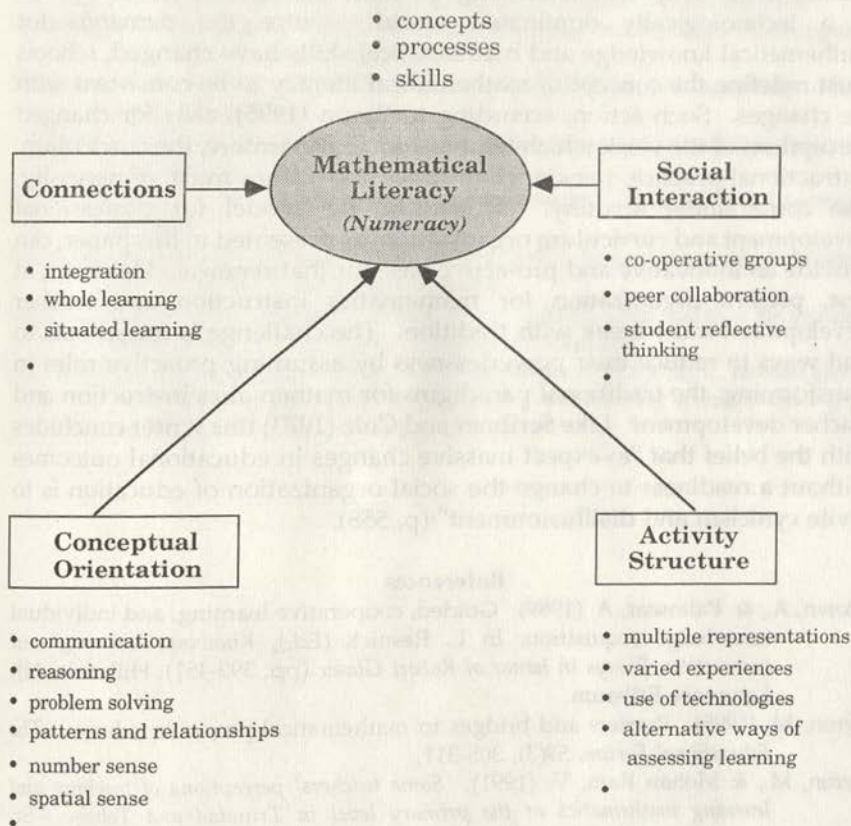


Figure 2. Four-parameter model of instructional organization

## Conclusion

The ideas presented in this paper are not unique to the primary level or to mathematics. The strategies are applicable to curriculum reform in other curriculum areas and at other levels of the system. Specifically for mathematics, they suggest that the expressed goals for mathematical literacy must be synchronized with the mathematical activities required in a technologically dominated world. Since the demands for mathematical knowledge and mathematical skills have changed, schools must redefine the concept of mathematical literacy to be consistent with the changes. Such action, according to Byron (1995), calls for changed perceptions of the work which teachers do. Furthermore, the curriculum, instructional practice, personnel attitudes and values must, of necessity, also come under scrutiny. Hopefully, the model for professional development and curriculum organization, as presented in this paper, can provide an innovative and pro-active base for that renewal. However, at first, present organization for mathematics instruction and teacher development must break with tradition. The challenge is for schools to find ways to reduce their powerlessness by assuming proactive roles in transforming the traditional paradigms for mathematics instruction and teacher development. Like Scribner and Cole (1973) this writer concludes with the belief that "to expect massive changes in educational outcomes without a readiness to change the social organization of education is to invite cynicism and disillusionment" (p. 558).

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