INTENSIVE MATHEMATICS INSTRUCTION FOR MATHEMATICS DISABLED STUDENTS : THE MATHEMATICS LEARNING CENTRE APPROACH

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Access to effective learning opportunity for students who have mathematics learning disabilities is an on-going concern for teachers, students, educational policy makers and the community at large. The types of opportunity offered range from the traditional "clinic" approach (for example, as described by Englehardt (1985), Irvin and Lynch-Brown (1988) and Scheer and Henniger (1982)) to the delivery of support within the student's classroom, often via teacher in-service. The Mathematics Learning Centre (MLC), developed in the former Melbourne College of Advanced Education lies between these two extremes in its approach to opportunity provision. This paper reports a recent evaluation of the effectiveness of the service delivery in the MLC. It examines the guiding model of mathematics learning on which the program is based and the evaluation procedures used to measure change.

Any educational practice makes assumptions about issues such as preferred outcomes, learner characteristics and the nature of learning learning process. These drive the implementation of the practice and influence its evaluation. The first assumption made by the model relates to the desirable outcomes of mathematics learning. The model identifies outcomes in the following areas: (1) mathematics content: conceptual and procedural knowledge, the use of formal mathematical symbolism and the automatization of parts of this knowledge and mathematical thinking, (2) a knowledge of how to learn mathematics, (3) attitudes towards mathematics, how it is learnt and one's self as a mathematics learner. These aspects are assumed to operate interactively in the mathematics learning. Students usually acquire outcomes (2) and (3) incidentally and spontaneously. In the present context these outcomes are targeted directly both in the teaching program and in its evaluation because, as will be discussed later, many mathematics underachievers have difficulty acquiring them in this way.

The second assumption relates to how mathematics ideas are learnt. The model assumes a constructivist view of mathematics learning (for example, Cobb, 1986; Steffe, 1990). The construction process involves student action and the investment of attention. Attention is more likely to be invested in learning when students have framed up for themselves purposes or challenges for learning. They are assumed to have a range of representational formats in which they can build these ideas. Their activity in the construction process can be described in part in terms of mathematics learning strategies; both mathematics-relevant reasoning strategies and the self-instruction strategies used to direct and manage the reasoning strategies. These strategies are used spontaneously and selectively. Regular successful use may lead to a strategy gradually becoming automatized. The ideas are built gradually through an hypothesis production, trialling and modification process. With an emphasis on "partial construction" the concept of failure is inappropriate. Errors are seen as signalling the need for further work on an idea. Belief in one's ability to learn is important; students who don't believe that they can learn or who believe that others don't expect them to learn are less likely to build.

These assumptions have implications both for the approach to teaching and for the evaluation of the MLC program. Attitudes about how matematics ideas are learnt, their use of mathematics learning strategies, their knowledge of what they can do when they find learning difficult are desired outcomes of the approach. Pupils are encouraged see how their purposes have been partially achieved through partial constructions. As discussed in the following section, many mathematics-disabled learners do not acquire these incidentally.

The learning characteristics of mathematics disabled students. Four approaches to the description of mathematics underachievement are discernible in the literature (Munro, 1987); the psychological descriptive approach, focussing on psychological difficulties that co-occur with mathematical difficulties, the error analysis approach focussing on the types of errors made by students, the neuropsychological approach that relates mathematics underachievement to neurological disorders and the information - processing approach, focussing on the relationship between mathematics difficulties and information processing. These approaches focus on students in isolation rather than on students in relation to their mathematics educational history. They rarely refer to the characteristics of the instruction to which the students have been exposed.

The present approach assumes that a student's mathematics performance at any time is a function of the interaction between the student's preferred ways of learning and the assumptions made by the learning environment about how students learn. Students differ in their preferred ways of learning. Mathematics learning situations differ in the demands they make on how students learn. Mathematics underachievement occurs when there is a significant mis-match between how students prefer to learn and the demands made by the learning environment. Transitory mismatches may be expected as a regular component of any learning situation and are resolved as students develop new learning strategies and as the learning situation adapts to match student learning styles. The greater and more chronic the mis-match, the more likely is mathematics learning disability. The present approach assumes that mathematics underachievement can be more satisfactorily be reduced by focussing on the student-learning environment interaction than by examining intra-learner deficits.

A framework for analysing the types of mis-match that lead to mathematics underachievement is described in Munro (1992). In summary, frequently occurring assumptions that mathematics curriculum make about preferred ways of learning include the following

(1) The learning environment assumes that students can manipulate and process particular types of information in various ways. Mathematics disabled students may have difficulty processing quantitative data, visually-presented symbolic data or spatial symbolic data (Kosc, 1986), arithmetic operations mentally (Rourke & Strang, 1983) or related verbal information (Share, Moffitt & Silva, 1988). They may not be able to handle all of the information necessary for completing a mathematical task or to recall information from long-term memory.

(2) The learning environment assumes that students can use spontaneously a range of general-purpose learning strategies. Learning disabled students are characterized as non-strategic learners (Torgesen, 1980), less likely to activate spontaneously the range of strategies necessary for learning (for a review, see Flood and Lapp, 1990).

(3) The learning environment frequently assumes that in the acquisition of a idea, students can allocate most of their mental resources to building this idea, that is, they can manipulate subordinate ideas in a relatively attention-free way (Ackerman, Anhalt & Dykman, 1986). Mathematics underachievers have difficulty meeting this demand, for example, in automatizing "basic number facts" (Fleischman, Garrett & Shepard, 1982). The issue of automaticity can be applied to the use of mathematics learning strategies.

(4) The learning environment assumes that the students believe that they can learn mathematics and are motivated. Self-confidence in learning mathematics and achievement are moderately correlated. Self-confidence is determined in part by what students tell themselves about success and failure. Students who lack self-confidence frequently believe that success is beyond their control, failure is inevidable and that effort is useless because it will probably not lead to success (Kloosterman, 1988).

Thus, while the assumptions about learning made by mathematics curricula are valid for most students, they can be shown to be less valid for underachievers. Teachers working with mathematics-disabled students and the students themselves need to be aware of these assumptions and the steps that can be taken when they are not justified.

Who are the students for whom intensive mathematics instruction is most appropriate? The group of students who have had chronic difficulty benefiting from regular mathematics teaching comprises two sub-groups; those who can be assisted within their regular classroom by relatively minor curriculum modifications and those who don't know how to go about learning mathematics and who present as innumerate. These latter students need the opportunity to learn how to learn mathematics, to experiment and to take risks and to see themselves as able to learn mathematics. This "opportunity to re-learn" can best be provided in an intensive strategies context. In psychometric terms, students in the first sub-group may achieve at stanines 3 and 4 on normal mathematics tests and students in the second sub-group at stanines 1 and 2 (Pickering, Szaday & Duerdoth (1988).

The present investigation examines the effectiveness of the M L C model as a means of service delivery to mathematics-disabled learners in the second sub-group. It examines the extent to which disabled mathematics learners are assisted to integrate themselves gradually into regular classroom mathematics learning by helping them to: increase their mathematics knowledge, their repertoire and use of mathematics learning strategies and their perceptions of mathematics, how it is learnt and themselves as mathematics learners.

METHOD

Subjects : 76 students aged from 6 years to 14 years (median age ranged 10-5 years) are from grades 2 to 9. All were achieving at a mathematics level that was at least 2 years below their grade level and all met accepted mathematics disability criteria (Pickering, Szaday & Duerdoth, 1988).

Design : The effectiveness of the program is measured in terms of changes in mathematics knowledge, attitudes and mathematics learning strategies on an individual basis. The extensive use of normative - summative procedures is not seen as appropriate. Subjects differed on a range of criteria. The design focusses on the monitoring of change in learning behaviour and the reporting of change on several dimensions on an individual basis using mathematics tasks, behavioural checklists and subject reporting.

Materials : The test used to screen mathematics performance is the Diagnostic Mathematics Tasks (DMT) (Schleiger, 1980). Given the nature of students' level of performance, the DMT two grade levels below the grade level of a particular student was used initially to screen performance.

Procedure : The MLC teaching program is administered in several components;

(1) a 'teacher preparation' component in which teachers examine the nature, assessment and remediation of mathematics learning disabilities implemented in lecture-workshop context.

(2) a diagnostic - assessment component in which each teacher completes an initial evaluation of one student's mathematics learning needs by collating information from several sources: (a) the pupil's mathematics performance on reasonable mathematics tasks, error analysed in a clinical interview to identify the conditions under which the student can complete or self-correct tasks (b) the pupil's affective behaviours while working on mathematics tasks are monitored using a behaviour rating scale) (c) the pupil's mathematics learning in the regular classroom context, collated using a checklist to tap the classroom teacher's perception of the pupil's mathematical difficulties, (d) the pupil's mathematics learning at home and (e) general referral information, such as possible causes, correlates of the pupil's learning difficulty, learning difficulties and strengths in other areas and relevant family information.

(3) a planning component in which the student and teacher plan and negotiate an initial set of goals and program. The teacher's impression of the nature of the mathematics learning disability is discussed with the student, a consensus is reached about how the student can learn best and a program is negotiated. The focus here is "What would you like to learn in mathematics?" The teacher plans a teaching-learning program and discusses this with the group of Centre teachers, the pupil's classroom teacher and parents.

(4) a teaching component in which the teacher works with the student for 10 to 15 11/2 hour sessions under the supervision of a master-teacher skilled in the study of mathematics learning disabilities. To facilitate the pupil's gradual integration into regular mathematics lessons, the mathematics content studied where possible is that being taught in the student's regular class. This frequently involves assisting the student to acquire prerequisite knowledge. Each session is reviewed and evaluated by the teacher. Pupils monitor their progress and to complete regular homework tasks. Throughout the program, communication with the pupil's parent and class teacher is maintained using a journal. Wherever possible the location of the program is gradually moved to the pupil's scho

(5) Each pupil's performance on each of the following criteria is re-assessed at session 11; (1) achievement, (based on the pupil's entry DMT and the proportion of set goals achieved, (2) frequency of use of each type of learning strategy, (3) attitude towards mathematics, (4) display of mathematics learning behaviours in the pupil's classroom and (5) parent perception of mathematics learning. A % gain score was calculated for each student (% gain score = change in score / total number of items x 100) and a median score for the group.

RESULTS AND DISCUSSION

The median % gain on each of the evaluation criteria across grade level and content area are shown in Table 1.

Table 1

Demonstrated gains in mathematics performance

Criterion	Assessment Procedure Used	Median % Gain
Achievement	1. Entry DMT.	58%
	2. Proportion of set goals achieved by Session 11	74%
Use of Learning Strategies	Frequency of using each type.	71%
Attitude Towards Mathematics	Frequency of positive-rated responses to attitude scale (42 item questionnaire).	83%
Performance in Child's Classroom	Frequency of positively rated behaviours (20 item behavioural rating scale).	68%
Parent Perception	Frequency of positively rated behaviours (using 24 item behavioural rating scales)	79%

These data show a substantial gain on all criteria. They indicate little, however, about the value of the program for individual students and the extent of individual change. As well, this analysis does not permit analysis of the precise factors that are most influential in bringing about the observed group changes. Individual reporting by students (several of whom had been involved unsuccessfully in earlier programs) identified most frequently the following as the most valuable aspects :

(1) the emphasis on 'having another go', being able to ask questions and to say "I don't know", being able to try things out without having to worry about avoiding errors,

(2) the emphasis on 'things to do' to learn matematics, for example, "telling yourself what to do / to use what you already know", using mental visualization and imagery,

(3) being able to learn things in different ways,

(4) being able to do things better in mathematics classes at school, being able to "show my classmates that I can learn maths",

(5) the emphasis on "knowing what works best for you",

(6) knowing what you can do to learn a difficult idea, knowing that although "something might be hard, you might know something about it a bit later", knowing what can make an idea hard to learn and possible things to do about it, and

(7) "planning my own program, seeing myself learning / making progress ", "understanding why I used to find maths hard to learn.

To examine the extent to which the gains made by session 11 were sustained six months later, 46 of the students were examined on a number of criteria. These criteria and outcomes were:

1) How valuable / effective / useful did the student judge the program ? A 20 item questionnaire with a 5-point rating scale for each item was used. The mean rating was between "good" and "very good".

2) The spontaneous use of relevant strategies when working through mathematics tasks was monitored by having students "thinking aloud"; 71% of the students used the appropriate strategies on at least 80% of possible occasions

3) The maintenance of a positive attitude towards mathematics; the median % of positive responses on the attitudinal questionnaire was 89% (range 82% - 90%).

5) Classroom teachers rating of pupil's current progress; (for example, whether the student continue to be engaged in mathematics lessons, takes learning risks spontaneously, attempts to solve problems without seeking assistance); 86% of the students were rated as making at least adequate progress .

6) Parent rating of the success or value of the program; 93% rated the program as having been of substantial benefit for their child and supported their ratings with a range of positive behavioural statements (for example, students attributing their current progress to their involvement in the program).

This evaluation supports the claim that the MLC program has been successful intervening in the mathematics learning of a group of students, who, at the beginning of the program, was seen as having severe mathematics learning difficulties. The gains in achievement, attitudes and mathematics learning strategies were shown to be sustained six months after the conclusion of the program. The individual gains made support the efficacy of the model.

The original aim in developing the MLC was to implement an evolving facility by which several purposes could be achieved simultaneously within a structure that had a sound mathematics learning base, that was optimally flexible and versatile, that could respond to changing needs and that was "resource-lean" (in other words, that made maximum use of existing resources). Several educational institutions in Victoria have adopted aspects of its model for the development of parallel facilities. The MLC continues to evolve. Parallel evaluations have examined its effectiveness as a teacher training facility. Future evaluations may be expected to target changing directions in the provision of services for mathematics disabled students.

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