LEARNING SUPPORT FOR MATHEMATICS: LESSONS FROM 100 LESSONS

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This paper reports on an analysis of the teaching practices of 50 learning support teachers for mathematics based on tutor observation reports of 100 lessons. The practices are compared to those recommended in the literature. Overall, the quality of instruction observed was very good with some exemplary practice observed. At the heart of this was the ability to individualise instruction and utilise an eclectic range of empirically validated teaching and learning strategies to promote learning. However, there was also evidence of shortcomings such as inadequate planning, failure to differentiate, non-use and inappropriate use of concrete materials, non-use and poor use of mathematical software and not realising the potential of small groups working collaboratively on shared tasks and learning from each other.

INTRODUCTION

A diverse range of strategies have been highlighted in the literature for supporting pupils who experience difficulties in learning mathematics. In terms of raising standards in mathematics for pupils with general learning disabilities Porter (2003) stresses the following: tailoring the learning context to the pupils' needs and interests, connecting the abstract with the practical, linking skills with understanding, reducing the emotional impact, scrutinising and adapting the language of instruction, paying attention to old as well as new learning, providing contexts for consolidation and generalisation and using visual cues to reduce the load on working memory.

A key theme of research in this area is that the range of strategies which proved effective crosses pedagogical philosophies incorporating constant time delay, peer tutoring, time trials, direct instruction, strategy instruction and using concrete materials (Butler *et al.,* 2001). Learners benefited from "interventions stressing frequent feedback, explicit instruction, and ample drill-and-practice" (p.29). At the same time "strategy instruction promoted student independence in addition to increasing mathematics performance" (p.29).

Baker *et al.* (2002, p.67) having set up their "gold standard" (Whitehurst, 2003) criteria

maintain that: “Although this is not a large body of research, four findings are consistent enough to be considered components of best practice.” First, providing students and teachers with specific information on how each student is performing seems to improve mathematics achievement, “raising scores, on average, by 0 .68 SD units” (p.67). Second, using peers as tutors or guides enhances achievement. This is confined to computational abilities and “holds promise as a means to enhance problem-solving abilities” (p.68). Third, based on two studies, providing “specific, objective, and honest” feedback to parents of low achievers and detailing “successes (or relative successes) as opposed to failures or difficulties” have the potential to enhance achievement (p.68). All of these seem very low cost measures on the surface, but the level of knowledge and skill involved in diagnosing strengths and needs to be used for feedback and further teaching should not be underestimated (Pitt, 2001). The fourth finding is that “in terms of curricula, a small body of research suggests that principles of direct or explicit instruction can be useful in teaching mathematical concepts and procedures” (Baker et al., 2002, p.68).

The literature among other areas also highlights the benefits of targeted early intervention based on diagnostic assessment (Dowker, 2004), cognitive/metacognitive problem solving strategies (Xin and Jitendra, 1999), while Conway (2002) argues the benefits of a socio-cultural perspective, which would entail a shift from a psychology of individual differences to building learning communities with more attention paid to the social context and participation structures. The present study sought to ascertain the actual pedagogical practices of learning support/resource teachers of mathematics in Irish primary schools.

METHODOLOGY

Two of the courses I teach on in the Special Education Department in St. Patrick’s College involve observation of experienced teachers teaching in a learning support or special educational context. Detailed field notes are taken on these observations to facilitate both formative and assessed feedback to the teachers. While the field notes are not compiled for research purposes, they represent a unique data source in relation to

actual pedagogical practice and permission was sought for their use from 65 teachers. Just over 50 teachers replied granting access, giving a total of 100 lessons observed by six tutors, which could be analysed.

The pro forma for the lesson observation included detailed information on size of groups, classes taught, resources used, topics taught, descriptions of lessons and evaluative comments on pedagogy observed. The main focus of the observation was on the teaching and learning situation. Thus, a detailed description of the lessons observed was gained, incorporating both teacher and pupil behaviour. All pupils were experiencing difficulties in mathematics ranging from mild to those assessed with a general learning disability. While practice was judged against recommendations from the literature the reports are inevitably affected by the subjective views of the tutors.

TEACHING AND LEARNING

In relation to the lesson evaluations teachers had a mean number of 3.6 pupils in their groups with a mode of 4 (38%). The lessons covered all primary classes except junior infants (first year in school) with 81% of the lessons in classes between 1st and 4th (third year to fifth year in school). While all aspects of the mathematics curriculum were covered, the topics most frequently covered were aspects of number (observed in 45lessons), word problem solving mainly for addition and subtraction (observed in 20 lessons) and fractions and place value (observed in 18 and 17 lessons respectively).

Lesson evaluation notes were analysed firstly in terms of positive descriptions made by the tutors informed by criteria identified in the literature as supportive of pupils experiencing difficulties in mathematics. Ninety-one of the lessons contained evaluations that were interpreted as positive comments. These were then further analysed for key themes and issues in practice. The following emerged as the areas most positively evaluated and interpreted as best practice: the quality of planning and an eclectic range of appropriate teaching strategies.

Planning

The quality of the planning particularly when tailored to pupil needs and linked to weekly and termly plans were highlighted (DES, 1999, 2000). Also evident in the planning was subject competence:

> *…high level of subject competence was displayed in the planning and teaching of the lesson. (Tutor evaluation of lesson 28)*

Other features mentioned included lesson cohesion, organisation and systematic planning.

There was a strong emphasis on teachers developing pupils' conceptual understanding of the mathematical material:

> *Strong emphasis on conceptual understanding and making linkages, and monitoring understanding; very good use of mental strategies and concrete materials to promote understanding, very good pace of instruction; well planned in five different parts; engaging manner with the pupils. (Tutor one evaluation of lesson 69)*

This emphasis on conceptual understanding goes to the heart of all recent reform efforts in mathematics education (NCTM, 1989, 2000).

Appropriate teaching strategies

Teaching strategies that were highlighted as being appropriate for the mathematics' lesson objectives were of an eclectic nature. They included the development of metacognitive skills (Bley and Thornton, 2001), direct instruction (Baker *et al.*, 2002), peer tutoring (Dowker, 2004) and teacher modelling of thinking strategies by "thinking aloud" (Conway and Sloane, 2006):

> *Inculcation of metacognitive skills, through guided reflection, on part of the pupil e.g. What method do you have to remember your tables? Do you just learn them like a poem? Do you see them in your head? Do you count on up from the one that you are sure of? (Tutor one evaluation of lesson 9)*

> *…superb teacher questioning/comments. Self-talk was effectively used to show understanding of both the sequence and concept. (Tutor one evaluation of*

lesson 46)

Direct teaching was used when necessary but you always posed questions that first enable the pupils to reason and problem solve and when successful expressed delight and praise for their successful efforts. (Tutor four evaluation of lesson 18)

The explicit modelling of strategies by thinking aloud, though validated in the literature is not observed all that often:

> Considerable research suggests that teachers rarely use think alouds and other strategies that model and make explicit complex and expert problem-solving. This is especially troubling as such strategies have been demonstrated to be effective with lower-achieving students in both primary and post-primary settings (Conway and Sloane, 2006, pp.101-102).

Other strategies observed which have been validated in the literature include helping pupils make connections (Askew *et al.*, 1997) and appropriate use of concrete materials:

…content very well sequenced, new knowledge was related to prior knowledge. (Tutor six evaluation of lesson 36)

…related decimal fractions to fractions, excellently grounded in continuous "thinking aloud " strategy that helped pupils understand each step, use of song to reinforce link between fractions and decimal fractions. (Tutor four evaluation of lesson 42)

Pupils guided from the concrete, to pictorial and symbolic representation, appropriately paced and pitched allowing for challenge and progression, performance was monitored, all actively engaged." (Tutor three evaluation of lesson 17)

Maintaining attention through active engagement of the pupils in purposeful and appropriate activities also strongly featured. Giving the pupils opportunities for application, practice, reinforcement and over learning (Baker *et al.*, 2002; Lerner, 2006):

…and lots of practical applications so the children had lots of opportunities to grasp and practice concepts. Reinforced with lovely rap. (Tutor six evaluation of lesson 85)

Monitoring and assessing understanding before moving on (Westwood, 2007) was a key component of many lessons:

> *Works through the problem orally, making sure the children are ready before proceeding, thorough rigorous teaching, well planned, children really becoming competent in this difficult area of maths. (Tutor five evaluation of lesson 92)*

Attention to the language of mathematics and the direct teaching of mathematical terms was a feature of many lessons (Porter, 2003):

> *…attention to language of the four operations; excellent focus on language and on using problem solving strategies; very good use of discussion to elicit thinking. (Tutor four evaluation of lesson 53)*

Linking learning to pupil experience and environment which is one of the principles of the revised primary curriculum (DES, 1999) was evident in many lessons:

> *Very good use of personal benchmarks to illustrate cm and metre, good emphasis on hands-on work and actual process of measuring and monitoring understanding. (Tutor one evaluation of lesson 83)*

> *Cue cards, my personal challenge card, multiplication rap (made up by pupils), attention to language of the four operations activity; excellent focus on language and on using problem solving strategies, very good use of discussion to elicit thinking. (Tutor one evaluation of lesson 80)*

The individualising of instruction to challenge the pupils at an appropriate level was also evident (Dowker, 2004):

> *…individual needs catered for, differentiation through questioning and through acquired tasks. (Tutor four evaluation of lesson 18)*

> *Excellent use of overhead projector as a material resource, monitored the group to ensure task engagement, most impressive aspect was the gradual inbuilt increases in level of challenge for each individual, motivating activities with a great element of fun were a feature. (Tutor two evaluation of lesson 16)*

There was also extensive use of a range of concrete materials and visual cues to facilitate understanding (Porter, 2003). The range of materials used can be seen in Table 1. Materials relating to place value, number games and various cards featured most often

and, on the whole, were used appropriately. The low use of the calculator can be partly explained by the age range of the classes but the low use of software cannot.

Table 1 Use of mathematical resources in 100 lessons

Resources used in observed lessons	Number of lessons	Types of the resource observed
Place value materials	21	Diene's blocks, lollipop sticks, place value boards, unifix cubes
Maths Games	20	Number bingo, dice games, snake and ladders, dominoes, number snap, lucky dip, numero, fraction game
Cards	17	Number cards, playing cards, fraction cards, word cards, arrow cards, cue cards, number chain cards, flash cards with number facts
Number line	15	Plastic number lines, number "washing line", number strips on tables, number ladder
Whiteboard/blackboard	13	
Counting materials	13	Blocks, cubes, teddies, spindle box, objects
Materials for time	11	Clock, calendar
Fraction materials	10	Fraction wall, paper folding, cutting apples, game and cards
Hundred Square	9	Magnetic, blank, colour- coded, large walk on
Magnetic board	7	Magnetic numbers, 100 square, magnetic fruit
Shapes	7	Two and three dimensional and fraction shapes

Money	7	Coins, notes, shop and catalogue, price list
Materials for length and weight	5	Metre stick, balance, scales, objects
Pegs	5	Pegboard, 100 square and number line
Charts	4	Flip chart, problem strategy chart, place value chart
Computer software	3	Numbershark and Destination maths
Songs	3	Counting songs
Other	2	Drill, mitre saw, dado rail, holiday brochure
Calculator	1	
Overhead projector	1	

Pupil learning strategies observed and praised included self-checking and monitoring, using recall strategies for learning basic facts and problem solving strategies (Bley and Thornton, 2001; Xin and Jitendra, 1999). There was some evidence of the use of real life contexts for problem solving. These included using holiday brochures, shopping catalogues, rail and bus timetables and TV schedules as contexts for realistic and genuine problems. The use of rich non-mathematical contexts for problem solving is a feature of the realistic mathematics education movement, which has its roots in the work of Hans Freudenthal (Conway and Sloane, 2006).

Opportunities given for the pupils to ask questions were also observed. A small number of observer comments highlighted small groups working collaboratively as a group as opposed to individually in a group. Such collaborative work has been advocated as a very appropriate way to develop pupils' mathematical language and reasoning skills (Haylock, 1991).

Aspects of teaching style, which received positive comments, included intensity in the teaching, high-energy fast paced instruction, and respectful and positive behaviour management techniques (Heward, 2003). The quality of teacher-pupil interaction and relationship were also valued.

SHORTCOMINGS IN OBSERVED LESSONS

Areas of lessons where shortcomings were identified were analysed across the lesson evaluations. Forty-six of the lesson evaluations contained comments that could be interpreted as representing a shortcoming. Comments made were grouped according to similar patterns and then into categories. These shortcomings emerged as the opposite or weaker approximations of many of the practices observed in the more exemplary lessons. The categories which emerged from the analysis were: inadequate planning, failure to differentiate, shortcomings in teaching strategies, non-use and inappropriate use of concrete materials and other issues grouped under other shortcomings.

Inadequate planning

Shortcomings at the planning stage of lessons were identified. Some of the plans had an over emphasis on content to be covered as against how the content would be used to develop pupil skills and strategies. Some appeared like isolated units or were not integrated with longer-term plans. Others included a lack of attention to teacher actions to meet lesson targets and a failure to differentiate in the plans for different pupil needs:

> *Notes and planning were minimum. Does not have a grasp of writing targets and objectives. (Tutor two evaluation of lesson 77)*

Failure to differentiate

At the heart of special education is personalising instruction to meet individual needs (Heward, 2003). Inadequate attention to this was a feature of critical comments. This can be traced back to the planning phase and can manifest itself with regards to content, materials and teaching and learning approaches (Lewis and Norwich, 2005). Failure to differentiate can result in material being too difficult or some pupils not being sufficiently challenged. Illustrative comments included:

> *This work needed to be differentiated for both more able and less able children in term of content and teaching strategies; not enough challenge for some and others were lost. Needed to think about individual children. (Tutor five evaluation of lesson 71)*

Children could have been working on more challenging concepts and skills. (Tutor six evaluation of lesson 33)

Shortcomings in teaching strategies

Difficulties with sequencing, structure, consolidation and monitoring of understanding were evident in the evaluations:

More structure needed, necessary for the child to put the blocks in a line before counting them; more time needed explaining the commutative property of addition; child needed strategies for counting on and counting back apart from the number line. (Tutor three evaluation of lesson 3)

Too many strategies for tables introduced at the one time, needed to consolidate understanding more fully, moved too quickly to discrete units with fractions. (Tutor one evaluation of lesson 6)

Insufficient time devoted to consolidation, need to monitor learning and adjust to individual needs. (Tutor three evaluation of lesson 38)

Inadequate attention to reviewing and linking with prior knowledge also featured. This has been identified in the literature as a weakness in practice (Dixon *et al.*, 1992):

Required much greater structure and preparation. It would have benefited from links with prior knowledge and review of tens and units material covered to date. (Tutor four evaluation of lesson 58)

Non-use and inappropriate use of concrete materials

Some lessons had shortcomings in use of concrete materials which featured in the following ways: not used when they should have been; not linked to the representational and symbolic; removed too quickly before pupil had mastered the skill or understood the concept; premature progression to other materials; appropriate materials offered to pupils but used inappropriately; and inappropriate materials used to try and support conceptual understanding. While the importance of using concrete material and linking their use to representational and symbolic understanding has long been a feature of the literature in mathematics education (e.g. Bruner, 1966), there is considerably less on inappropriate use. Evidence of this from the lesson observations included using a number line to develop the skill of counting on while allowing the pupils to use counting all, in which case the concrete is not supporting the mental operation (Fuson and Fuson, 1992). The movement from proportional models of place value to non-proportional models like the abacus and money was done too quickly for some pupils, as

was the progression from continuous models of the fraction concept, using for example paper strips, to discontinuous models using for example discrete objects. These have been highlighted by Reys *et al.* (1998) in relation to place value and Behr *et al.* (1998) in relation to fractions.

Excerpts from the evaluations included:

> *…link concrete and symbolic in mathematics. Ensure mastery before moving on, pace too fast for some, need further consolidation with base ten materials. (Tutor one evaluation of lesson 37)*
>
> *More support from concrete materials would be helpful e.g. set out cubes when singing counting songs and add or remove cubes as the song progresses. (Tutor five evaluation of lesson 29)*

Other shortcomings

Not covering enough content, not making connections, inadequate attention to mathematical language, not engaging all pupils in the lesson, lack of attention to problem solving and too slow a pace were also picked up as shortcomings:

> *Important problem solving section barely touched on. (Tutor four evaluation of lesson 65)*
>
> *Relevant links were not made between the content presented and the students' life experience. (Tutor four evaluation of lesson 58)*

The non-use and poor use of mathematical software and the calculator also received critical comment.

CONCLUSION

Overall, the quality of instruction observed was rated very satisfactory. At the heart of this was the ability to individualise instruction and utilise an eclectic range of empirically validated teaching and learning strategies to promote learning (Heward, 2003). Lewis and Norwich (2005, p.218) also emphasise this point: "An underlying theme, meshing with the notion of the *intensification of common pedagogic strategies*, is the skilfulness required to apply a common strategy differentially."

Giving pupils time and attention on an individual basis was no guarantee that instruction was individualised. This could result simply in more of the same. The evidence from the observations supports the notion of "high intensity" within a continua of pedagogic strategies (Lewis and Norwich, 2005, p.6). This could be seen in the references to more explicit, direct teaching; using smaller steps; giving more examples; teacher monitoring of understanding; carefully scaffolding instruction; teacher modelling of thinking strategies and increased use of concrete hands-on equipment.

One of the concerns in the literature on pedagogy from socio-cultural theorists is that there is an over emphasis on individualised teaching and not enough on fostering communities of learners (Conway and Sloane, 2006; Brown, 1994). While there was some evidence of peer tutoring and paired work, the opportunities to exploit small groups working collaboratively on shared tasks and learning from each other were not fully realised.

While the principles of fostering communities of learners are primarily focused on classroom settings, the potential to enact them may be more feasible in small group withdrawal sessions initially. Such settings should be conducive to an emphasis on classroom discourse, active participation and self regulated learning (Brown, 1994). Learning support teachers might then be in stronger position to support class teachers in developing such practices in mainstream classes.

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