Developing children's communication skills to aid mathematical understanding

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New Zealand's national mathematics curriculum addresses the importance of children communicating their mathematical understandings as an aid for improving mathematical performance. This paper will discuss what is meant by communication in mathematics and the effect of richer communication on mathematics learning. It identifies different communication skills children will need to develop, and examines the implications for classroom teachers in terms of professional knowledge, assessment and classroom culture.

Introduction

Mathematics teaching and learning has moved away from a mechanical view of mathematics, to one with an emphasis on problem solving, understanding and communicating mathematically with others. In the past children have been mainly taught algorithmic formulae and repeatedly practised such an approach, in tasks that have been removed from meaningful contexts and with an expectation of working individually. They are now, however, expected to work with others to solve problems, to trial strategies, and to find effective strategies that work for them.

For children to be successful in working with others, and in explaining their own understandings, they must develop the mathematical language necessary to help them express what they believe. Discussion, amongst themselves and with a teacher, provides children with opportunities for social interaction, and for shared understandings to be negotiated and developed (Bicknell, 1999). These discussions provide opportunities for using their mathematical language in a shared learning environment. In addressing the importance of mathematical language we firstly need to discuss what is meant by communication in mathematics and then explore some specific issues such as the culture of the classroom and the role of the teacher in developing appropriate communication

skills in their children.

Communication in the mathematical context

An emphasis on mathematical communication is clearly indicated through its inclusion in the curriculum document (Ministry of Education, 1992). The document states that there will be opportunities provided "for students to develop the skills and confidence to use their own language, and the language of mathematics, to express mathematical ideas" (p. 9). The importance of language in helping children make sense of their world is supported by Campbell & Rowan (1997: 64) who assert that "Language has the power to help children organise and link their partial understandings as they integrate and develop mathematical concepts".

A key requirement of the curriculum is that children use their own language to express mathematical ideas. Bicknell (1999) and Cotton et al. (1995) both discuss the need for children to be exposed to informal and formal styles of communication within mathematics. *Informal* styles are associated with the initial thinking and constructing of knowledge, whereas the *formal* style is the process of sharing their understandings, with teachers and or children, using formal styles of speech and writing. Cotton et al. argue that informal talking and writing are actually ways to develop understanding. Furthermore they indicate the need for teachers to recognise that, as well as using their own language, children need to learn to use technical mathematics language to express mathematical ideas.

A number of writers argue as to whether mathematics is a language in itself. Anghileri (1995: 10) discusses how the "language of mathematics consists of words and symbols that have meanings related to particular contexts and to procedures for solving problems". Meanwhile Pimm (1987, cited in Bicknell, 1999) discusses that rather than seeing mathematics as a language in itself it should be seen as a register. Pimm cites Halliday (1975, in Bicknell, 1999: 204) who defines a register as "a set of meanings that is appropriate to a particular function of language, together with the words and structures

which express these meanings". This means that although mathematics is seen as having some of the functions of a language it is not defined as a language in itself. Bicknell (1999) discusses how the language is based in a social context, in this case a mathematical one, where it utilises particular vocabulary and symbols. She describes how the vocabulary can be adapted and altered according to the changes in the social context. Whether people define mathematics as a language, or as a register, a clear implication for teachers is that an understanding of the words and symbols associated with mathematics must be developed along with the mathematics. Children need to become familiar with these and their use so that they can better communicate their understandings.

The tension inherent in the philosophies underpinning the (Ministry of Education, 1992) are reflected in views on communication. The document is underpinned by two diametrically-opposed learning theories, behaviourism and constructivism. Behaviourist theory asserts that learning can be broken up into hierarchical stages that are observable and measurable and this is indicated by the inclusion in the mathematics curriculum of achievement objectives that are specified as outcomes to be attained within a set of hierarchical levels. However, the teaching approaches recommended by the document are, at heart, constructivist. The constructivist view is that people make "sense of the world in ways that are always historically and culturally specific" (Begg, 1999: 5). It is here that children need to have a strong language base to be able to succeed. Begg emphasises that learning is not transmitted by linguistic communication but that language is a tool to help students construct their own knowledge. Therefore, for children to be able to succeed in mathematics they need to use mathematical language to help them make sense of the learning situation, rather than merely being expected to solve problems in the manner in which they have been shown. A constructivist learning environment provides opportunity to call upon their own personal ideas and knowledge to find solutions to these problems. The solutions the children use may not necessarily be the same across the group and so they are expected to be able to explain the methodology that they used. Developing a shared meaning of mathematical ideas is a key process

within constructivist learning theory. This means that children should have the ability to vocalise someone else's understandings to themselves so that they can re-organise external language into an 'inner language' or 'internalised thought'.

Developing children's communication skills to aid mathematics understanding

Within mathematics education there seem to be a number of issues relating to the forms of communication expected of students. Underlying these issues though, is the expectation that children need to communicate effectively. Gadamer (1975, cited in Sfard, Nesher, Streefland, Cobb & Mason, 1998) discusses how a true dialogue is a process of open conversation where each point of view is considered valuable. As people listen and accept others ideas they truly begin to understand what has been said. Therefore, there is a reciprocal link to effective communication. Children need to impart their mathematical knowledge to others and they need to make sense of what is being said to them by their peers. Mumme & Shepherd (1990, cited in Bicknell, 1999: 206) recognise language as a catalyst for the promotion of mathematical understanding and argue that mathematical communication helps to:

- enhance understanding
- establish some shared understandings
- empower students as learners
- promote a comfortable learning environment and
- assist the teacher in gaining insight into the student's thinking so as to guide the direction of instruction.

Children's ability to accurately describe how they worked on problems is not necessarily a natural skill and therefore, needs to be purposefully developed. Sfard et al. stress the importance of developing children's communication skills but questions how this will be done and what should actually be taught and comment that this is an issue that has not really been given much thought by the mathematics education community. They argue that children need to be taught how to communicate with their peers and teachers so that

there is a base line of shared understanding.

An issue arising from this reciprocal dialogue is the need for all to understand that there is not necessarily one correct way to solve mathematical problems. It is stated explicitly in the curriculum document (Ministry of Education, 1992: 11) that

> learning to communicate about and through mathematics is part of learning to become a mathematical problem solver and learning to think mathematically. Critical reflection may be developed by encouraging students to share ideas, to use their own words to explain their ideas, and to record their thinking in a variety of ways, for example, through words, symbols, diagrams, and models.

Hence teachers need to genuinely value children's understanding as it is evidenced through their communication.

Although, much of what has been discussed refers to communication in an oral setting, several studies (Bicknell, 1999; Campbell & Rowan, 1997; Cotton et al., 1997) refer to the need for children to communicate through writing. Their justification is that children are more able to make judgements about their thinking, evaluate the quality of their explanations and make necessary adjustments when writing. By expressing themselves in a written manner, children can separate their ideas from themselves (Smith, 1994, cited in Bicknell, 1999). This is an opportunity they do not get when speaking and listeners, through questioning, can demand clarification of the speaker. When children have to write for an audience they must be careful, and more reflective, to ensure that their meaning is clear. This reflective process initiates higher order thinking skills. Journal writing is an effective way of encouraging children to reflect on what they have been doing in mathematics, self-assessing their attitudes or behaviours and identifying areas for improvement. (Campbell & Rowan, 1997; Stenmark, 1991). Teachers should encourage the writing in a "natural" style so that it is easily accessible to others. If the writing is easily accessible it is likely more learners will understand it Herche (1993,

cited in Bicknell, 1999)

Bicknell (1999) discusses the value of genre-writing in mathematics and lists the various types of genre and their purpose. For example: procedural writing is used to explain how something is done; writing an explanation provides a reason why a judgement has been made; and an exposition argues why a thesis has been proposed. She writes that, 'Marks and Mousley argue that it is important that mathematics teachers become aware of, and make use of, genres from the factual strand as they are essential to the work of mathematicians' (Bicknell, 1995: 211). In a classroom setting, if children are asked to share their ideas orally we are limited as to how many students can participate and be listened to effectively. Whereas, if they are asked to explain their understandings in a written form, the teacher and the children are able to 'hear' a greater range of viewpoints.

Teachers' understanding of mathematical language

For children to have the opportunities to communicate their understandings in mathematics teachers, themselves, need to have an understanding of mathematical language and alongside this, the multiple meanings that some words have. Mathematics uses words in particular ways, that out of a mathematical context have a different meaning: for example words such as takeaway, odd, and fraction and volume can have multiple meanings. Unless children are aware of the specific meaning of words, when applied in a mathematical context, confusions will arise. Cotton et al. (1995: 39) emphasise that

> technical terms should be introduced by the teacher when they can be appreciated by students as convenient labels for ideas which they have already developed, rather than as mysterious terms whose meaning has to be fathomed.

It is important to realise that some mathematical symbols contain multiple meanings as well. Teachers need to make sure that students are aware of this so that they are not

limited in their understanding of the diverse meanings attached to symbols as well as words.

Class management strategies to aid communication

Teachers may need to consider how they manage mathematics-time in their classes to enable children to be successful problem-solvers. Traditionally children have been grouped according to ability. Anghileri (1995) discusses differences between higher- and lower-achieving children in relation to problem-solving. The higher-achieving children are able to select from a variety of strategies to solve problems while lower-achieving children tend to use the strategy that had previously worked successfully for them. Lower-achievers do not seem to have the ability to select appropriate strategies for different problems. Teachers, therefore, need to provide opportunities for children to experience alternatives to ability-groupings, such as using mixed-ability groups, as this can enhance the language growth of students (Campbell & Rowan, 1997). When teaching mixed- ability groupings it is very important that the less-able children are encouraged to communicate with others. This can be done by directing questions specifically to them, or by calling on them earlier, so that they share ideas that are more easily apparent. Campbell and Rowan stress how this then requires the more-able children to think at a sophisticated level, stretching for new ideas. Students of all abilities should be comfortable sharing their findings with others so that they will grow in confidence and become more willing to articulate their mathematical ideas.

Assessment and Communication

Assessment procedures need to move away from ones that just test algorithmic skills to ones where children can voice their understandings. As children are encouraged to share and communicate the ways in which they operate to solve mathematical problems, teachers will gain insights into how their children think (Campbell & Rowan, 1997). Teachers should provide open-ended assessment tasks that allow children to use multiple strategies and encourage them to demonstrate how they went about solving the problem (Campbell & Rowan, 1997; Stenmark, 1991). The task, if designed well, can be a total

education experience, providing learning for the children and providing diagnostic and evaluative feedback to the teachers (Shiu, 1995). It could provide much more valuable information than just an answer to a problem and will highlight strengths, weaknesses and confusions that the children might display. These confusions might be in the way they read the problem, their understanding of what the problem is asking them to do, or the strategies they employ to find a solution (Stenmark, 1991).

Aitken (2000) believes that teachers need to have highly-developed skills in assessment in order to successfully analyse what children are doing so that they can give appropriate feedback. The skills needed are observation, recording, assessing probabilities and identifying and managing risk. The purpose of the assessment task is to add value to the child's learning, and so the techniques need to be valid, useful, legitimate and fair. From children communicating their understandings, teachers can use information to make decisions related to their instruction, such as the grouping of children, the provision of feedback and how to alert children, themselves, to their future learning needs. Therefore, as children develop their communication skills in mathematics, teachers can enhance their skills in making informed and appropriate instructions (Campbell & Rowan, 1997).

Culture of the classroom and its importance in developing communication in mathematics

Barton (1995) writes about the importance of teachers addressing the needs of different cultural groups, referring not only to ethnicity but also to classroom culture. The teacher and children within the room, and their interaction, influence this classroom culture. The level of influence the teacher has is determined by their personal level of understanding of mathematics, mathematical learning and the learning process itself (Lane, 1999). The way the culture of the classroom has been molded by the teacher is very important. If children are not willing to share their mathematical ideas because they do not feel that their contributions will be accepted or valued, then the above practices will not eventuate. Creating a safe environment, that encourages children to be open, and share with others, will hopefully make learning more engaging for those who may have previously

struggled to make mathematics a part of their lives.

As mentioned earlier, Lane (1999) discusses the fact that coming to know is both social and individual. He also writes about students who feel confident, and have a strong sense of well being, having more mental space to be thoughtful. Students under stress will not have as much mental space to think. Therefore, if we want to have productive classrooms with children achieving in mathematics, the school and classroom need to be safe and friendly places. Several studies, (Anghileri, 1995; Bicknell, 1999; Campbell & Rowan, 1997) highlight the importance of developing the classroom culture so that an openness to children expressing their points of view is encouraged, so that all children feel part of the proceedings. Every child needs to be provided with opportunities to participate in mathematical discussions with their peers and feel safe to do so.

Conclusion

The paper has highlighted the importance of teaching children how to communicate their understandings, especially if we want children to have a secure knowledge and confidence in working mathematically. There is a need to make sure teachers are providing children with the opportunities to develop the mental strategies necessary to solve problems. Children need opportunities to participate in pairs, small group and whole class discussions. This is a time for them to observe the strategies that others use so that they can increase their own repertoire by later practising what, to them, are new strategies. It is important to encourage all children to participate in these discussions as a way to helping them to fully understand the mathematics and the language of mathematics. Through questioning and using such language, children can clarify their own thinking thus allowing them to take greater control over their mathematical learning.

Finally the culture of the class needs to be one in which children feel safe and that their contributions are valued. Teachers must make sure that children understand the importance of listening and responding appropriately to others, so that everyone becomes an active participant in communicating their ideas. The more that teachers can encourage children to listen, share, write and reflect on their own and others' understandings, then

the greater the confidence, and level of skill, they will demonstrate in mathematics.

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