CHILDREN'S QUESTIONS ABOUT GEOMETRY

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Question-asking is a key process in mathematical thinking, and is recognised as such in the 1992 New Zealand National Mathematics Curriculum which emphasizes the need to encourage children to ask questions in various mathematical contexts. However, observations suggest that this is something which few New Zealand primary school teachers do and, further, there seems to be almost no research into children's question-asking in mathematics which might provide some guidance. The present paper reports the results of a small investigation into middle primary school children's ability to ask questions about geometry. It also provides a first glimpse into preservice primary school teachers' perceptions about both the value of children's questions for teaching and learning in mathematics, and difficulties involved in eliciting them.

Until the beginning of this year, one of the objectives of the New Zealand Mathematics Syllabus was to help children develop their urge to enquire (Dept of Education, 1985; 1986), but there was no indication that this meant children being encouraged to ask questions as part of their mathematics learning (Dept. of Education, 1986). However, in the mathematics curriculum which came into effect at the beginning of this year (Ministry of Education, 1992, 24) this key enquiry process has been made explicit, "Within a range of meaningful contexts, students should be able to pose questions for mathematical exploration." Further, there is mention that students should be exploring their own interests and brainstorming possible questions for investigation. But how does this new emphasis on children's questions fit within the perspective that most teachers, and indeed the mathematics education community generally, hold about learning in mathematics? And what research is there which might provide some guidance to practice?

In contrast to science education (see, for example, Biddulph, 1989; Biddulph and Osborne, 1984), little comparable recognition of the value of children's questions seems evident in the field of mathematics education. Perhaps not surprisingly, the focus seems to have been largely on teacher questions (see, for instance, Cemen, 1989; Sullivan and Clark, 1991; Wigley, 1992). Relatively few references to children's questioning appear in the literature on mathematics education. Biggs and MacLean (1969) propose that mathematics education should build on young children's natural curiosity by encouraging them to ask questions. Griffiths (1988) takes a similar view and comments that children who have the confidence to ask questions are less likely to become confused about mathematical ideas. Bobis (1991) and Whitin (1989) have suggested that children be encouraged to ask questions to enhance their number development. "When children ask the 'why' question in their mathematics classroom, they are on their way to strengthening their number sense" (Whitin, 1989, 26). Baker and Baker (1990) and Chambers, Cunningham-Craig and Hammond (1987) believe that children's genuine involvement in investigations relies upon them asking the questions to be investigated. And finally, Tobias (1987) makes the point that learners in mathematics should take their own questions seriously and persuade their teachers to take them seriously too; she accepts mathematician Peter Hilton's view that true mathematics takes one from answers to questions.

Research into children's questions in mathematics appears to be almost non-existent. Can primary school aged children actually generate investigable questions in mathematics? What questions might primary school children ask about geometry, for instance, if given the opportunity and encouragement? What difficulties do teachers experience in eliciting children's questions? Could children's questions about geometry lead to worthwhile investigations? What might be the effect upon children's learning in mathematics if they investigated questions which they themselves had raised? And if the effect were positive, how might teachers be helped to adopt children's questions as an integral part of their teaching approach? The second and third of these questions were the focus of a small-scale study reported in this paper.

METHOD AND SAMPLE

Questions about geometry were elicited from a total of 100 children in four classes in two Hamilton primary schools by 32 second-year primary student teachers under the guidance of the author. One school was semi-rural and served children from a predominantly middle income group. The 48 children in the two classes at this school were aged about eight to eleven years. The second school was an urban school situated in a mainly lower socio-economic area. The 52 children in the two classes in this school were aged approximately nine to eleven years. One of the classes contained 22 Maori children being educated in a bilingual programme. These children were more fluent in English than Maori so the 11 student teachers, who were themselves Maori, interacted with them in English to elicit their questions.

Since the experience in primary science had shown that children frequently need some exploratory-type experiences as a basis for asking questions, the 100 children in the present study were first provided with a set of geometrical experiences chosen from activities to do with (i) distinguishing 2D and 3D objects, (ii) identifying angles on drawings of various objects, (iii) bilateral and rotational symmetry, (iv) tessellation - modelling a cobblestone driveway, (v) enlargement - of an umbrella drawn on a 3x3 grid, and (iv) nets - drawing a flat plan of a pyramid on paper, and then folding it to make a pyramid. In the course of these experiences, and at the end, the children were invited to say what questions they had about various aspects of geometry. The student teachers were advised that they may have to frame their invitations in several different ways, e.g. "What questions do you have about what we have been doing?" What things about these activities have puzzled you, or have you found a bit tricky?" "What have you wondered about as we have done these activities?"

The sessions with the groups of children lasted approximately 45 to 50 minutes. During this time the author observed different groups at work, and modelled for about 12 student teachers a way of helping children turn some of their comments into questions.

The questions were recorded by the student teachers as they occurred. The student teachers were also asked to reflect on the difficulties and usefulness of eliciting children's questions, as they perceived them, and to write these in their reports about their teaching experiences with these children.

CHILDREN'S QUESTIONS

The children's questions reveal a number of interesting features.

1. Number of questions asked

One feature that stood out immediately was the difference in the number of questions elicited in the two schools. Whereas the 48 children in the semi-rural school asked a total of 50 questions, the 52 children in the urban classes asked only 23 questions altogether. Whether this stemmed from the children in the urban school being more socialised into non-questioning, or from the group of student teachers who worked with these children being less able to elicit questions, is not known. Experience in science education suggests that the larger groups of urban children, with whom the 11 student teachers worked, would have produced more questions, not less, so the difference probably had nothing to do with group size.

2. Focus of questions

As would have been predicted from the research into children's questions in primary science, the questions asked about geometry were largely to do with the aspects raised in the exploratory activities. Apart from some general questions asked about geometry itself, there were questions raised in both schools about angles, 2D and 3D shapes, symmetry, and tessellation. The children in the semi-rural school also asked about enlargement. This suggests that teachers can have considerable, if subtle, control over the directions that investigations might take.

3. Similarity of questions

Some of the questions from the two schools were remarkably similar. For example, "What is geometry?" was asked by children in both schools, with someone in the first school also wanting to know, "Is geometry basically shapes?" and a child in the urban school inquiring, "Is geometry like shapes, or what?" In both schools children wanted to know whether circles have angles and, more generally, what are angles or how do you know something is an angle. Further, some children in both schools wondered what 2 dimensional and 3 dimensional things are, and what shapes will tessellate. An inquiry in each school about symmetry was not too dissimilar either. In the semi-rural school a child

asked, "What is the line that separates the two sides [of a symmetrical tile] called?" and in the urban school a child wanted to know, "How can you find the line of symmetry?"

These responses suggest that research may be able to alert teachers to the kind of questions they can reasonably expect children in their primary classrooms to ask about geometry. If teachers can anticipate some of the questions that their children are likely to ask, then they can be better prepared for resourcing investigations that may flow from them.

4. Questions can indicate children's thinking

Many of the children's questions revealed their current understanding about aspects of geometry. The children's questions above about symmetry suggest that the children already have some understanding of this concept. So do their questions about enlargement: "What would happen if there were heaps of small squares?" "Do you always need to draw squares or a grid to enlarge something?" "Would it be harder if the square sizes were different?" Children can be helped to build upon such understandings.

In other cases their questions revealed considerable lack of understanding. Take angles for example. Children asked, "Do angles cross?" "Are angles something that lean to one side?" "Is an angle something that isn't straight?" "Is something an angle as long as it bends?" "Are angles different lines joining together?" There is no hint in these questions of an angle being a measure of rotation, and perhaps it is not surprising when in everyday life children usually hear the term 'angle' applied to something that is sloping, and in school mathematics to the corners of a shape. The point about questions such as these is that they can alert a teacher to the need to assist children towards the basic mathematical idea of angle. Here it is a matter of helping children to restructure their ideas rather than extend them.

A few of the children's questions suggest that they are interested in the origin and status of some terms, for example, "Who made up the word 'geometry'?" "Who invented it?" A few children were also interested in how it connects with their world: "Are there lots of things that you use geometry for?" "Who uses geometry?" "Is a car part of geometry?"

Several of their questions were totally unpredictable and it is difficult to know, without further probing, what the children were thinking; for instance, "Is geometry safe?" "How come when you push a 3D wheel forward it returns?" "Why don't circles go crinkly round the edge instead of smooth?" "Is 3D something coming true?"

5. Questions and investigations

Inspection of the children's 73 questions indicates that perhaps 80% could provide worthwhile investigations in geometry, and that many could be grouped for investigative purposes. The children's questions above about enlargement are in this category. So are many of their questions about tessellation: "What shapes can be in a tessellation?" "Can you use two shapes to pave a driveway?" "Can hexagons do tessellation?" "Can it work with a shape with wavy lines?" "Does it change if the piece of paper [tile or paving stone] is different sizes?" Questions such as these, and others such as, "What is a pyramid?" "If you make a pyramid from a plan, how many sides has it got?" "How many different 3D shapes can you get?" "How many angles have different shapes got?" could lead to the development of ideas which the curriculum writers suggest are appropriate at this level of schooling.

STUDENT TEACHERS' EXPERIENCES OF ELICITING AND USING CHILDREN'S QUESTIONS

This seemed to be partly because the children themselves were not used to asking substantive questions during mathematics learning. As one student teacher reported, "I don't think that they [the children] were used to being asked to ask questions" and another noted, "I found it hard, initially, getting questions from the children. They were more used to me asking them questions and often when I asked them if they had any questions they would say to me, 'Yes, what are we doing this for?' "

The difficulty in eliciting children's questions was also partly due to the inexperience of the student teachers. As one of those at the urban school commented, despite having obtained eight questions from her group of five children, "I need more practice with that skill." She was also aware of a strategy that she might use, "If I could have, like, turned what some of the things they were saying around so that they could see that they could make a question out of it, I would have got more questions."

Some others had managed to use this strategy in the course of their initial work with their children: From discussions, the children's thoughts and queries can be transformed into questions which can be investigated in future lessons." Another also found an indirect approach more effective: "I found it more effective to discuss as a group each activity, rather than asking them directly for questions. I found that through discussions the children asked me questions."

And did the children's questions provide a basis for meaningful investigations? The results seem to have been mixed. In many cases they did, for example, "Focussing on children's questions and allowing the children to investigate them proved stimulating, meaningful learning for the children." In at least one case this was not the student teacher's perception; her group of children "seemed to do the activities because they had to, not because they wanted to find out the answers."

CONCLUDING COMMENTS

This study represents a small first step towards understanding factors relating to children's questioning in mathematics. It suggests that although it is a new experience for many children at the primary school level, they are capable of beginning to ask questions in mathematics. These questions are likely to focus on aspects of mathematics incorporated in exploratory activities, often provide valuable insights into the children's thinking, and can frequently lead to useful investigations.

The results also indicate that special skill is needed to elicit children's mathematics questions at first. The primary science experience suggests that most primary teachers will need considerable support to develop this because it is also likely to require a considerable shift in a teacher's mental picture of what one does as a mathematics educator.

This investigation leaves many questions unanswered. Apart from those raised in the introduction to this paper which were not addressed by this study, it would be interesting to know whether a different set of exploratory activities would have produced more and/or different questions, whether children with some experience of asking questions in mathematics would ask more, and what is the prevalence of various questions across a range of schools. It also raises the issue of whether printed curriculum expectations about children engaging in question-asking in mathematics are likely to be realised without a relevant research foundation. Obviously there is scope for considerable research in the area of learners' questions in mathematics.

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