Children's questions about number

Fred Biddulph

University of Waikato

This paper outlines a rationale for making children's questions an integral part of their learning in mathematics. It then analyses questions about number collected by student teachers, using two different approaches, from 276 students aged 11-12 years in Hamilton, New Zealand. Results indicate that the students can ask some substantial and insightful mathematical questions but that it is not easy to elicit questions from learners who have no experience of asking questions during school mathematics.

Question-asking in mathematics: A rationale

Although question-asking by students is listed as an important mathematical process in the New Zealand mathematics curriculum (Ministry of Education, 1992), there are few references in the mathematics education literature to children generating questions as a basis for investigations in mathematics. Some of the few were mentioned by Biddulph (1993). For example, Ann Baker (Baker and Baker, 1990) describes the success she had with a class of primary children in Australia in the context of the story 'Jonah and the Whale'.

> *...the children generated a range of complex questions, questions much harder than I thought they could possibly answer. They developed investigations and strategies of great sophistication and practicality to find answers. (p.131)*

The question, 'How many children standing side-by-side would be as long as a whale?' was not atypical of later questions asked and investigated.

Perhaps the paucity of research on children's questions in mathematics stems from lack of appreciation of their value. Although in some cultures, such as that of the Navajo Indians of North America, question-asking by children almost never happens (Pinxten, 1994), in western-type cultures there are several grounds, both theoretical and pragmatic, on which they can be justified as a central component of mathematics education. These are outlined briefly below.

1. Theoretical Grounds

There are at least three theoretical bases supporting children's question-asking in mathematics - philosophical, psychological and sociological.

(a) Philosopical

Mathematics is now recognised as an important intellectual process of inquiry and problem-solving using concepts and associated processes (e.g. patterning, modelling) constructed by mathematicians over the years. Central to inquiry is question-asking. If children are to gain access to mathematics as process then they must be encouraged to ask questions as part of their learning in mathematics. As Love, (1988, p.260) puts it, to foster mathematics as a way of knowing, children should have opportunities for *identifying and initiating their own problems for investigation.* The writers of a mathematics text for young children express a similar view when they hope that pupils using their book *develop the habit of asking questions which take the ideas further* (Blinko and Graham, 1988, p.7).

(b) Psychological

Several learning theories provide further justification for making children's questions an integral component of their

mathematics education. Inherent in the constructivist notion of individuals generating new meanings from the interaction of prior ideas and incoming stimuli is the intellectual process of inquiry, albeit largely internalised. Associated with this is the idea from humanistic psychology that meaningful learning is self-directed and marked by qualities of personal involvement and self-evaluation (Glasser, 1986; Rogers, 1969). As Confrey has claimed (1990, p.111) *personal autonomy is the backbone of the process of construction,* and as Baroody and Ginsburg (1990, p.54) have observed, *Children are naturally curious. They have an inherent drive to make sense of their environment and cope with it. They are naturally inclined to search out patterns and relationships.* Ernest (1992) also connects questioning with involvement and learning, *Problem posing offers ownership of problems and empowerment of learners* (p.4). This is supported by Stacey and Grooves (1986) who suggest that *Mathematical problem solving starts with a disposition to ask questions in the expectation of finding useful answers,* and that *Children need to feel that they have power over and responsibility for their own mathematical learning* (p.330).

(c) Sociological

Internal questioning by children is largely directed to self-inquiry, such as the searching for patterns and relationships mentioned above, but a proportion of children's questions is likely to be directed at others. Interactionist theory, *which is epistemologically compatible with the constructivist psychological perspective* (Voigt, 1994, p.276) would support the latter kind of questioning by children on the grounds that some mathematical meanings develop in the course of social relationships among individuals.

2 Pragmatic Grounds

Children's question-asking can also be justified on pedagogical and curriculum grounds.

(a) Pedagogical

When teachers are keen to understand their children's mathematical thinking, the children's questions can provide valuable insights. More generally, when children's questions are given a central role in learning it helps promote a truly constructivist learning community. This last point is perhaps best summarised by Burton (1993) who noted that a pedagogy compatible with constructivism involves a mathematics classroom community *where discourse is negotiated through the active pursuance of learner questions and enquiries which are seen to define the learning process* (p.10).

(b) Curriculum

As the quote from Ann Baker above illustrates, children's mathematical questions can provide them with very meaningful investigations. In this sense their questions help shape the structure of the mathematics curriculum in ways that enhance learning. One of these ways, as indicated above, is self-evaluation. As Edwards (1990, p.38) has observed, Leading children to ask meaningful questions helps not only the teacher in assessing the students - and the teaching techniques - but assists the children to develop their own problem-solving strategies, thought processes and self-assessment procedures. Edward's observation is therefore consistent with the theoretical position outlined above, and with the goals of the most recent New Zealand mathematics curriculum (Ministry of Educaiton, 1992).

However, as Biddulph (1989) found in science education, although children's questions can be justified as an integral part of their programme, the Ann Bakers who are able to successfully implement this are special teachers; most teachers are likely to need some guidance. As noted previously (Biddulph, 1993), such guidance to incorporate children's questioning into mathematics education practice can be informed by research. The present study was undertaken to further this process. The focus this time

was senior primary children (11 to 12-year-olds) and their questions about number - could questions be elicited from them, what features might such questions have, could they form the basis of useful investigations in mathematics?

Investigating children's number questions

Method

As with the previous study (Biddulph, 1993), Year 2 student teachers collected questions from a sample of children. This was done in the course of four or five teaching sessions on number which they spent with small groups of two to five, 11 to 12-year-old children in the children's schools. The schools represented a socio-economic cross-section of the primary school population of Hamilton city, New Zealand. Altogether 85 student teachers (54 in 1993, and 31 in 1994) worked in 8 classes (four in each year) with a total of 276 children (136 in 1993, and 140 in 1994).

Two different approaches were used to elicit questions from the children. In 1993 the student teachers used a group interview schedule developed by the author in which children in their group were shown a series of review items in four categories (whole number, fractions, decimals, percentages), asked for their comments about whether they thought they could do those items if they had to, and after each item invited to ask any questions that the item raised for them. Examples of items used were:

If a person won a race in 69.51 sec. what is that to the nearest second?

(2/3 x 12) + (3/5 x 20) = [ ]

Write 1/10, 1/100, 1/1000 as decimals.

The items covered the main mathematics relating to number listed in the New Zealand mathematics curriculum for children this age. Although the interview schedule may have looked similar to a conventional class test in mathematics, it was designed to be non-threatening; the schedule made explicit that the children were not expected to work out any 'answers'. It was hoped that it would highlight for the children aspects of number which they did not fully understand and could therefore ask about.

In 1994 no interview schedule was used. Instead it was decided to see whether questions could be elicited from the groups of children as they undertook investigations set in meaningful fraction, decimal and percentage contexts suggested to the student teachers by the author. For example, 'When we arrived home we found 1/2 a pan pizza left in the fridge, so we cut off 2/5 of what was left and ate it for supper. We then tried to work out what fraction of the original pizza was left in the fridge.' The rationale for this different approach was that it was considered more consistent with what might be manageable in the normal classroom. If it yielded sufficient investigable questions then it was thought that it may be adopted more readily by teachers.

The children's questions, together with details of the student teachers' experiences and reflections of working with the children, were compiled in their reports. These reports and the author's own observations working with the student teachers in schools and university classes provided the data for this paper.

Results and discussion

For both years the children asked a total of 377 questions, 216 (57%) of them being different. In 1993, 136 children asked a total of 293 questions in four areas of number, 156 (53%) of them being different questions. In 1994, 140 children asked a total of 84 questions in three areas of number, 67 (79%) of them being different. The greater number of questions asked by children in 1993 may seem significant but is probably not so important when quality of questions is considered, and when it is recognised that the 1994 student teachers were new to the idea of teaching children mathematics via investigations and, from the author's observations, missed

recording a number of questions asked by their children.

The questions asked by the children under the two conditions were almost all different; only seven were similar. With respect to fractions, only one question asked by the two samples of children was similar, and only three were similar in the case of decimals and percentage respectively. It was clear that the question-asking context influenced the type of questions asked. Those asked in 1993 focused almost entirely on the specific items in the group interview schedule, whereas those asked by the children in 1994 in the course of investigations were, on the whole, far less specific. For example, two children in 1993 asked (referring to the item 'What is 25% of $5?'), 'What is 25%?' whereas two children in 1994 asked more generally, 'How do you work out percentages?' This does not mean, however, that the 1993 questions were without merit. An analysis and discussion of the nature of the children's questions from both years is provided below.

1. Similar questions

The seven similar questions were asked by the children highlight several features of the children's questions generally. The questions were: (fractions) 'What does fraction mean; what are fractions?'; (decimals) 'What is a decimal?' 'How can you work out decimals?' 'How can you turn a fraction into a decimal?'; (percent) 'What does percent mean?' 'Can you have above 100%?' 'Can you use a calculator to work out percent?' These questions seem to indicate the children's desire to develop both conceptual and procedural understanding of these dimensions of number. These features are considered further below.

2. Meaning-seeking questions

A considerable number of the children's questions, particularly in 1993, sought to make sense of the ideas involved. Meaning-seeking questions ranged from 34% of the questions asked by the children in 1993 to 19% in 1994, giving an overall figure of 30%. For example, 23 children in 1993 wanted to know, 'What is a factor; what does it mean?', 27 children in the same year asked, 'What does a mixed number mean?' and two children in 1994 enquired, 'Why is there a decimal point; what's it mean?' Questions such as these suggest that making sense of the key ideas in mathematics is important to children.

3. 'How do you do it?' type questions

Many procedural or calculation-type questions were asked by the children in both years - 102 (35% of the total) in 1993, and 34 (40% of the total) in 1994. For example, children in 1993 asked, 'How do you round it off?'. 'How do you work it when the 11 is on top of the 3 [11/3]?'', 'How do you do 2.34 x 5.6 roughly without a calculator?', 'Is there an easy way of working out percentages?' A few examples of such questions asked in 1994 were: 'How do you change fractions down, like 2/6 = 1/3?', 'How do I write 1/4 as a decimal using a calculator?', 'How do you work out percentages on a pie graph?'

Meaning-seeking and procedural-type questions combined accounted for just over three-quarters of all questions asked by the children in this study. Perhaps in the future as children are helped to use an investigative approach in keeping with the new New Zealand mathematics curriculum (Ministry of Education, 1992), proportionately fewer procedural-type questions (for instance, "Is there a specific rule for working out percent?") will be asked.

4. Questions can reveal insights into children's understanding

Most of the questions asked by the children reveal considerable insight into their understanding of number. For instance, with respect to whole number children asked, 'Does the 3 in 329 481 mean 300?' and 'What is 5x5x5; how do you make it shorter without answering it?' Questions about fractions included,

'Do you tell how big it is by the number on the top or bottom?' and '[With 11/3] You can't have the higher number on top can you; don't you have to swap it around so the top number is smaller than the bottom?' In the area of decimals children asked, 'Are you allowed two decimal points in a number?' and 'Would 3/8 be .24? Would 5c [as a decimal fraction of $1] be 0.5?' Examples providing insights of children's understanding of percentage included, 'Does percent mean part of something?' and 'How do you get a percent if the total isn't 100?'

5. Heartfelt questions

Question-asking by children tends to be more than just an intellectual process. Their feelings can be imbedded in their questions too, as is obvious in questions such as, 'How do you not get mixed up between factors and product?', 'I wouldn't have a clue how to do it; what's the use of this?' and 'I can never get long division in my head and make it stay there; how can I go about remembering long division?' Questions such as these remind us that as mathematics educators we are dealing with thinking and feeling children.

6. Question clarification

Given an awareness of the contexts in which the children's questions were asked, hardly any of their questions appeared to be ambiguous. However, with a question such as, 'How do you change a number into a percentage?' it would be necessary to ask the child to clarify what he or she was wanting to know before either answering it, or helping the child devise an investigation to answer it.

Investigability of questions

Inspection of the children's questions suggests that the great majority could be usefully investigated. For instance, the following question about naming decimal numbers could provide a meaningful way into investigating decimal place value: 'Why don't you say the full number, like you would with the other numbers that come before the decimal?' Of course a question such as, 'How do you work out what they [numerals] mean when they are behind the decimal point?' provides a more direct lead into an investigation of decimal place value. In some cases (for example, 'What does the dot mean?') children's questions lend themselves to a consideration of the history of mathematics. Even a question containing a false assumption (for example, 'Why is 0.06 a larger number than 0.7?') could be investigated.

8. Difficulties in eliciting questions

As in a previous study (Biddulph, 1993) the student teachers found that most children did not respond readily with questions when invited to do so. As one student teacher wrote in her report,

The children asked very few questions, despite being encouraged to. Most questions were in the form of, 'Do you mean...?' when they wanted assistance or, 'Does that mean...?' when they wanted confirmation of an idea. Throughout the entire unit the children hardly ever dared to question.

Possible reasons for the children's reluctance to ask questions were suggested by some of the student teachers, for example,

> *It is often difficult to encourage children to ask questions. This is possibly because they are afraid that asking questions may show them up as unintelligent. They may also avoid asking questions because they are so used to being told what to think and fed information that they are not conditioned to seeking for themselves, and are uncomfortable in this strange situation.*

Children find it difficult to construct questions unless they have some idea of the concept under consideration. Otherwise they do not know what to ask.

These reasons are probably valid. Unfortunately, negative school experiences do tend to make many 11 to 13-year-old New Zealand children sensitive about revealing their ignorance in various subject areas. Lack of

experience by the children in asking questions was substantiated by another student who asked her group about it explicitly, 'When I talked to them about it they said they were not used to it.' The need for some conceptual insight as a basis for asking questions was evident in the science education literature (Biddulph, 1989) and is probably also true of mathematics. As one student teacher reported of her group, 'They did say they didn't like asking questions because they didn't quite know what to say.' A fourth reason, not mentioned above, was that the student teachers themselves were inexperienced at eliciting questions from children. This was the first time that they had attempted to do so in mathematics. From the author's observation, the feeling of many is captured in the reflection of one who wrote, 'I think I need to develop more strategies to encourage children to ask questions.'

Conclusions

Although the student teachers were inexperienced at eliciting questions from children in mathematics, a sufficient number were obtained to suggest that children's questions can provide (i) valuable insights into children's understanding of and feelings about mathematics, and (ii) a guide to meaningful investigations that the children could undertake. The data seem to support the justifications set out at the beginning of this paper for encouraging children's questions in mathematics education.

The data also indicate that context influences the focus of questions. Although use of the schedule resulted in more questions being recorded, it is probably inappropriate to conclude that using investigations as exploratory activities is less effective. In the latter case the student teachers were trying to do two new things at once - use an investigative approach and encourage their children to ask questions - which made their task much more difficult than that of the 1993 group. The issue of the best type of exploratory activities for generating questions is one that requires further research. Some teachers known to the author have simply asked the children what they already know about a particular mathematics topic, and what they would like to know. This approach could also be investigated. It seems to yield some questions from children who are used to question-asking but may be limited, as one student teacher said, by the children's lack of awareness of what may be asked.

The student teachers' reports suggest that even when effective exloratory activities are available, more can probably done to help the student teachers develop useful strategies for eliciting questions from their children. This is a teacher education issue which also warrants further research.

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