The Concerns and Issues in Primary and Secondary Mathematics Teaching as Reflected in Questions to Mathematics Educators

Doug Clarke
Australian Catholic University (Christ Campus, Oakleigh, Victoria)

Using email, academics, consultants and other teachers of mathematics were surveyed as to the most difficult question they had ever been asked by a mathematics teacher. The 110 questions that were received in response to this request were then coded using "Hyperqual". A range of themes emerged, with interesting similarity across the four contributing countries; assessment issues being the most common theme. Implications are discussed.

Background

Many readers of this article will frequently be in the situation of making presentations or leading workshops concerning their research or trends in mathematics education with teachers or preservice students. In the course of such workshops or presentations, we are often faced with questions which challenge our beliefs about mathematics teaching and learning, and make clear the concerns of practitioners.

Such questions can leave us stammering, interrupt the flow of a session, and have us looking for a hole in the floor into which to jump. However, on the positive side, such questions enable us to "tap into" the issues that are of immediate concern to teachers, enabling us to make our seminars, workshops and teaching responsive to the needs of the group.

In seeking to gain an overview of the more difficult questions that colleagues in mathematics education have been asked and therefore a new perspective on issues of concern to teachers, I encouraged colleagues with whom I had an "email association" to share their most difficult question. This paper discusses those responses and the implications of these for the work of researchers and others involved in the professional development of mathematics teachers.

Methodology

The Sample

Being somewhat naive about the ways in which email networks work, I sent an email request to all 105 people in my email "Nickname" file and to all of those people on the MERGA and MESH (Mathematics Educators Sharing Network—Victoria) email list, there being some overlap in these three "directories". I asked them the following question:

> Could you please give me the most difficult (or interesting!) question you have ever been asked by a teacher (let's keep it to professional questions, preferably in the mathematics education domain)?

The next day, I received 85 replies; the following day another 59, with responses continuing for the next two weeks. Although more than half the replies were "undeliverable mail", I received many replies from people to whom I hadn't even sent directly the original request. I had someone who I had never heard of send all of my colleagues an advertisement for an algebra package, and a request from someone to take her off my mailing list immediately, when I didn't even realise that she was on it. This is a dangerous business. Despite these drawbacks, I was delighted with the range and interest of the kinds of challenging and interesting questions that I received.

Responses were received from colleagues in Australia, Germany, New Zealand, Sweden, the United States of America, and the United Kingdom. Of these, 75 included one or more questions.

Data Analysis

Using Hyperqual (Padilla, 1991), I coded each question or part of question according to the themes that were evident within it. Not surprisingly, some questions or parts of questions were coded in two or more different ways. For example, the following question from Tony Herrington (Edith Cowan University, Perth), was coded "Problem Solving" and "Assessment and reporting": "Problem solving is great—but how do I know the kids are learning anything?"

There is no claim that this was other than "convenience sampling", and given this and the fact that I had not asked for details on the setting in which the question was asked and by whom, this information was not able to be included in the coding process.

I sent a copy of all of the questions to anyone who had provided a question to me. A further stage in this small study was to consider the reactions of colleagues to the set of questions that emerged. Some of these will be discussed later in the paper.

Results

The following codes (expanded from the actual code used in *Hyperqual*, which are required to be no more than one word) were used to categorise the themes that emerged from the data. With each code, the total number of questions or parts of questions that were coded this way is given in parentheses, as is one example of such a question:

- ***Assessment and reporting (23)***

"How can I teach maths so children can converse, question, explore, discover, etc., and still prepare them to pass national standardised, multiple-choice tests?"

Joseph Zilliox, University of Hawaii, Honolulu.

- ***Difficult/unmotivated/special needs students (11)***

"I have these two (insert acronym or dysfunctional label here) boys/girls. They just won't (choose one of the following: sit still/listen/cooperate/learn). If I worry about them, I have to spend all of my time just keeping them on-task, so the rest of the class suffers. How can I teach with these types of kids integrated in my class?"

James Middleton, Arizona State University.

- ***The content of the mathematics curriculum (10)***

"Assume for a moment, that a student will only be able to master five critical concepts in mathematics. What concepts would you recommend?"

Robert Ronau, University of Louisville.

- ***Catering for mixed abilities (9)***

"I worry that in this climate of math reform, we are only really serving the best and brightest. Is this approach the right one for 'at-risk' kids? These kids really need the skills if they are going to get ahead."

Ron Ritchart, Harvard University.

- ***Teachers' pedagogical content knowledge (9)***

"How could I illustrate division of a fraction by a fraction when I mean 'shared between' and not 'how many'?"

Judy Mousley, Deakin University, Geelong, Victoria.

- ***Teachers' own mathematical content knowledge (8)***

"This [rectangle, made up of a series of smaller pieces] is not a real square metre—you cannot say that one square metre is one square metre if is not a square, can you?"

Ulla Oberg, Lund University, Sweden.

• ***Student understanding (8)***
"Isn't it easier just to tell (or show) them how to do it?"
Clarence Dockweiler, Texas A&M University.

• ***Teacher time (8)***
"I'm really confused and frustrated. I work very hard as a teacher. It seems that all I do is work day and night. You've given us so many wonderful ideas today, but what it all boils down to is I'll have to work even harder. Well, I can't work any harder, I simply can't do everything you're asking of me. How do I decide what is really important?"
Frank Lester, Indiana University, Bloomington.

• ***Professional growth of teachers/the change process (7)***
"My kids are doing well; why do I have to change?"
Jack Price, President, National Council of Teachers of Mathematics, USA.

• ***Organisation/management issues (5)***
[In situations in which new programs, guidelines or policies need to be addressed and it is true that they do involve some extra effort]:
"I can't get a turn to use the computer lab"/"I teach in a different room every lesson"/"Do you expect me to carry these materials with me every lesson?"
Howard Reeves, Tasmanian Department of Education.

• ***Parents (4)***
"What can you do about parents who show no interest in their children's mathematics learning?"
Rosanne Fulton, Boulder Public Schools, Colorado.

• ***General pedagogy (3)***
"How can a teacher possibly teach in such an active way with so much stimuli coming in from so many students?"
Frederick Silverman, University of Northern Colorado.

• ***Research (2)***
"What are some of the latest studies in learning?"
Gaea Leinhardt, University of Pittsburgh.

• ***External support/pressure (2)***
"Who is pushing this?" [by "this", teachers meant the unit standards of the New Zealand Qualifications Authority].
Derek Holton, University of Otago, New Zealand.

• ***Resources (2)***
"How am I going to have my students do 1996 math stuff when they are using 1986 textbooks?"
James Bierden, Rhode Island College.

• ***"The basics" (2)***
"How do I get students to remember "the basics"? They all use calculators to perform simple additions these days".
Vince Geiger, Hillbrook Anglican School, Enoggera, Queensland.

• ***Time for mathematics (1)***
"You don't really expect me to teach this stuff (or use this stuff) and teach all the math I have to cover, do you?"
Shari Coston, Arkansas Educational Renewal Consortium, Arkansas.

• **Gender (1)**
"What do I do to eliminate gender differences in math in my classroom?"
Elizabeth Fennema, University of Wisconsin.

• ***Problem solving (1)***
"Problem solving is great—but how do I know the kids are learning anything?"
Tony Herrington, Edith Cowan University, Perth.

• ***Integration with other disciplines (1)***
"How do you integrate mathematics with the other school disciplines?"
Frederick Silverman, University of Northern Colorado.

• ***Relevance (1)***
"Under what circumstances does the erstwhile engaging context of a mathematizable situation become distracting to my students rather than empowering?"
Jon Manon, University of Delaware.

I did not use any code that related to teachers' beliefs about mathematics learning or a philosophy of teaching and learning, as, in a sense, all questions reveal something about where the questioner is coming from.

A careful examination of these questions reinforces the statement that a given question can relate to a variety of themes. In the following section, I will discuss several of these themes and implications for researchers, mathematics educators, and others involved in the professional development of mathematics teachers.

Discussion

As indicated earlier, these questions were drawn from a convenience sample, and therefore there is not an even spread of questions from the five countries involved. I acknowledge the helpful comment of one reviewer that the data are not necessarily questions asked by a large number of students or questions frequently asked, but, as appropriate to my original request, questions that respondents found interesting or difficult to answer. It is quite conceivable that other questions are asked more frequently, but are considered by respondents to be neither difficult nor interesting. Nevertheless, several important points can be drawn from the data.

Commonality of issues

Although there are several aspects of particular questions that tie them to local contexts (state and national), a frequent comment from those who have considered the list subsequently is that the issues raised appear to be "universal".

Assessment was the most common issue to be raised, and this probably reflects a growing worldwide realisation that given new content and pedagogy in the mathematics classroom, pencil and paper tests are limited in providing information on growth of mathematical understanding (Ellerton & Clements, 1995). Questions such as "how do we know when the pupils know?" (Laurinda Brown, University of Bristol) were common. Interestingly, this realisation was balanced by questions which referred to the pressures created by external authorities in, for example, the use of standardised tests across a state or country in measuring performance.

If the number of questions related to difficult/unmotivated/special needs students were combined with those relating to catering for mixed abilities, the total would exceed the number of assessment questions. In my experience, this concern with catering for the wide range of students that arrive in our classrooms is longstanding, and any answers can only be partial ones. One apparent difference across countries however (one which is also reinforced by personal experience), is that such concerns in the United States tend to reside more with the lack of motivation and interest of students than with competence.

Do these questions have answers?

Laurinda Brown of the University of Bristol made the following important point relating to context: "You seem to think that it is possible to 'answer' such questions but surely any (inevitably?) partial solution is going to be embedded in a context and is therefore not easily transferable?" (email communication, February 16, 1996). Local factors and issues are clearly important, but hopefully a response to such questions by someone who is unaware of the local situation can nevertheless provide some food for thought, and we must give teachers credit for adapting a response to their own situation.

The point should also be made that we are unwise to claim complete answers in any situation, and one of the points that has been made to me is that many of the questioners appear to presume that there *is* an answer to each of these questions, and that it is only a matter of finding the right person to ask.

Bill Juraschek from the University of Colorado—Denver in commenting that the questions seemed similar to those that he was asked 25 years ago, described his reaction to the following question offered in his master's class: "Assessing by probing for conceptual understanding seems a good idea, but how do you make it easy?" Bill describes his reaction:

> After I calmed down and allowed the poor fellow to return to the room . . . Actually this query, variants of which appear throughout your list, belies the major paradox: humans always want to "make things easy" in the sense that they want to reduce problems to predictable routines—which is a major goal of mathematical research—yet teaching, historically, is intractable in this regard. As long as the system assumes the factory-production model the questions will never go away.
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> (email communication, February 27, 1996)

The notion that *someone* has the easy answer is also evident in this question provided by Marj Horne (Australian Catholic University, Victoria): "Which is the best textbook? And if there isn't one, why not?" Many teachers continue to seek "teacher-proof" materials and methods, particularly in a climate of increased class sizes and increased teaching allotments, but a discussion of the limitations of such a concept is important.

On the theme of teacher-proof materials, I recall leading a two part workshop with teachers in Providence, Rhode Island, with the sessions spaced two months apart. On the first day, a teacher asked a question similar to that raised by Marj Horne: "Why doesn't someone just put all this good stuff together, give it to me, and I'll teach it?"

Two months later, the same teacher had by then tried a range of ideas that he had gained from myself and other teachers. However, in seeing the power of problem solving approaches in his classroom, he had then, in his words, "thrown away the textbook", and in the recall session shared photographs and samples of student work from five or six wonderful mathematical investigations that *he* had developed. This teacher, who had sought to be shown the easy way, had learned that with the provision of some innovative models of what the mathematics classroom might be like, he was then in a position to take these models and create his own activities and tasks, as he responded to the needs and interests of his students.

Teachers' content knowledge

A question offered by Joseph Zilliox from the University of Hawaii ("How can I teach topics in maths that I myself do not know very well—content about which I am not very confident?") reflects an important issue at a time when the numbers of qualified mathematics teachers appears inadequate, and relatively few mathematics teachers are in training in Australia.

I believe that one of the reasons why content knowledge becomes even more important in an era of curriculum reform is because it is less common for a typical lesson to consist of worked examples on the blackboard followed by students practising a single algorithm over and over. Such teaching requires minimum preparation and mathematical understanding on the part of the teacher. On the other hand, teaching in a problem solving environment demands a *connected* view of mathematics. As Brophy (1991) claimed:

> Where [teachers'] knowledge is more explicit, better connected, and more integrated, they will tend to teach the subject more dynamically, represent it in more varied ways, and encourage and respond fully to student comments and questions. Where their knowledge is limited, they will tend to depend on the text for content, de-emphasize interactive discourse in favor of seatwork assignments, and in general, portray the subject as a collection of static, factual knowledge. (p. 352)

Having said that, I believe that the difficulties that teachers experience with content are not due to a lack of study of traditional university mathematics units (see Fennema & Franke 1992), but rather the lack of opportunity for teachers to study mathematics in the kind of problem solving environment which they are being encouraged to create for their own students.

In a study of teachers struggling with the content demands of a problem solving environment (Clarke, in press), I asked an experienced middle school teacher to suggest the best way in which she could be supported in her own mathematical growth. She commented that she had learned more mathematics over the previous two years during which she had been teaching problem solving units than during any previous time, and she attributed that to the opportunity to team-teach with someone "strong mathematically." Of equivalent importance to this teacher was the chance to work collaboratively with three colleagues, when the teachers planned their teaching of particular activities or units of work. She felt that the provision of such opportunities for other teachers would be the most helpful strategy in helping teachers to understand important mathematical ideas (Interview, Ms Bartlett, September 10, 1992).

A lack of focus on pedagogical content knowledge

In recent years, I have been concerned that there is relatively little discussion at conferences and inservice programs of mathematics teachers (as reflected in session titles) on matters relating to *pedagogical content knowledge*. This term has been coined by Shulman to refer to

> The most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations—in a word, the ways of representing and formulating the subject that make it comprehensible to others. . . . [including] an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning. (Shulman, 1987, p. 9)

Only eight questions out of the 110 which I received were of the kind that sought advice or help on student understanding, misconceptions and possible growth paths, or the best explanations, examples and illustrations for particular content. I have also noticed that few students wishing to undertake research studies through our institution identify such areas as those upon which they wish to focus, preferring rather to concentrate on student affect, classroom organisational structures, and assessment alternatives, for example.

If a major part of the task of mathematics teaching is to find the best ways to provide support to the mathematical growth of students in particular content areas, then it is reasonable to assume that many of the questions asked of mathematics educators and others working with teachers might relate to the challenges of providing such appropriate support, and building pedagogical content knowledge.

Implications for Further Research and the Work of Mathematics Educators

Although this study was small and no claim is made for representativeness other than the extent to which the questions "ring bells" for colleagues with whom I have shared the list, it nevertheless provides a starting point for a study of teachers' concerns as reflected in the questions. Other researchers may wish to conduct similar, larger, and more systematic studies, which seek to extend the range of participants to other countries, and to define more precisely the setting in which the question was asked. Another study might seek responses to such questions from eminent mathematics researchers and educators.

As well as giving an idea of the universality of issues in mathematics education, these questions have the potential to be used by academics and consultants working with networks of teachers, while teaching courses or leading inservice programs. Readers of this paper could usefully share the questions with teachers in their own districts or work settings, encouraging them to identify those of personal interest and to share their own "answers" (if answers are possible), and, perhaps more importantly, their views on the issues that underpin these questions. So many of the questions reveal much about the teachers' beliefs and philosophies about mathematics teaching and learning.

A final quote from a teacher that was coded under the heading of "Teachers' Content Knowledge" is my favourite question so far, and one which illustrates the benefits of this small study, showing as it does the way in which a short question can encapsulate a whole range of issues in mathematics education:

> Could you show me how to add fractions? I know how to teach it, I'm just not sure how to do it".
>
> (Alistair McIntosh, Edith Cowan University, Perth).

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