The roles of question/answer techniques in secondary school mathematics

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Introduction

In this paper we discuss an analysis of transcripts taken from secondary school mathematic classrooms. In particular, we focus on a selection of question and answer interactions, and are particularly concerned with the purposes teachers appear to have in using these questions.

Questions involving mathematical knowledge or applications

Our data appear to indicate that the mathematics teachers we studied emphasise quick question and answer interactions. In particular, our data indicate that teachers' questions are generally concerned with recall and comprehension, and with application, with few instances of questions concerned with higher order cognitive skills such as analysis, synthesis and evaluation.

Here is a transcript taken from a year 7 lesson on measurement, from the beginning of the lesson, when the teacher questions students about the meaning of centimetre.

T:Well now to question five please. Write down one thing that is one centimetre long, it's not a big measurement. Lynne?
S:A bit of the board?
T:Yes what bit of the board? Do you think that is one centimetre?
S:I know.
T:Do you know one.
S:A fly.
S:A fingernail.
T:Good. It doesn't have to be exactly one centimetre but round about one centimetre. One more please?
S:A piece of string?
T:It could be if you made it one centimetre long but something you can show me that is one centimetre long straight away.
S:A ruler. A smartie.

His purposes appear to be to establish what students know about a centimetre, and to revise its name and meaning. For example, he asks write down one thing that is one centimetre long and it doesn't have to be exactly one centimetre but round about one centimetre. There also appears to be a purpose related to increasing student participation in the lesson, with the request one more please. The lesson continues, by moving from centimetres to metres.

T:What we are trying to do is to show some understanding of the size of one centimetre, and those things there would be about one centimetre long. What about one metre, tell me something that is one metre long?
S:A one metre ruler.
T:A one metre ruler. Of course, that is the obvious answer. Something else?
S:The window.
T:The length of that window over there is about one metre. Is there something else?
S:The stairs.
T:The width or the length? Which is the length? This one? Can anybody tell me something which is about one kilometre away from the school?
S:The newsagent.

T:The newsagent, okay. Anything else that is one kilometre from the school?
S:(inaudible)
T:A sporting complex.

Another purpose of these questions becomes clearer now, since as the lesson continues the teacher is concerned not only with units of length, but also with relationships between units.

T:Now what we see here when we talk about these measurements or these distances is that we have names for distances, for a short distance or a very small distance, we use the name centimetre. Distances that we can see round about as long as our arm or something like that we use the standard measurement which is a metre and then for other distances we have the kilometre. One thing before we move on, how many of these are there in one of those? How many centimetres are there in one metre?

S:One hundred.
T:Thank you good. We have a hundred centimetres and we end up getting one metre. Think of the word dollar and cents. How many cents are there in a dollar?
S:One hundred.
T:How many years are there in a century?
S:One hundred.
T:And we are coming across that word or part of that word, cent and that comes from or it means the number one hundred and we use that word commonly in words which refer to one hundred something.
T:Now what about from metres into kilometres? How many metres are there in one kilometre?
S:One hundred.
T:Don’t call out or you might make a mistake.
S:One thousand.
T:There are one thousand metres in one kilometre and again the other word which contains that part there, the kilo part, things like kilograms and so on, all stand for one thousand. A kilolitre is one

thousand litres. A kilogram is one thousand grams and so on. You are not paying attention to me. The century means one hundred and the kilo means one thousand. Any questions so far? We have some simple additions and then we had a look at some measurements as well, any questions about those?

Here the teacher's purpose appears to continue to be revision, clarifying what students know, and encouraging student participation, for example, how many cents are there in a dollar? and how many years are there in a century? He may also be using these questions to evaluate student progress.

Our data also seemed to suggest there was another kind of question whose purpose was less clear. In particular, in these questions teachers seemed to want pupils to "guess what's in my head". Here is a Year 9 class, studying the topic plane figures, where the teacher has folded a square piece of paper along a diagonal, and has asked students to write down "anything about folding", when he wants students specifically to recall the term axis of symmetry.

T:What do you call them? Does anybody know the word you use when you fold that from there to there and there is no overlapping whatsoever?
S:A mirror image.
T:A mirror image. Come on what is another word?
S:A reflection?
T:A reflection. Come on, we need more words. What about if I open that back up. Somebody has already used the word diagonal.

S:A straight line.
T:A straight line, John. I'm searching for a word and I can't get it.....long pause as students talk among themselves.
T:What is the place where you bury them?
S:A coffin. A cemetery (laughter).
T:Do you mean to say I am going to be buried in the cemetery. What do you know about symmetry?
S:The axis.
T: The axis of symmetry.

Up to this point, the kinds of questions that we have analysed from our data are almost all intended to elicit a one-off response, with very little elaboration and little attempt to develop students' cognitive structure.

Questions involving mathematical relationships
There were also instances in our data where teachers questioned students in a manner that suggested they were moving away from the teacher question-student answer-teacher response triad. For example, here is an interaction between a teacher and her Year 8 class where she is providing a long logical deduction involving a range of mathematical

concepts, related to the topic of indices.

T:All right, now I want to multiply two terms together (a3 x a5). What are these things called Bronwyn?
S:Letters.
T:Letters, very good. They are letters. What do we call them if this is the index?
S:Base.
T:We say this is the base. Thank you. Do they both have the same base Bianca?
S:Yes.
T:Yes they both have the same base. Do they both have the same index?
S:No.
T:Okay, so the terms have the same base but they don't have the same indices.
S: Would it be a to the power of 15?
T:Let's explore and see what happens. Some of you might think the answer is a to the power of 15. Let's explore and see and thank you for attempting to get an answer Teresa. Okay let's see what cube means, Steve. Let's write it out in its expanded form.
S: a times a times a.
T:So this is a and this is a and this is a. Rhonda how many would I write down for the next one?
S:Five.
T:So I would write down a times a times a times a times a. Now how many of these can you see Kate?
S:Eight
T:Eight of them. Three from here multiplied by five from here to give us a to the power of eight. Let's try it for another one just in case I may have done something illegal here. I may have fiddled the numbers or something, so let's double check and see.

This appears to be quite an efficient manner in which to deal with this topic. Put simply, there is a mathematical relationship to be established that leads to a rule that students need to remember and apply, and the teacher is moving through a series of steps to outline the relationship prior to forming the rule.

These last two transcripts are about mathematical relationships, situations where there is likely to be considerable potential for student investigation. But they were not "good" questions according to

Sullivan and Clarke's (1991) criteria, in that they did not require more than recall, they did not involve doing any mathematics and there were not several acceptable answers.

Implications of these questioning practices
It seems that teachers in the mathematics classrooms we observed were concerned with keeping control of the discourse. They appear to have

clear ideas as to the intended learning outcomes of the lesson, and maintained a direction towards these ends. There were almost no instances where student answers, questions or other remarks were followed by appreciable changes in lesson direction. While there were some instances of teachers seriously answering student generated questions, the teacher never allowed the possibility of broader discussion among other students even when it appeared to us that this possibility was there and was likely to be an effective pedagogical step.

It appears to us that students in these lessons are likely to have a particular view of mathematics, and of teaching and learning mathematics, foisted upon them through this teacher control of discourse. That is, they are likely to see mathematics as the study of a field concerned largely with achieving correct answers to nonsensical questions through the application of an arbitrary rule, that mathematics is largely irrelevant to them, and that there is no creativity in mathematics since there is nothing new in mathematics. Students are also likely to come to the view that discussion is pointless in mathematics since there are no opinions or debatable points, only correct answers, and that the only way to learn mathematics is through teacher telling followed by student practice.

Teachers appeared to hide this control of classroom discourse through implicit appeals to students. For example, teachers wanted to be friendly towards their students, they seemed to be saying "I am giving you the chance to discover mathematics for yourself", but this pseudo-amicability had a harder edge since "I have the knowledge and you do not." In particular, there seemed to be the belief that it was only through teachers that students could come to know mathematics, and that students should trust these teachers since teachers knew what was best for them mathematically.

Other pedagogies

Lemke (1990) noted that there was little scientific talk in science classrooms, our data appears to indicate a parallel in mathematics. That is, if learning mathematics requires learning to talk mathematically, it is not happening in mathematics classrooms. We found few instances where teachers asked questions whose principal purpose appeared to be to encourage problem solving or to help students form and articulate arguments. That is, there were few questions where students were encouraged to reflect, and where their responses were relatively unanticipated, creative and divergent. Here is a Year 9 class with an opportunity for genuine discussion on problem solving.

T:Fred has six dollars less than Paul so Fred has got x minus 6 and they have $52 between them, so the two amounts add up to 52. That's the hard bit over.
S:Sir, wouldn't you do x plus 6 plus x?
T:If you did x plus 6 plus x, which one of those is Paul's?

S:No, it's not Paul's then.
T:Say you get x plus 6 plus x equals 52. Two x plus 6 equals 52, you have to minus 6 to get 46, x is 23, there is nothing wrong with that but that is Fred's. But you have to know that is Fred's and that is the trouble. If that is x and x plus 6, this one here is 6 more than that,

so you have to figure out which one has got the most. So Paul has got the most which means it is the x plus 6, so you add 6 to that and you are back where you started. So it's probably easier if you make the pronumeral belong to the person who..
S:...has got the most.
T:But it doesn't matter as long as you know what you are doing.

This encounter shows a case where a student initiated question, reacted to sympathetically by the teacher, led to reflection and complexity of thought on the part of that student, but the teacher ignored the opportunity to ask questions of other students to enable a more general discussion to take place.

Discussion

The interpretations we have given to our data are consistent with Ellerton and Clements' (1991) view that language in mathematics classrooms is more likely to be used to lead to a predetermined conclusion than to provide an opportunity to engage in a discussion about mathematical relationships, and with Mousley and Marks' (1991) view that school mathematics is highly structured and controlled through teacher dominated talk.

But it does seem from our data, and from applying some of the strategies Sullivan and Clarke (1991) claim will create good questions, that these teachers have the potential to use more open questions in their classrooms. For example, we have identified in our data points at which more meaningful discussion would have been possible, through strategies such as asking the student to explain, clarify or reconstruct the reasoning behind the answer. The necessary teacher professional development seems to require both some new skills in pedagogy and an altered frame of mind in terms of control. A more radical, but important step, would be for teachers to reconceptualise their understanding of mathematics and mathematics learning to take into account mathematics as a creative and constructive endeavour.

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Text 1
A year 7 lesson on measurement.

T:Well now to question five please. Write down one thing that is one centimetre long, it's not a big measurement. Lynne?
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T:Yes what bit of the board? Do you think that is one centimetre?
S:I know.
T:Do you know one.
S:A fly.
S:A fingernail.
T:Good. It doesn't have to be exactly one centimetre but round about one centimetre. One more please?
S:A piece of string?
T:It could be if you made it one centimetre long but something you can show me that is one centimetre long straight away.
S:A ruler. A smartie.

T:What we are trying to do is to show some understanding of the size of one centimetre, and those things there would be about one centimetre long. What about one metre, tell me something that is one metre long?
S:A one metre ruler.
T:A one metre ruler. Of course, that is the obvious answer. Something else?
S:The window.
T:The length of that window over there is about one metre. Is there something else?
S:The stairs.
T:The width or the length? Which is the length? This one? Can anybody tell me something which is about one kilometre away from the school?
S:The newsagent.
T:The newsagent, okay. Anything else that is one kilometre from the school?
S:(inaudible)
T:A sporting complex.

T:Now what we see here when we talk about these measurements or these

distances is that we have names for distances, for a short distance or a very small distance, we use the name centimetre. Distances that we can see round about as long as our arm or something like that we use the standard measurement which is a metre and then for other distances we have the kilometre. One thing before we move on, how many of these are there in one of those? How many centimetres are there in one metre?

S:One hundred.
T:Thank you good. We have a hundred centimetres and we end up getting one metre. Think of the word dollar and cents. How many cents are there in a dollar?
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T:And we are coming across that word or part of that word, cent and that comes from or it means the number one hundred and we use that word commonly in words which refer to one hundred something.
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in one kilometre?
S:One hundred.
T:Don't call out or you might make a mistake.
S:One thousand.
T:There are one thousand metres in one kilometre and again the other word which contains that part there, the kilo part, things like kilograms and so on, all stand for one thousand. A kilolitre is one thousand litres. A kilogram ..

Text 2
A Year 9 class, plane figures, "anything about folding", axis of symmetry - "guess what's in my head".

T:What do you call them? Does anybody know the word you use when you fold that from there to there and there is no overlapping whatsoever?
S:A mirror image.
T:A mirror image. Come on what is another word?
S:A reflection?
T:A reflection. Come on, we need more words. What about if I open that back up. Somebody has already used the word diagonal.
S:A straight line.
T:A straight line, John. I'm searching for a word and I can't get it.....(long pause as students talk among themselves).
T:What is the place where you bury them?
S:A coffin. A cemetery (laughter).
T:Do you mean to say I am going to be buried in the cemetery. What do you know about symmetry?
S:The axis.
T: The axis of symmetry.

Text 3
Year 8 class, indices, logical deduction.

T:All right, now I want to multiply two terms together (a3 x a5). What are these things called Bronwyn?
S:Letters.
T:Letters, very good. They are letters. What do we call them if this is the index?
S:Base.
T:We say this is the base. Thank you. Do they both have the same base Bianca?
S:Yes.
T:Yes they both have the same base. Do they both have the same index?
S:No.
T:Okay, so the terms have the same base but they don't have the same indices.
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T:Eight of them. Three from here multiplied by five from here to give us a to the power of eight. Let's try it for another one just in case I may have done something illegal here. I may have fiddled the numbers or something, so let's double check and see.

Implications of these questioning practices

Teacher control of the discourse;
no instances where student answers, questions or other remarks were followed by appreciable changes in lesson direction;
teachers never allowed the possibility of broader discussion.

Mathematics is concerned with
achieving correct answers,
to nonsensical questions,
through the application of an arbitrary rule.

Discussion is pointless in mathematics,
since there are no opinions or debatable points

If learning mathematics requires learning to talk mathematically, it is not happening in mathematics classrooms.

Teacher professional development
new skills in pedagogy;
altered frame of mind in terms of control;
reconceptualise understanding of mathematics and mathematics learning.

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Introduction

As part of two research projects we studied secondary school teachers in mathematics classrooms: videos were transcribed and texts analysed. The purpose of this paper is to discuss with the audience possible interpretations of sections of these transcripts, particularly a selection of question and answer interactions.

Our paper will briefly examine the literature on questioning techniques in mathematics classrooms, especially the question/answer/evaluation sequence. We will also relate our interpretations of the texts to interpersonal relationships in the classroom, to the kind of discovery learning these texts imply, and to the implications of these texts both for students' making meaning of the topic under consideration and for student construction of mathematical meanings in general.

We anticipate the discussion will focus on the extent to which "guess what's in my head" questions are used in mathematics classrooms, and what this suggests concerning values and beliefs about mathematics teaching and learning. These questions inevitably raise issues about knowledge transmission and construction, about interpersonal relationships in the classroom, and about power and control through language. For example, some of these texts seem to suggest that learners studying a topic for the first time already have this mathematical knowledge in their heads, and that questioning is primarily concerned with extracting it.