Teachers' Perceptions of How Open-Ended Mathematics Tasks Assist in Overcoming Barriers to Learning

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The data reported are part of a project called *Overcoming Barriers to Mathematics Learning*, which has explored pedagogies associated with maximising student participation when implementing open ended tasks in mathematics lessons. This paper presents data that support a number of the claims made about the advantages of using open-ended questions, and especially about creating opportunities for achievement for all students.

Overcoming Barriers to Mathematics Learning

The data reported in this paper arose from a larger project exploring barriers to learning mathematics. The *Overcoming Barriers to Mathematics Learning* project first identified and described aspects of implicit pedagogy (see Sullivan, Zevenbergen, & Mousley, 2002). An outcome was the production of a manual that lists a range of strategies that teachers could use to make implicit pedagogies more explicit (Sullivan, Mousley, & Zevenbergen, 2002) and so address aspects of possible disadvantage of particular groups of students. The project then enlisted teachers from senior primary grades in four schools serving populations with significant proportion of students from lower socio-economic backgrounds. The aim was to explore the effect of adopting particular pedagogies, and especially making some aspects of the pedagogy explicit. The teachers in the project were involved in extended professional development seminars addressing issues such as open-ended questions in mathematics and the pedagogies that can be used to implement them. The teachers incorporated open-ended approaches into their planning and teaching, and support was offered to help them in this endeavour. They were also asked to address the needs of individuals in their class.

The key issue is whether and in what ways teachers chose to use open-ended questions to support student learning, and in particular to overcome barriers to learning experienced by some students. The key relevant theoretical considerations are summarised in the symposium presentation by Sullivan, in this volume.

A range of data were collected including 57 classroom observations, observations of target students, teacher surveys and completion of a planning instrument, and the eleven teachers involved were interviewed at the start and the end of the year.

Two Teachers Reflecting on Their Use of Open-Ended Approaches

The data below are from the final structured interviews with two of the 11 teachers. The interviews were audiotaped and transcribed, and the transcripts were analysed to identify themes. The teachers making the particular comments are not identified since it is the individual variables that are the focus rather than the coherence of an individual teacher's approach. These two teachers were chosen because they adopted similar approaches with respect to the key issues of open-ended questions and inclusive teaching. It should be noted that not all of the teachers incorporated open-ended approaches as effectively as these teachers, but these data are presented to demonstrate

that this approach to teaching is feasible, and can be successful in the right conditions. Even though many more issues were covered in the interviews, only data that illustrate their perspectives on open-endedness; the way that they saw the tasks contributing to the success of all students; and the extent to which they were explicit about aspects of the pedagogy are presented.

Examples of Open-Ended Activities

An interview question invited the teachers to give an example of an open-ended task they had used recently. One of the teachers replied:

> They had to design a game in which they could not fail to win. And the partner they were playing with had to lose. That came as a result of doing our chance and data with the throwing the dice, and we had a chance—or a chance and a half—of being red, and it would work out that if you were on the red you'd win more times than with a different colour.

The other teacher described a lesson that had been observed by a researcher:

> The task material consisted of a graph … The axes were labelled with months, and numbers of worms, in thousands. The text on the page read: "Look at the line graph. The graph represents the population of worms in our worm farm at particular times throughout the year. Write a story.

Incidental to answering another question, one of the teachers described a decimal multiplication task that had been posed:

> Something point something times something is equal to something point something. What can the missing values be? A simple thing like that kills a whole hour with the kids and they're involved in really valuable decimal work.

Each of these tasks was created by the teachers, but they are similar in nature to the tasks recommended as part of the project.

A key characteristic of all of these tasks was that students were given considerable control over the direction of the learning and the nature of their activity. This is seen as desirable (Ball & Bass, 2000). With multiple possible responses, it was obvious to the students that they needed to engage their own thinking. These are indeed examples of the type of open-ended task that we hoped to see. Incidentally, most of the 11 teachers were able to describe similar experiences.

Creating Opportunities for Success

It goes without saying that it is better if students experience success rather than failure, yet success depends on providing appropriate levels of challenge (Cohen, McLaughlin & Talbert, 1993). One of the interview questions sought comment on what they had hoped the students would learn from an open ended question that they had used recently. For example, one of the teachers, in commenting on the way the students responded to the open-ended approach said:

> I know my class loves it, because they're never wrong …some of the kids aren't what you'd call particularly good at maths, so they get some measure of success out of doing these.

One also commented on the way that individual students responded to the open-ended approach based on their own needs and experience:

> Some have worked on an activity which said turn 90 degrees, and others like (Child 1) weren't there for that activity, and they said "Well I'm going to use compass points for mine and I'm going to say forward three steps, or right hand turn". All the different things from their past experiences came out in their own talk and in their own page. You know (Child 2), she has

> problems in a lot of areas in maths, but she wrote a clear description and sentences like "and then you go around the rock …", and she's just written very basic directional language.

In other words, it is not only the opportunities for success, but is the nature of success that is different for each student. Another comment by one of these teachers emphasised not only the reduction in the potential for failure, but also the positive sense of the students feeling in control:

> … what I focus on really is the fact that no child in class is going to experience absolute failure, because they've basically got control of the task from the start, because their answers will be respected and they won't be marked with a cross. The graph one was a beauty because … every kid seemed to come up with a different idea. … So basically using a simple thing like a line graph that had no markings on it at all … all this talk came and the kids were able to write I think 4 or 5 sentences on what their graphs were, and as I said, they were allowed to mark their graph with an x axis and a y axis, and represent whatever they wanted to on that. So the other thing is that with the open-ended tasks they really do complement the other work that you are doing, and I know the kids really look forward to it, and it is not only the sharing aspect with their partner, but because it is not a thing that you can take home and correct, whether it is wrong or right and then hand back to the kids the next day.

In this case, the control and the different suggestions from the students enhanced the learning experience by emphasising the applicability of the graph to various contexts. The tasks also engaged students experiencing difficulty with learning mathematics:

> (Some of them) want to be spoon-fed and wet-nursed along and just coerced into doing it, and it was not quite so much concern, I was quite pleased that we had young (Child 3), who has struggled for most of the year, and in his free time he devised a game, and he is working on it at the moment …. So I have found that he is now taking an interest in the maths. And I have found that through using the open-ended questioning it turns out … that the whole class could contribute or participate in some way – not just the children who are good at maths ... They can all achieve something including a couple of those children who struggle with maths.

The difficulty of doing this should not be underestimated, given individual differences. Another response of one of the teachers emphasised the variability between children:

> … that maths is really about thinking, and the children should start thinking in different ways to have a go, some were stumped, and some were thinking we could do this and we could do that others would be quite perplexed. You see maths really involves critical thinking and there's all various ways of coming to a solution … and we've got 24 children in the class, and 24 different ways of achieving a result, so I think some children … think that there is only one way of doing things, … they don't see that there are various ways of addressing the situation.

To some extent, this teacher was referring to the importance of persevering (Davis, 1997), and there were instances were students did demonstrate a willingness to persist:

> Last week … we came back in after play and, they didn't want to do silent reading. They said "Can we keep on going with this?" and I just said "Go for it, if you haven't finished or you haven't evaluated, well then go for it".

It seems that use of open-ended approaches allowed at least these two teachers to engage their students, with a greater sense of control and in ways that created opportunities for all students to succeed. While it is not possible from these data to allow articulation of the specific aspects of the pedagogy that contributed to this, one characteristic is that there seems to be sensitivity to the students as individuals.

Explicitness

One of the features of the pedagogy that we suspect should accompany open-ended approaches is that of explicitness. This seemed to be more difficult that we anticipated.

For example, in the interviews the two teachers were asked about whether they usually emphasise the number of different answers to a task. One teacher replied:

> Not so much the number of different answers to a question, but the number of different methods of actually achieving an answer.

One described being specific about the possibility of multiple answers:

> Usually if I give an open task I might mention that there will be more than one answer. Sometimes they will discover that themselves as well. …for instance, I said ... it was to do with footy ... See, a footy game goes for 2 1/4 hours and what are the starting times and finishing times of the game? … So some kids started at 12 and went through to 2.15, the whole range of different answers came out about that, but I never specified to say at the start that there are going to be 6 or 7 answers, because it is limitless.

However, even for these two teachers who were more articulate about the nature of open-endedness than others, they did not articulate a broad range of aspects of pedagogy about which they might be explicit, and indeed to some extent even sought to de-emphasise this. Perhaps the teachers only considered the possibility of multiple responses to be sufficiently different from their usual teaching to warrant attention.

Summary and Conclusion

The data presented here are from one aspect of a project investigating ways to overcome any possible barriers that use of open-ended tasks might present for students. After professional development sessions, and one on one observations and feedback, we found that the teachers were willing and able to incorporate open-ended approaches into their teaching but less willing to spend time making explicit aspects of the pedagogy. The data are from two teachers who described not only tasks that were open-ended, but also the tasks could be used to engage students (including those who experience difficulty with learning mathematics) in effective and sustained learning. These data demonstrate that similar approaches and results are possible in normal classrooms.

On the other hand, even these two teachers found the type of explicit pedagogies we were exploring challenging. Sullivan et al. (in press) reported that, even though included in the professional development and the advice manual, in the lessons observed very few teachers made explicit pedagogies that would support the use of open-ended tasks.

We suspect that more research is needed on the key pedagogies supporting open-ended approaches and especially on those that assist teachers to engage students who are potentially disadvantaged in the mathematics learning.

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