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In many Western countries, it is not uncommon to hear of students who ‘switch off’ when it comes to mathematics and teachers who feel that they are overworked and feeling unsatisfied with their work, particularly given the (over) assessment that appears in much contemporary reform. In such contexts, it would suggest that different approaches to teaching, learning and assessment are timely. One reform is that of open-ended tasks. Such an approach shifts significantly from the dominant modes of teaching and assessment and has the potential to improve learning outcomes. What is less well known about open-ended tasks are the potential barriers to learning when adopting such an approach. From a sociological perspective, there exists both theoretical and empirical work to suggest that pedagogical approaches that mask the assumptions and expectations underpinning the task can effectively exclude some groups of students. At this point in mathematics education, there has been little systematic study of what such factors may be. This paper reports on the first phase of a larger project seeking to identify (and later address) barriers to learning when using open-ended tasks. It is our position that open-ended tasks have considerable potential to improve learning, yet we are cautious about the approach on grounds of equity and inclusion.

In her detailed analysis of two UK schools, Boaler (1997) argued that the school using a more open approach to teaching mathematics was able to produce more sustained outcomes in learning in mathematics than the traditional format used by the other school. While Boaler’s study involved only two schools, it offered a very rich and detailed view of the impact and effect of school reform supporting open approaches to teaching mathematics. Within the Australian context, Sullivan (Sullivan & Clarke, 1991;
Sullivan & Lilburn, 1997) has worked extensively on the development of, what he refers to as, ‘good questions’. He sees this as being an important part of teaching. Sullivan’s work on good questioning becomes more important since the forms and types of questions posed by a teacher have potential to impact on the overall quality of the classroom environment. Within this approach, open-ended tasks are an exemplar of a good question in that they move significantly beyond the superficial and have the potential to be far more inclusive of students in the classroom. From studies such as these, there is an empirical base that supports the use of open-ended tasks in mathematics education.

What is an open-ended task?

By definition, an open-ended task is one that has the potential to include a range of ‘correct responses’ so that they are more encompassing than the typical closed questions used in most teaching situations. Where a closed question typically has one correct response — for example, ‘What is the sum of 3, 5 and 10?’ — an open-ended question is one where there are multiple correct answers and students can answer at a level that is appropriate to, and represents, their current level of understanding. An open-ended task that is similar in content to the previous example could be, ‘What three numbers add up to 18?’. Such a question allows for students to offer a range of responses that are correct — such as 1, 1 and 16; 6, 6, and 6 or for students who have some understanding of fractions or negative integers there is potential to include these in their responses as well. All in all, the responses offered by the students also provide the teacher with some insights into a student’s level of understanding — far more than would be possible with a closed question even when considering the potential of error analysis to provide some further information to teachers.

For many teachers, the use of open-ended tasks provide excellent teaching and learning opportunities but also invaluable assessment information. In the previously cited example, the variety of responses that students offer allow for them to participate at their level of understanding without being considered inferior or lacking since the responses they offer are correct ones. This potential of open-ended tasks cannot be underestimated given that many students feel alienated by mathematics, particularly since it is the one discipline where they are either wrong or right. For too many students, the former situation is the one that they experience the most frequently. One of the advantages of open-ended tasks is that they challenge the dominant myth in mathematics that there is only one correct answer. Across any classroom context, students are able to offer a range of answers that are suited to their current levels of understanding. Such challenges to the status quo are useful as they allow greater discussion among students and the recognition that, like other areas of the school curriculum, mathematics is not constrained by always having a single answer. By using the variety of answers as a catalyst for discussion at either whole class or small group levels, students are able to discuss not only their answers, but also how they arrived at these answers. In so doing, multiple pathways become possible and students are able to negotiate other ways of calculating answers as well as evaluating more effective and efficient means by which they can arrive at their answers. This process allows greater access to knowledge and understanding that would not otherwise be possible.

The dividing of teaching and assessment is a common practice that places considerable extra pressure on teachers. In contrast, other approaches to teaching and learning suggest that assessment is integral to teaching. An effective teacher is continually assessing students and pedagogy as
she/he works through a program of study. In fact, some would argue that teaching and assessment must be inextricably linked if they are to be effective: ‘Good instruction = good assessment’ (Sullivan & Clarke, 1991, p. 41).

Open-ended tasks can form the basis of a lesson through to a unit of work whereby the teacher can assess the products being produced by students. In the case of the simple tasks such as, ‘If the area of a plot of land is 15 square metres, what are its dimensions?’ it is conceivable that within a classroom some students may offer responses whereby the plot of land is a rectangle of 5 m × 3 m and thus offering evidence of understanding of area, shape, multiplication and so forth. However, within the same class, some students may be operating at a different level and have been exploring areas of triangles and offer responses that support their understandings of this aspect of area and shapes. Such responses may not have emerged when using closed questions, but by opening the questions in this way, teachers are able to access more knowledge of their students’ levels of understanding than would have otherwise been possible. As such, open-ended tasks become both teaching and assessing tools where assessment is integrated with teaching.

Barriers to learning mathematics

Most of the literature that seeks to identify barriers to learning is founded in psychology and hence focus on the individual student. These models suggest that the students are lacking in some way or another and as a consequence, intervention is premised on a deficit model. In contrast, we are taking a more social view to learning and see the classroom and background of the students as being important components of learning. While there has been some research, and theoretical analyses, in this area, there is little consideration of issues specific to mathematics education. As such, we are drawing on a diverse knowledge and extrapolating this to mathematics education in order to identify what aspects of classroom practice may be influential in enhancing or hindering success in mathematics. Some of the issues that we have identified from this sociological literature address the mismatch between the cultural norms those students bring with them to school and those of the school context. Hence, rather than see students lacking in some way, we prefer to think of them as different. Underpinning this project is the assumption that some students enter the school context with different social and cultural norms from those of the school, so that when they participate (or attempt to participate) in school, they are often positioned by the teacher as not conforming or even failing. This failure is probably less to do with some innate ability, but rather an inability to read the unspoken rules of the game — that is, the culture of the classroom.

From the literature on classrooms and schools, we know that students who are not from English speaking, middle-class, Anglo-Saxon backgrounds have less synergy with the culture of schools and classrooms than their peers from such backgrounds (Lamb, 1997). There is less chance of them being seen as effective students since they cannot crack the code of classroom life.

Bernstein’s (1996) work is useful in the approach that we are taking in this project. His notion of invisible pedagogy is central to our theoretical model. His central thesis is that some aspects of teaching remain invisible to students yet it is through this practice that mathematics is relayed to students. Students must be able to unpack both the mathematics and the pedagogical practice in order to make sense of the interactions. However, some students, as a consequence of their familial background, will have a greater synergy with the practices in the mathematics classrooms than their peers. Our project seeks to identify what these may be and how they may impact on learning, particularly when using open-ended tasks as these represent a significant shift in the dominant teaching practices of school mathematics. In the following sections, we discuss some of these aspects of pedagogy that may create difficulties for students.
Questioning
When students are given directives in classrooms, it is likely that many will be of the pseudo-question form so that it is likely that students who have familiarity with the unspoken demands of the directive, ‘Could you get out your maths books?’ see it for what it is: a demand to take their maths books out. In contrast, students for whom such directives are not a part of their everyday experiences, there is greater potential for misinterpretation of the task. What is often interpreted as resistance — when students respond in ways different from the expectation of the teacher — may, in fact, be due to cultural misinterpretation rather than misbehaviour.

Language
In concert with the styles of expression, consideration should also be made of the language that students bring with them to school. It is recognised that the language of the middle-classes tends to be rich and embellished, whereas the language of the working class tends to be more functional. This is important for work such as open-ended tasks where there is considerably more language involved in the tasks than for closed questions, and the language requires a particular orientation on the part of the learners.

Pedagogy
Work in the area of social interaction has shown that particular forms of interaction govern the classroom. Typically these are of a simple three-phase pattern where the teacher initiates a question, a student responds, and the teacher evaluates. While there are issues associated with this form of interaction, it is commonly used in mathematics lessons to introduce content and keep control of the flow of content and lesson. Middle-class parents are more likely to interact with their children in ways that resemble the school context when undertaking pseudo-school work. In contrast, working-class families are less likely to engage in such patterns of interaction.

The project
Our project explores two aspects of mathematics teaching — using open-ended tasks and making pedagogy explicit. We do not know the effects of implementing open-ended tasks in classrooms where there are socially and culturally disadvantaged students. Based on earlier work, we know that open-ended tasks have significant potential as tools for learning, teaching and assessment, but we exercise caution in using this approach in disadvantaged contexts as the pedagogical approach may further restrict the learning of these students as they are not able to ‘crack the code’ of the practice and hence be further excluded from mathematics. This paper addresses the first phase of the project where we have been working with teachers to identify aspects of teaching practice that may be problematic for disadvantaged students.

In subsequent phases of the research, the outcomes of this first phase will be used to identify aspects of teaching that can be seen to be hidden from students and to make such factors explicitly taught. A matrix will be developed whereby there is a mix between students who are exposed to open-ended tasks, and those who are explicitly taught aspects of hidden pedagogy. The outcomes of this matrix will be analysed in order to evaluate the effectiveness of the approaches.

Results
While many of the points raised by the participants confirmed earlier research, a number of clear points need to be aired: first, those aspects of invisible pedagogy relevant to this project; second, and of concern to us, the dominant focus of the participants. In most cases, this was heavily imbued with psychological and deficit models, and tended to focus more on the teaching of content rather than the teaching of students.

Potential problematic areas of implicit pedagogy
The focus groups helped to identify a number of aspects of teaching practice that could be problematic for our target students. While the issues raised in the earlier section were central to the snippets selected from the classroom videos, we were surprised to
note the absence of language in the discussions of the participants. Other aspects—pedagogy and questioning—were raised.

1. Multiplicity of responses
As mentioned earlier, one of the advantages of open-ended tasks is that they offer potential for all, or most, students to participate through the capacity to include a range of answers, all of which could be correct. This is seen to be inclusive as it caters for the diversity in a classroom and students can offer responses that reflect their levels of understanding. However, this was identified as being a potential area for problems for students since the dominant culture in mathematics is that there is one correct answer. Many students (and parents) see this as a defining characteristic of mathematics. Teachers identified that this aspect could be a problem for indigenous (and working-class) students.

Similarly, another teacher responded that mathematics teaching traditionally taught concepts, such as fractions, in a very discrete way so that there were clearly divisions between concepts and that they should not be mixed. In a task where students were asked to offer some fractions between two points, there was potential to include both decimal and common fractions, yet, as this teacher argued, students would not see this as a potential response due to the traditional modes of teaching.

From these types of responses, it would suggest that in making the tasks more available to students, there is a need to challenge the dominant modes of teaching mathematics—compartmentalising concepts, one correct response and so on.

2. Contexts
Two aspects of contexts were raised—relevance and meaningfulness. One of the segments shown to the focus groups involved the calculation of mean heights and the teacher had used a poster of a police line up with the height bars behind the suspects as a catalyst for discussion. Most members of the focus groups recognised the importance of context. However, in this case, this context may be totally inappropriate, as many of the target groups could be quite antagonistic towards the police and the law. Hence, there was considerable recognition of the importance of establishing contexts that were relevant for the students.

Suggestions were made that students could work in small groups and develop their own contexts for problems—in this case, it could be the mean height of their netball teams or something that is personally meaningful. The notion of meaningfulness was seen to be a critical factor in the approach being taken.

Some participants recognised that the contexts often imposed on mathematical tasks were of a particular kind and often unrelated to the students. Where the students were already being marginalised in and through mathematics, it was essential that the tasks and contexts be made relevant and purposeful for the students. For many teachers this is highly problematic as the worlds of the students are often substantially different from those of the teachers.

3. Purpose to be clearly articulated.
Not unrelated to the context, was that of making the task known to the students. Some of the segments shown did not make their purpose clear, particularly when there was an expectation of ‘discovery learning’.

Disadvantaged children give up more readily. They need to know what they are doing and why they are doing it. Not just for immediate reasons—like you have to do this worksheet, but also what the purpose of the activity is—like to learn how to calculate averages. If they do not know why they are doing something, they will see no reason for doing it and then lose motivation and just give up.

4. Classroom organisation
Insofar as classroom organisation, the video segments showed a range of ways of organising classrooms from teacher directed and highly structured, through to small groups with significant hands-on work. We had anticipated that such segments might stimulate discussion as to the perceptions that the participants held of the preferred learning environments for our target groups. In considering the points raised in the three previous subsections, participants suggested that a classroom that allowed for greater interaction through which students could clarify the tasks or
create more meaningful (or relevant) contexts for their problems was desirable.

However, participants equally acknowledged that the target groups of this project may not have the skills for small group work and participatory discussion. The overall consensus was that students should be given ample opportunities to discuss their mathematics but within an environment where they had considerable support to develop the necessary skills for small group work and discussion. However, the use of small groups alone was not seen to facilitate quality learning environments for the target groups.

**Conclusion**

The work of Bernstein has been particularly powerful in developing our insights into this project and we are cognisant of how the pedagogy of mathematics may be creating difficulties for some students in our classrooms. His notion of invisible pedagogy offers potential in recognising the cultural aspects of classroom interactions. Our initial work with teachers and others experienced with working with our target groups supports some of the issues that have been raised by other researchers. This confirms that there are aspects of pedagogy that could be problematic for teaching mathematics, particularly when the approach is different from that which is common in mathematics. We see these aspects of teaching practice as potential stumbling blocks for students who come from different social and cultural backgrounds to those of the school context. By thinking about how practice may create barriers for some students and not for others, we are seeking to make explicit aspects of teaching practice that may hinder learning. In this case of open-ended tasks, our focus groups have alerted us to some of the potential areas where the students may not be able to interpret the demands of the pedagogical approach since these are seldom made explicit.

Our concern with the data to date is that there has been little recognition of the impact of language on mathematics teaching and learning. This is a point that has been the focus of recent work and there are considerable points where the language background of the students represent considerable barriers to learning mathematics. Furthermore, the profession of teaching has had as central to its work, the notion of teaching rather than learning. For our focus groups, we found that we needed to spend considerable time working with our colleagues to focus on the teaching of the students, rather than the teaching of the concepts. Teachers emphasised the faults in the teaching of particular mathematical concepts, whereas our concern was the difficulties that such teaching may pose for the students. This clearly represents a considerable shift in teachers’ practice and thinking about practice, and hence, may become a critical consideration when we move into the next phase of the research where we work directly with teachers in developing open-ended tasks and making explicit aspects of teaching practice that may be barriers to learning for our target groups.

**References**


**Editors’ note**

Interested readers may wish to contact the authors to obtain a longer version of this article.

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