

## **Contexts in mathematics education: Help? Hindrance? For whom?**

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Until the early 60s school mathematics consisted of students undertaking repetitive tasks where there was considerable calculation and manipulation of numbers. By and large, this form of curriculum could be best conceived as arithmetic. From this time on, the concept of school mathematics has broadened considerably to a point where is now is more encompassing and includes topics such as chance (probability); data; measurement; space, geometry, shapes, location; and algebra depending on the ways in which the authorities decide to organize the knowledge. Even more so, an emphasis is being placed on working mathematically where there is an expectation that there will be transfer between the knowledge learnt at school to the problems encountered beyond school; mental computation, problem solving, communicating mathematical ideas and knowledge and other skills that move beyond the manipulation of numbers. One of the key strategies used in schools for working mathematically is to employ contexts in which to embed the school mathematics with the intention that such contexts help to give the problem a sense of authenticity, reality for students. In this paper, we challenge this assumption on the basis that, when used without due consideration to the socio-political dimensions within which it is being used, there are potential problems – mathematically, linguistically, politically and ethically – for teachers and students. Our experiences suggest that the use of contexts in mathematics education can enhance the learning for students, however, there is considerable cause for concern when such a strategy is used simplistically and without due consideration of the contexts within which it is being implemented.

### **Contexts, transfer and hegemony**

As a term, “context” has many different meanings within mathematics education. Mathematics in a cultural context has been used by some have explored cultural contexts of indigenous people researchers (Barton, 1993; Harris, 1990); workers (Masingila, 1993); street sellers (Carragher, 1988; Saxe, 1988) or everyday activities (Lave, Murtaugh, & de la Rocha, 1984) in order to investigate the ways in which mathematics is undertaken in other activities. In some cases, these authors have sought to uncover, what Gerdes (1986) has termed hidden or frozen mathematics. This body of research has been keen to identify hidden mathematics in indigenous activities. For example, in her work with Indigenous Australian people and their art, Harris (1992) examined dot paintings for mathematical understandings or skills that are in the work.

Typically, paintings were analyzed and claimed to provide evidence of mathematical understandings of shapes (circles, concentric circles), symmetry and so on.

Dowling has been critical of this type of work in that it is at risk of subjugating the indigenous activity – for example basketweaving or dot painting – for western mathematical viewpoints. In the case of the dot paintings, the artists' intentions were not to demonstrate mathematical concepts, but rather to represent other aspects of their cultures. Similar examples can be found in studies of workplaces where workers undertake activities that help them in their day-to-day lives but rarely use (or at least see that they use) school mathematics to work through their tasks. These studies have sought to find school mathematics embedded in contexts outside of the school context – often under the guise to show transfer between the two contexts. Underpinning this work is the intention that by finding school mathematics embedded in non-school activities that the participants in everyday or cultural contexts are able to do the mathematics of schools. The logic of this approach is that if indigenous students or workers undertake tasks that are mathematical, then they are able to do school mathematics.

In the case of other studies – such as the Brazilian street vendors (Carragher, 1988) – the researchers have shown that the invented methods for calculating and undertaking complex bartering are performed satisfactorily in the vending contexts but the equivalent tasks in the school contexts are not understood. For example, consider the common task of asking to purchase a candy bar for 75 cents, how much change will he get from \$5? This problem produces better results when the students are able to answer this when it is embedded in an everyday context yet when the similar algorithm is written down  $500-75$ , or worse still using decimals ( $5.00 - 0.75$ ), students are more likely to answer incorrectly and to have less confidence with their answer. This non-transferability between the non-school contexts and the school contexts has been well documented. In these studies, serious questions are posed about the differences between school mathematics and out-of-school mathematics and how the contexts of these divergent forms of mathematics may produce very different understandings about practice.

In the third broad area related to the study of contexts in mathematics education, the studies of Lave have been very powerful. In this work, she studies the mathematics of shopping for example. In seeking to explore the reasoning behind purchases being made, she found very little use of mathematics. Rather than use ratios to calculate the price of cheeses that appear to be incorrectly labeled, she found that other strategies – such as hunting for similar weighted cheeses - were used. Similarly, choices for purchasing products were not based on a best value for money strategy where ratios and proportions would be calculated but rather based on very practical decisions – will there be enough product to last the time needed, will it fit in the cupboard and so on. This type

of study has shown the lack of resonance between the practices of school mathematics and the non-school context.

These very different approaches to understanding “context” and mathematics education raise issues about the ideological assumptions behind the links and roles of school mathematics. In part, school mathematics gains its powerful status in the school curriculum under the guise that it has application in the world beyond schools. These studies indicate competing views – in the first view of context there is a mathematizing of the activities so that the mathematics in the activity can be revealed. In the other two approaches, it is argued that these are very different practices and that the demands for school mathematics in non-school contexts may be minimal (if at all). As such, the studies have raised questions about the transferability of school mathematics to (and from) other contexts.

### **Contexts, problems and mathematics**

At the level of the classroom, the ideology of school mathematics linking to contexts beyond the school is omnipresent in the texts and activities undertaken by the students. In attempting to move beyond the manipulation of figures and other activities there is an attempt to link mathematics to out-of-school activities, that is, embed them into problems so that the students can ‘see’ the application of the mathematics. Textbooks have the general structure of practice with algorithms (which increasing difficulty) and then what are seen to be applications of the mathematics to real world contexts. A quick scan of any textbook will show the application of skills to contexts of cooking, purchasing, construction, and so on. This practice supports the ideology that mathematics is a very practical subject and hence legitimates its status in the curriculum. However, some criticism of this practice needs to be raised.

While the general consensus among teachers is that the practice of embedding school mathematics into some pseudo-real context supports learning, there is some revealing research that indicates that this is not the case. In their comprehensive review of the national testing system in the UK, Cooper and Dunne (1999) have shown how contextualizing mathematics creates another layer of difficulty for students. They have undertaken a sociological analysis of the tasks and argued that the contextualizing of tasks creates particular difficulties for working-class students, so much so that they perform significantly poorer than their middle-class peers on these tasks whereas performance on decontextualized tasks is equivalent. Drawing on a very large sample, these findings are important as they pose a new dimension to understanding how practices in school mathematics – in this case contextualizing tasks – creates a further barrier to success for some students. Drawing on the theoretical position of Basil Bernstein, Cooper and Dunne (1999) argue that the process of recontextualisation whereby school mathematics is being recontextualized into another field - in this case the

everyday – creates a new set of demands previously not recognized. They argue that the students need to identify the recontextualisation process so that they recognize the demands of the task as being school mathematics in spite of its immediate appearance of being an everyday task.

Consider the following example where one of the authors posed the following problem to a cohort of Year 7 students (12 year olds):

There are 315 students at the sports carnival. If a bus holds 60 people, how many buses are needed to get all the students back to school?

The students offered the following range of responses:

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*5 and 15 rem*

*5 and then put some kids 3 to a seat*

*5 and some can stand up*

*5 and a mini bus*

*Depends on how many teachers come*

*5 and some can go in the teachers' cars*

Of these responses, mathematically, the preferred answer is the first one and it would be reasonable to expect that educators would describe the second response as typically belonging to a student who did the division task but without recognizing the demands of the task in terms of rounding up. The other five responses are very much related to the everyday or practical contexts. The last five responses make sense and in the everyday contexts are the responses that are most likely to be undertaken given the economic imperative of cutting costs. However, in a mathematical context, these responses are deemed to be incorrect – particularly when offered on a national or wide-scale testing scheme. While there have been some researchers who have focused on the readability and comprehension of these types of tasks (Clements & Ellerton, 1992), Cooper and Dunne's work point to the social differences in responding to these tasks. They argue that working-class students are more likely to interpret such tasks as being practical ones and hence respond within that framework. In contrast, middle-class students are more likely to have the cultural capital needed to recognize that there are two discourses operating – a practical one and a mathematical one - and it is the mathematical discourse that is needed for a response to this task. From this research, the context of the problem becomes one of students being able to identify the social norms of the mathematics and deciphering which are the norms through which the problem is being posed. Correct responses demand students being able to identify the implicit norms of the problem in order to respond appropriately. This work has been important in alerting researchers and educators to a bias in curriculum and assessment that has not been addressed earlier. As such, questions such as the bus one need to be reconsidered in terms of their value in supporting learning for students. Indeed, there is some common

belief that this is a concretization of a problem and hence this makes it more amenable to resolution (particularly for people who have been traditionally considered as working in lower levels of cognition) whereas Cooper and Dunne's research poses serious challenges to this assumption.

### **Implicit pedagogy and contexts**

In the work that we are currently undertaking in Australian schools where we are applying the notion of implicit pedagogy to mathematical practices, we are seeking means through which we are able to identify the ways in which classroom practices are facilitating or hindering student learning. In terms of our study, we are using the term "implicit" pedagogy to refer to those aspects of pedagogy that remain invisible to students but which they must be able to interpret in order to participate effectively in the mathematics classroom. Often the aspects of implicit pedagogy that we seek to identify are not made explicit to teachers, educators or students but rather are like other aspects of culture where they are learnt through participation. Similarly, like other aspects of culture, they represent particular social and cultural norms and as such, will have greater or lesser synergy with some students' cultural and social backgrounds than others. We see as central the notion that the practices within a mathematics classroom may represent some cultural norms and not others so for some students there is greater or lesser potential to be successful depending on the norms that are embedded with those practices. We would suggest that many of the practices that have been seen to be good teaching can often be a particular cultural representation and through practices such as research or policy, may reify such practices as normal and legitimate for good teaching.

One aspect of this study is to identify practices that are potentially exclusory for some students. Using a series of focus groups with teachers who have worked in classrooms, a series of videos have been shown where what is traditionally seen as "good" practice is central to the teaching episodes. Participants were asked to identify aspects of the teaching that they thought their particular experiences would suggest could be problematic for some students. In terms of this study, we are particularly interested in indigenous students, working-class students and students whose first language is not English. In the remainder of this paper, we discuss one teaching episode that had been previously used by one of the authors for professional development of mathematics teachers. It was seen to offer a quality orientating phase to the lesson where the teacher had used a catalyst (a poster of pop stars lined up against a height grid), the use of questioning that was spread across the room, and the use of questions rather than description to involve students in the lesson. For this paper, we focus on the context the teachers used for this lesson.

### **The teaching episode**

The classroom is a Year 10 class in a Catholic school in Melbourne Australia. The teacher is introducing the lesson where the objective is for the students to calculate mean heights of a group but through an open-ended question where they will need to form groups of four where the mean height is a nominated length. The task to be posed is to find a group of four people where the mean height is 1.55 metres. To introduce the lesson, she has chosen a promotion poster for a popular band where the band members are in what appears to be a police line up where height lines are drawn and against which they are compared. This poster is left on the board and no reference is made to it. She then begins the lesson by talking about a bank robbery and what descriptors could be used to help catch the robbers. Students offer comments about their hair colour, what they were wearing and so on until someone states height, whereupon she then moves into the lesson and makes reference to the poster, police line ups and the notion of height. Reference is then made to comparative heights and the use of benchmarks to guess people's heights. There is significant dialogue between the teacher and students. In other contexts, teachers and teacher educators have praised this lesson as being a quality lesson in the ways in which she interacted with the students; provided a strong catalyst and reality basis to the lesson; used open questions to involve the students.

However, in the study being reported here, the teachers and researchers we selected were identified as having worked in the area of social disadvantage and had either practical experience in the teaching of disadvantaged students or were involved in researching in this area.

The context, which was the basis for this lesson, was criticized heavily by the indigenous educator (those who worked with indigenous students, and those educators who were also indigenous). Within the Australian context, there are huge concerns with the incarceration of indigenous people. Significant proportions of indigenous people are incarcerated but within these incarcerations, significant numbers of them die. This has resulted in the "Deaths in Custody" Royal Commission. Against this backdrop, the focus groups raised concerns that this context was totally abhorrent for indigenous students. At one level, there would be any likelihood that many students in a class would have someone in their close and/or extended family network who had been involved in a police lineup and many would have lost relatives through deaths while in prison or detention. This was not seen as appropriate to use such a poster. Aside from the obvious concerns raised in relation to the potentially personal effects of deaths in custody, the values that were implicit in the lesson were called into challenge.

The values of the teacher and class were seen to be very moralistic and that there was an expectation that it was "the right thing" to do to turn in someone who had robbed a bank. Questions were asked as to whose values were these? Would they be the values of the students? Many students would feel that

perhaps it were more appropriate not to indicate who had robbed the bank. The teachers did not want to take a relativistic viewpoint, but rather, were keen to recognize that there were particular views being represented in the context of robbing banks and police line ups some of which were inconsistent with the views potentially held by (some of) their students. Hence, a context of police lineups would not be appropriate for some students. A more appropriate context may have been for a team of netballers or footballers. Such a context was more likely to resonate with the students as this was an activity central to their life experiences, one which was enjoyable and one where there is a need to have shorter players in central or roving positions and taller players in defense or attack positions.

### **Questioning**

Within the context of the classroom itself, focus group participants also noted that many social and cultural norms were being violated by the teacher's actions. Many of the practices – seen as quality practice in the traditional sense of teaching – were antithetical to the expectations and experiences of the students. The use of questions and questioning style were a key area of concern.

The teacher's interactional style was seen to be representing a particular cultural perspective. Her hand gestures as she turned her wrist and used an up-pointed hand were seen to be offensive by many of the teachers. She failed to name many of the students when asking questions but rather used this signalling technique to identify the student to answer the question. This was seen to be a condescending practice for indigenous students in particular but also by many of the participants for students in general. The demeanor the teacher in using this action was seen as one as aloof and hence unapproachable to some students.

The use of questions to set the context for the lesson was also seen to be problematic for indigenous and working-class students. The teacher used very open questions that were meant to arouse curiosity in the students. However, the focus group participants saw this as being highly problematic for these students. In their experiences, they had found overwhelmingly that it was far more productive for the students to be given explicit directions or opening statements so that the students could identify early in the lesson as to its purpose. By using open or vague introductions so that the purpose was not clear, many of the students would be lost as to what the lesson was about. Hence, setting the context for the lesson was important at the beginning and that this is made clear from the onset. This is not meant to say that the introductions were to be boring and highly structured, only that there needed to be clarity in the focus. In part, this reinforces the work of Cooper and Dunne (1999) cited earlier on the basis of the Bernstein's recontextualisation. By providing vague introductions, students from disadvantaged backgrounds may experience difficulties in the recontextualisation of the teacher dialogue – in this case using the police lineup to introduce a lesson on finding average heights. In this case, it

is possible that the students have contextualised the lesson as being about police and policing rather than mathematical with its emphasis on lengths. Thus the recontextualizing of length in to a context of police serves to send the students off into a tangential practice rather than focusing them on a mathematical discourse.

The use of open-ended tasks is gaining considerable emphasis as a tool for engaging students and allowing students to respond in ways that give a fair representation of their understandings. This was also identified as a potential cause for difficulties for our target groups of students. Educators in the focus groups saw this type of questioning as one that created difficulties for the students on the basis that many students get frustrated with the notion that in mathematics there can be a number of “correct” responses for a question. Again, this practice suggests that changing the dynamics of what is seen to be “normal” mathematical practice – where there is a “right” or “wrong” answer in mathematics creates particular difficulties for students. Their experiences of school mathematics have created particular expectations and norms for classroom practices and the use of open-ended tasks potentially violates these norms, thereby creating difficulties in understanding the changed demands.

## **Conclusion**

The focus groups in this project identified practices within a video excerpt from a lesson as potentially problematic for students based on the social and mathematical norms implicit in the lesson. Many of the norms identified were seen to create barriers for effective participation of the students. Using the theoretical tools offered by the writings of Bernstein, it becomes possible to theorize the ways in which the context of the lesson becomes an obstacle for many students. Using the notion of context in very broad terms – where the context set by the teacher through the use of particular stimuli (in this case a poster) or through the use of questioning where the interactional context was established – it becomes possible to see the ways in which particular norms are represented through the pedagogical relay in school mathematics. In this case, social norms in terms of morals, values and interactions can be unpacked to identify how they work against the successful participation and engagement of some students.

The approach taken in this paper sought to understand the ways in which practices in school mathematics are recontextualized so as to effectively disguise the goals of the mathematical discourses and thereby creating an obstacle for working-class and indigenous students to overcome in order to be able to participate in the interactions.

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