Rich Mathematical Tasks in the *Maths in the Kimberley* (MITK) Project

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Rich mathematical tasks are central to the pedagogy that underpins the MITK project. In this paper I present and discuss the characteristics of rich tasks as we have defined them in the project. Activities that have the qualities outlined here can provide the 'tools' for teachers to develop their pedagogy so that deep mathematical learning is promoted for all.

Overview

In this symposium we will discuss four aspects of the pedagogy that underpins the MITK project. The project is based in six schools in the remote Kimberley region with the express intention of enhancing the mathematical learning for Indigenous students in these communities. Over three years, the project will investigate, implement and evaluate particular strategies that are likely to enhance the learning of mathematics. The four papers in this symposium each focus on one aspect of the range of pedagogical components of the MITK project (for further details see Zevenbergen, Niesche, Grootenboer, & Boaler, 2008).

Introduction

A central and critical component of the pedagogy that underpins the MITK project are the tasks and activities that make-up the mathematics lessons. The importance of rich mathematical tasks is not new, as was highlighted, for example, many years ago by Afzal Ahmed (1987) in his ground-breaking work in the UK. Furthermore, the ideas about what constitutes a rich mathematical task here are not radically new, but rather we have drawn on the wealth of research-based knowledge that already exists, in particular aspects of Boaler's work at Railside (2008; Boaler & Staples, 2008) and the *productive pedagogies* that were developed from the Queensland study of schooling (Lingard, et al., 2001). We have rested upon these projects because they had a strong emphasis on pedagogy that caters for diversity and promotes equity. The development and use of rich mathematical tasks is pivotal to the pedagogy of the project, but we are aware that they can only "provide a set of constraints and affordances", and it is in the implementation "that the learning opportunities [are] realised" (Boaler & Staples, 2008, p. 627-628).

In this paper I will briefly outline and discuss the characteristics of rich mathematical tasks as we have defined them in the MITK project pedagogy.

Characteristics of Rich Mathematical Tasks

The term 'rich task' was employed as a central platform in the *New Basics* program that emerged from the Queensland longitudinal study (Lingard, et al., 2001). In the New Basics, a rich task was seen as a substantive, transdisciplinary problem that would "require students to analyse, theorise and engage intellectually with the world" (Education Queensland, 2001, p. 5). Such a task would have intellectual depth and educational value, and it would require a significant amount of time to complete. In the New Basics program

the Rich Tasks were largely used for assessment purposes and they were not limited to mathematical learning. Boaler's work at Railside School had a particular focus on mathematics education, and in this project there was a strong emphasis on mathematical problems that were "groupworthy" (Boaler & Staples, 2008, p. 627), meaning that they not only had to be substantially mathematical, but they also had to have opportunities for multiple representations, multiple solution pathways, and require the shared resources of the collective. Drawing upon these two seminal works, the key aspects of rich mathematical tasks in the MITK pedagogy include:

- Academic and intellectual quality
- Group work
- Extended engagement
- Catering for diversity through multiple entry points, multiple solution pathways
- Connectedness
- Multi-representational

Academic and Intellectual Quality

Rich mathematical tasks will have academic and intellectual quality because they facilitate deep mathematical learning (Zevenbergen & Niesche, 2008). These sorts of tasks require students to work mathematically by inviting them to rationalise and make conjectures, to hypothesize and then test their ideas, and to justify their findings and represent them in meaningful ways. In short, these are the activities of mathematicians that are central to mathematical practice, and as such, are essential for a task to be deemed appropriate for mathematical pedagogy (Burton, 2004).

Boaler and Staples (2008) noted that students in their Railside study, whose mathematical program largely consisted of tasks with academic and intellectual integrity;

> regarded mathematical success much more broadly than students in … traditional classes, and instead of viewing mathematics as a set of methods that they needed to observe and remember, they regarded mathematics as a way of working with many different dimensions. (p. 629)

By employing rich tasks that are dense with mathematical knowledge and processes, the students at Railside not only performed well in standard formal assessments, but they also developed a robust mathematical identity that would engender a positive attitude towards continued mathematical participation and engagement.

It is worth noting that Freedman, Delp, and Crawford (2005) found in their study into issues of equity in teaching English, that having culturally sensitive materials was not a prerequisite quality of appropriate tasks. However, they also noted that it is important that tasks that were challenging academically for the students.

Group Work

Opportunities for students to work collaboratively in groups are integral to rich mathematical tasks in the MITK pedagogy. Effective group work allows students opportunities for students to develop deep understanding through substantive conversations. (Group work is discussed in more detail by Jorgenson later in this symposium).

Extended Engagement

If students are going to develop deep and robust mathematical knowledge by engaging in tasks that have academic and intellectual integrity, then the tasks need to be prolonged in

nature. In both the productive pedagogies and the Railside project, the tasks required extended time and energy, and students were required to persevere on a task. Indeed, at Railside class periods were 90-minutes so extended engagement could be facilitated. Schoenfeld (1992) noted the folly of trying to develop mathematical thinking by giving students multiple questions to complete in a brief period of time (e.g., 30 exercises in 60 minutes). The unspoken, but pervasive message is that each question should take you no more than a minute or two, and the task is to finish them as quickly as possible. Extended engagement not only allows for richer mathematical outcomes for the students, but it also promotes the development of personal qualities such resilience and perseverance.

Connectedness

In the New Basics program the rich tasks were required to be transdiciplinary, and while our focus is primarily on mathematics, we also see connectedness as important. In the pedagogy of the MITK project, the mathematical activities should first of all, link and build upon students' background knowledge and experience – both mathematical and more generally. To this end, it is important that teachers know and understand their students (Grootenboer & Zevenbergen, 2008). Further, the tasks should connect with other mathematical concepts and ideas, and again, this allows students to build robust mathematical knowledge thus adding intellectual and academic quality. In this way students avoid building siloed and disconnected connected mathematical knowledge. Tasks that are problem-based can also link in meaningful ways to other discipline areas and the 'real world'. This sort of connection allows learners to see the ubiquitous and utilitarian value of mathematics and build enabling numeracy practices.

Cater for Diversity

A rich mathematical task must cater for a range of students in terms of previous mathematical achievement and interest, and different ways of thinking, learning and working mathematically. This means that tasks must have multiple entry points and multiple solution pathways (Freedman, et al., 2005). Tasks with these qualities not only cater for a range of students, but they also enhance the intellectual quality of the afforded learning by requiring students to analyse and evaluate the alternatives presented in their group.

Multi-representational

Finally, rich tasks also need to be multi-representational so students can express their mathematical ideas in ways that are appropriate for their solution path and context, and that suit the individual and/or the group. As was pre-empted in the discussion of diversity, students can extend and enrich their mathematical understanding by experiencing a range of representations of the mathematical ideas that are embedded in a rich task. In the Railside project tasks that allowed for multiple representations were seen as critical by the participating teachers and the researchers.

> At Railside, the teachers created multidimensional classes by valuing many dimensions of mathematical work. This was achieved, in part, by implementing open problems that students could solve in different ways. The teachers valued different methods and solution paths and this enabled more students to contribute ideas and feel valued. (Boaler & Staples, 2008, p. 629)

The desire for multiple representations does not imply that all are equal in value, but when they are shared there are opportunities for discussions about the limitations, merit, and elegance of each representation.

Concluding Comments

The sourcing and/or development of rich mathematical tasks are essential to the development of the pedagogical approach employed in the MITK project. However, they are not alone sufficient, as the teacher is the key critical component (Hayes, Mills, Christie, & Lingard, 2006). Therefore, while attention is paid to the nature of the mathematical tasks in the project, the central focus is on teacher professional development.

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