

Commentary: Problem Solving for the 21st Century

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Introduction

In a book that focuses on advances in mathematics education, it is essential that there is a chapter that focus on problem solving, because problem solving has been one of the prominent phenomenon in the development of mathematics teaching and learning. This chapter by English and Sriraman is a seminal piece of work because it provides a critical and thoughtful review of the history of problem solving that avoids idealising and valorising the value and impact it has had in mathematics education without diminishing its enduring importance. After affirming the crucial nature of problem solving for mathematics education and simultaneously discussing the disappointing limited influence it has had, the authors have provided avenues for further development. In particular, the focus on mathematical modelling as an integral part of the mathematics curriculum was valuable as it provided well-considered direction for research. This research-based discussion is timely and provides an important discussion of the topic that will ground future research and development. A broad range of research reports have been discussed and the extensive reference list is indicative of the comprehensive nature of the chapter.

In this commentary I have not tried to cover all the material in the chapter. Rather, I have focussed on some features that struck me as being particularly pertinent or fascinating. In this sense, this commentary is quite subjective and in no way comprehensive. The comments made here centre on three themes: (1) complexity; (2)

mathematical modelling; and (3) future directions. While these themes are inter-related, they are discussed in turn.

Complexity

A feature of the chapter is the consideration of the complexity of problem solving in mathematics education. Through their overview of the history of research into problem solving, the authors were able to show that researchers have gradually taken greater account of the complexity of problem solving in mathematics education, and as such the 'usefulness' of their findings have been increasingly valuable. We know that learning in general is very complex, and acknowledgement of this complexity is critical to advance our understanding of problem solving.

There is a difference between complex and complicated phenomenon. A complex phenomenon is one where the component parts are intimately intertwined such that if you pull them apart they lack meaning and you cannot put them back together.

Something that is complicated may be intricate, but its component parts can be separated, studied, and reassembled without damage. A motor could be considered complicated, but a human being is complex. Complex phenomena are constituted by an intricate web of mutually specifying relationships, and as such they need to be studied in the richness of their complexity because to study them otherwise would change their nature and diminish the meaning of the findings (Waldrop, 1992).

Of course, it is not possible to study learning (or any other complex phenomenon) in the fullness of their complexity. Researchers have to focus the lens of inquiry at some level, and in the process some aspects of the complex phenomenon will be ignored,

thus diminished the very nature of what is being examined. Perhaps then, the issue here in educational research is deciding at what level can a complex learning situation be examined in a meaningful way? What is a 'meaningful chunk' to research so the findings are worthwhile and resonate with the phenomenon in all its complexity? Where on the continuum from simple to complex should the researcher focus the lens of inquiry?

The history of research provided in this chapter shows clearly how initial studies explored problem solving as a relatively simple (i.e., not complex). This was appropriate because it enabled mathematics educators in these early days to develop a broad understanding of this new field. However, as was obvious in the chapter, the findings did not provide the educational benefits that were envisaged. As research into problem solving matured it took into account a more complex perspective by including broader factors like affective qualities and the social context, and later, inter-disciplinarity. This later research does not negate the previous work, but rather it builds upon it by providing a richer and more fulsome understanding of problem solving in mathematics education. The more recent research has provided a more perceptive and complex understanding of problem solving, but this does not mean the findings have been more useful in practice. A challenge that now faces mathematics education researchers and mathematics teachers is translating these findings into improved classroom practice for better student outcomes.

Mathematical Modelling

English and Sriraman commit a significant portion of their chapter to considering the challenge of improved student outcomes by discussing and promoting mathematical

modelling. Problems that demand mathematical modelling are not neat and tidy, sanitized of all extraneous information, or constructed so all the required information is clear and readily available. In short – these problems are more ‘real-life’ and complex. Thus, they have shown that while research needs to engage with problem solving as a complex phenomenon, so they have also suggesting that problem solving in the classroom also needs to be based on more complex problems.

A key point of the discussion of mathematical modelling was its appropriateness for all levels of schooling and examples were included from a range of school levels. Thus, while mathematical modelling allows for a more complex understanding of problem solving with more complex problems, it does not necessarily demand a higher level of mathematical knowledge. The traditional view of mathematics education sees students stair-casing their way up a well-structured developmental sequence of mathematical concepts which culminates at any particular level with the application questions (which are usually the extension questions at the end of the textbook chapter or the last ‘challenging question’ on the test). While there is a significant body of research that supports a developmental approach to mathematical ideas, English and Sriraman make it clear that problem solving, and in particular mathematical modelling, should be used at all levels of students’ mathematics education and with all students – not just for extension work for the gifted, talented or ‘fast’.

An extended example was discussed in the chapter and it insightfully showed how modelling can be introduced in the classroom to produce positive mathematical outcomes. The task, which focussed on the ‘First Fleet’ to arrive in New South Wales

in Australia, required students to make decisions about the best site for settlement based on judgments made from mathematical models developed from the supplied data. The decisions they made were grounded in objective and subjective reasons as they explored the complex 'real-life' situation. It was clear that the task drew on a range of information and it was complex and loosely defined.

As I read the account of the activity, it seemed to me that there were opportunities to enhance the authenticity of the task by drawing the lens a little wider to include a greater level of complexity and to ameliorate the Western hegemonic perspective of history. The First Fleet did not arrive to an uninhabited land and the possible settlement sites included in the activity had a rich and prolonged history of Indigenous Australian life. The arrival of the First Fleet drastically changed the world of people from Indigenous Australian nations and it is consideration of this data that could be included in the activity. In this way, students could not only appreciate the situation from the British settlers' perspective and the impact on their lives, but they could also appreciate and consider the impact on the existing custodians of the land. At least, the settlers would need to consider some sort of strategy to 'take-over' the land, but hopefully the students would be able to empathise with the physical and social ramifications of colonisation for Indigenous Australians. Mathematical modelling that would account for this added dimension is certainly more complex, but without this consideration the veracity of the model is limited because such an important component is ignored.

Future Directions

The chapter provides a thorough and comprehensive review of the research literature on problem solving in mathematics education and it highlighted the more complex approach that has emerged as the field has matured. However, what did strike me was the apparent narrow range of communities represented in the research in this area. For example, there appeared to be little research into the problem solving with students from Indigenous or educationally disadvantaged communities or cultures that do not engage in a largely Western view of mathematics. The authors have rightly highlighted the more recent acknowledgement of the social dimension of mathematics education in problem solving, and as research into the field continues to mature and grow, it appears that it is timely to broaden the nature of the participant groups engaged in this research.

The seminal work of Boaler (1997; Boaler & Staples, 2008) with disadvantaged students in both the US and the UK could provide some insight because, while her studies didn't focus particularly on problem solving per se, the use of rich mathematical tasks were integral. These tasks seemed to involve problem solving and aspects of mathematical modelling including multi-disciplinarity and multiple pathways. Her studies showed that pedagogy based on rich mathematical tasks produced improved outcomes, even in traditional external mathematics testing. This large body of work may assist in moving research and development ahead by providing insight into mathematical pedagogy associated with problem solving.

The pedagogy that was promoted by Boaler had several key features including:

- rich tasks with multiple entry points and pathways;
- group work with defined roles;

- quality interactions;
- the teacher as facilitator;
- the use of home language; and
- multi-representational.

This pedagogy required students to engage deeply with mathematical concepts and ideas through rich problem solving tasks through group work. Students were encouraged to interact and negotiate meaning in their first language, while still being required to report their findings in the dominant language (English). Also, the teacher's role was to scaffold the students' mathematical thinking and learning through keeping them on task and raising deep, open question.

The chapter by English and Sriraman clearly shows that problem solving is integral to effective mathematics education. However, the benefits of reforms in mathematics education based on problem solving have not been as successful as expected. Perhaps the work of Boaler indicates that what is required is a reformed pedagogy alongside a problem solving curriculum that includes mathematical modelling. Boaler's (2002) studies showed that significantly improved results can be achieved for disadvantaged learners, and it may be that this sort of pedagogy is good for all students. However, it is important to note that despite the wealth of research support for a mathematics curriculum based on problem solving and mathematical modelling, and reformed notions of pedagogy, wide-spread changes in mathematics education have not been achieved. So the enduring issue remains about how to translate the significant findings outlined in this chapter into mainstream classroom practice. While teacher development and classroom practice are not the particular foci of this chapter, it

seems to me that these concerns will hinder the development of problem solving and therefore, they require the attention of researchers and mathematics educators.

Concluding Comments

For many years now ‘problem solving’ has been a central theme of research and development in mathematics education. This chapter provides a timely ‘stake in the sand’ by looking backwards and looking forwards. By looking in the ‘rear-view mirror’ English and Sriraman provide a critical and honest evaluation of problem solving over more than 50 years and its limited impact on mathematics education. This review was necessary so the authors could then look ahead and discuss “problem solving for the 21st century”. Indeed, the argument for greater emphasis on mathematical modelling was compelling and was well illustrated by appropriate classroom examples. An emphasis on mathematical modelling in the curriculum will provide students with more authentic mathematical experiences and promote deeper thinking and problem solving, and this seems as important as it ever has been given our data-dense society.

References

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