The intent and processes of a professional learning initiative seeking to foster discussion around innovative approaches to teaching

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The following outlines the rationale and structure of a professional learning initiative that seeks to explore teachers' ways of engaging students more actively in building mathematical connections for themselves. An example of one of the suggested experiences is presented.

Introduction

The following describes the rationale and processes of a professional learning initiative that offered specific suggestions for the teaching of geometric reasoning (mainly angles) and to foster discussion around the experience. The intention was that the suggestions require students to persist with tasks for some time so that they have opportunity to engage with the specific content for themselves prior to instruction from the teacher.

The initiative built on previous similar interventions the results of which were explained to participating teachers. For example, Sullivan, Clarke, Cheeseman, Mornane, Roche, Sawatzki, and Walker (2014) argued that not only do students not fear challenges in mathematics, many welcome them (see also Dweck, 2000). Further, rather than preferring teachers to instruct them on solution methods, students prefer to work out solutions and representations for themselves. The earlier result that students learn substantive mathematics content from working on challenging tasks prior to instruction and are willing and able to develop ways of explaining their reasoning was explained. Similarly there was discussion of the findings from Sullivan, Askew, Cheeseman, Clarke, Mornane, Roche, and Walker (2014) who concluded that teachers welcome not only the suggested lesson structure but also the ways that the suggestions are presented.

There were two professional learning days for this, one before the start of the teaching and one after. As part of the professional learning, the rationale for posing challenging tasks was explained. The assumption, that students learn mathematics best if they engage in building connections between mathematical ideas for themselves at the start of a sequence of learning rather than at the end, was also presented.

The project titled Encouraging Persistence Maintaining Challenge was funded through an Australian Research Council Discovery Grant (DP110101027). We are studying the type of tasks that can be used to prompt this learning and the ways that those tasks can be optimally used, one aspect of which is communicating to students that this type of learning requires persistence on their part. Essentially the notion is for teachers to pose problems that the students do not yet know how to solve and to support them in coming to find a solution. In general, it was explained that the principles informing the design of the tasks were that students would have the opportunities to:

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- engage with important mathematical ideas that are central to the curriculum;
- plan their approach for themselves, especially sequencing more than one step;
- process multiple pieces of information, with an expectation that they build connections between those pieces, and see the concepts in new ways;
- choose their own strategies, goals, and level of accessing the task;
- spend time on the task, persisting if the task seems difficult, and record their thinking; and
- explain their strategies and justify their thinking to the teacher and other students.

Teachers were provided with a booklet containing nine sequential task and lesson suggestions, for which the focus is illustrated the following titles:

Suggestion 1: Angles that are more, the same or less than a right angle

Suggestion 2: Connecting shapes and angles

Suggestion 3: Angles on clocks

Suggestion 4: Working out the size of angles

Suggestion 5: Angles and compass bearings

Suggestion 6: Comparing angles to see which are the same and which are different.

Suggestion 7: Working out the size of angles in triangles

Suggestion 8: Working out the size of angles in quadrilaterals

Suggestion 9: Angles and parallel lines

While the task and lesson suggestions are suitable for a range of levels (e.g., in Australia, suggestion 1 might be accessible by year 2 students, and suggestion 9 focuses on conventional year 7 content), the project teachers were mainly teaching in years 4, 5 and 6 (years 5,6 and 7 in New Zealand). The task and lesson suggestions were not intended to represent everything a teacher might teach at a given level, but to augment existing programs in productive ways..

The provision of specific resources in this way is somewhat unusual in that it can be interpreted as "spoon feeding" the teachers. Our experience, though, is quite contrary to this in that we have found that teachers welcome the suggestions. We suspect that this is partly because this aspect of the curriculum, geometric reasoning, is unfamiliar to some teachers. We have also found that it offers a less threatening way for teachers to experiment with different pedagogies in that they have less ownership of the tasks and lessons and so the risk of failure is lower.

Teachers met either in teams or with a researcher before teaching the suggested tasks and lessons (to plan); during (to discuss progress); and after the teaching (to evaluate).

The rationale for the particular lesson structure proposed was elaborated by Sullivan, Walker, Borcek, and Rennie (2015). In all of the lessons there is more than one challenging task suggested. In some lessons there is an introductory task suggested to help students understand the first task. Generally, the introduction is intended to check the familiarity of the students with language and representations.

In each lesson there is a "consolidating" task that is posed subsequent to the discussion of the first task. The intention is that, having engaged with the first task, and listened to the successful strategies of others, students can then engage productively with the second task. Responses to this second task provide a better indication of what students know when compared to their responses on the first task.

One major difference between the lessons suggested and conventional teaching is that quite few tasks are involved. This accurately models processes with practical mathematical problems in which there is only one problem to solve, the problem is complex, and accuracy is important.

Research questions and data collected

This initiative examined the following questions:

What is the nature of lesson sequences that effectively incorporate challenging tasks?

What information can support teachers in planning these lesson sequences?

To what extent do students learn the mathematical concepts and processes when working through these sequences?

Students were invited to complete an on-line pre-test containing both fixed format and open response items, including some attitudinal items, to determine base line knowledge. Similar items were posed in a post test and schools were sent summarized and individual students' results on both pre and post test. The intent was that the pre-test results would inform the teaching emphases and the post-test results would assist in reflection.

Teachers also completed surveys seeking information on their usual pedagogical practices and their evaluations of the task and task sequences.

An illustrative example

The following is an abbreviated summary of information provided to teachers around Suggestion 3. The suggestions overall involve posing questions like the following and expecting students to develop their own approaches to the tasks:

The minute hand of a clock is on 2, and the hands make an acute angle. What might be the time?

Even though apparently complex, the task addresses two aspects of the curriculum in both Australia and New Zealand. A second consideration is the ways that the task activates the thinking of students. There are three ways that this happens:

- the task focuses the attention of the students onto two aspect of mathematics together, specifically time and angles: contrasting two concepts helps students see connections and move beyond approaching mathematics as a collection of isolated facts;
- the task has more than one correct answer: having more than one correct answer allows students opportunities to make decisions about their own response and then have something unique to contribute to discussions with other students subsequently;
- students can respond at different levels of sophistication: some students might find just one answer, while other students might find all of the possibilities and formulate generalisations.

The task can be described as appropriately challenging in that the solutions and solution pathways are not immediately obvious for middle primary students but the task draws on ideas with which they are familiar. An explicit advantage of posing such challenging tasks is that the need for students to apply themselves and persist is obvious to the students, even if the task seems daunting initially.

After the students have worked on the task for a time, the teacher manages a discussion in which carefully selected students share insights. This is an important opportunity to see solution strategies of other students, and especially to realise that in many cases there are multiple ways of solving mathematics problems. At this stage of the lesson, we recommend to teachers that they use a document camera or some similar technology to project students' actual work. This has the advantages of saving time in comparison with rewriting the work, it presents the students' work authentically, and it illustrates to students the benefits of writing clearly and explaining thinking fully. It also makes explicit that the creation of knowledge is a shared responsibility and is not the province of the teacher alone.

Subsequently, the teacher poses a further task in which some aspects are kept the same and some aspects changed, such as:

> The minute hand of a clock is on 8, and the hands make an obtuse angle. What might be the time?

The intention is that students learn from the thinking activated by working on the first task and from the class discussion, and then apply that learning to the second task. In other words, the students move from "not knowing" to "knowing".

A key way that the suggestions are different from many recommended approaches is that the differentiation of the tasks for different students is made explicit. For example, there may be some students who struggle disproportionally with the first task. Those students might be asked to work on a prompt like:

> What is a time at which the hands of a clock make an acute angle?

This has the advantage that it is similar to the first task but is less complex in that there is only one response expected and the constraint of the minute hand is removed. The intention is that those students, after solving this alternate task, then engage with the original task. Of course, there are also students who can find answers quickly and are then ready for further challenges. Those students might be posed questions like:

> Why are there six times for which the hands make an acute angle? Is there a number to which the minute hand might point for which there are not six possibilities?

Interestingly, we have found that there are students for whom even the initial task is not challenging. Such students can create challenges for the teachers once they are finished.

The combination of the students' responses to the task and the different levels of prompts ensure that students' work samples contain rich and useful information that teachers can use to give the students feedback and to plan subsequent learning experiences.

On a final survey, teachers gave this lesson a very high rating for the extent to which students persisted, only slight less so for their learning, and very high rating for a commitment to using the lesson again in the future.

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