Encouraging students to persist when working on challenging tasks

Some insights from teachers

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The Encouraging Persistence Maintaining Challenge (EMPC) Project has been working with secondary teachers in Melbourne as they seek to build persistence in students, during work on challenging mathematics tasks. We have developed sequences of tasks in various topic areas for Years 7 and 8, which require students to connect different aspects of mathematics, to devise solution strategies for themselves and to explore more than one pathway to solutions. There is an expectation that students record the steps in their solutions, and justify their thinking to the teacher and other students. We have surveyed teachers on their strategies for encouraging student persistence, before and after the experience of teaching some challenging tasks which we have provided to them. In this article, we provide examples of the kinds of challenging tasks our teachers are using with students, and share teacher insights on helpful strategies.

Introduction

It is important for students to learn mathematics, but currently too many miss out on the opportunities that successful learning creates (Kilpatrick, Swafford & Findell, 2001; Thomson, Hillman & Wernert (2012). While it is possible for everyone to learn mathematics, it takes concentration and effort over an extended period of time to build the connections between topics, to understand the coherence of mathematical ideas, and to be able to transfer learning to practical contexts and new topics (Sullivan, 2011). We use the term *persistence* to describe the category of student actions that include concentrating, applying themselves, believing that they can succeed, and making an effort to learn, and we term the tasks that are likely to foster such actions *challenging*, in that they allow the possibility of sustained thinking, decision making, and some risk taking by the students.

The notion of persistence is encapsulated in widely used principles of effective teaching that recommend that teachers communicate high expectations to students, which involves posing challenging tasks, and adopting associated pedagogies such as encouraging students to take risks in their learning, to justify their thinking, to make decisions, and to work with other students (Stein, Smith, Henningsen & Silver, 2009; Sullivan, 2011).

The authors of the TIMSS video study of Year 8 classrooms noted that "Australian students would benefit from more exposure to less repetitive, higher-level problems, more discussion of alternative solutions, and more opportunity to explain their thinking." They noted that "there is an over-emphasis on 'correct' use of the 'correct' procedure to obtain 'the' correct answer. Opportunities for students to appreciate connections between mathematical ideas and to understand the mathematics behind the problems they are working on are rare." They noted "a syndrome of shallow teaching, where students are asked to follow procedures without reasons" (Hollingsworth, Lokan & McCrae, 2003, p. xxi).

Yet two concurrent projects with which we have been involved in recent years found that, on one hand, teachers seemed reluctant to pose challenging tasks to students and, on the other hand, students seemed to resist engaging with those tasks, and exerted both passive and active pressure on teachers to over-explain tasks or to pose simpler ones (Sullivan, Clarke & Clarke, 2013).

Challenging tasks are important for *all* students. Pogrow (1988) warned that by protecting the self-image of under-achieving students through giving them only "simple, dull material" (p. 84), teachers actually prevent them from developing self-confidence. He maintained that it is only through success on complex tasks that are valued by the students and teachers that such students can achieve confidence in their abilities. There will be an inevitable period of struggling while the students begin to grapple with problems but Pogrow asserted that this 'controlled floundering' is essential for students to begin to think at higher levels.

Our project

The *Encouraging Persistence Maintaining Challenge* project[1] (EPMC) is researching a range of issues, including the kinds of teacher practice which might encourage students to persist when working on challenging tasks in mathematics. The EPMC is a collaborative project involving university researchers and classroom teachers in Victorian schools. Although the project has involved teachers and students across Years 4 to 8, only the secondary part of the project will be discussed here. Further information on the primary aspects of the project can be found in Roche, Clarke, Sullivan, and Cheeseman (2013).

The timing of this project is important in light of the current implementation of the *Australian Curriculum: Mathematics* (AC:M, 2013), and, in particular, with the focus on the reasoning proficiency, one of four proficiencies, the others being understanding, fluency, and problem solving. We believe that the challenging tasks discussed in this article lend themselves to students developing and using reasoning in a variety of ways.

1 The *Encouraging Persistence Maintaining Challenge* project is funded through an Australian Research Council Discovery Project (DP110101027), and is a collaboration between the authors and their universities.

The major research question of relevance to this paper is: What strategies on the part of the teacher (during planning and teaching) can support students to persist when working on challenging tasks?

Fifty-seven primary and secondary teachers met with the project team in February 2013, typically with four or five teachers coming from each school. An overview of the project was given, and teachers were provided with ten challenging tasks, in the form of detailed lesson notes. For the secondary teachers, the focus was on tasks involving the content areas of perimeter, area and volume, at Years 7 and 8. All lessons were written using the structure shown in Appendix 1 for the lesson, *One Hectare Park*. Feedback from teachers to date indicates that the sections in this structure appear to be helpful, and that the lesson notes are about the right length.

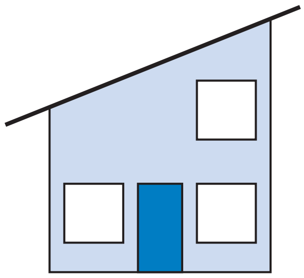
At different points in the project, we have collected information from teachers on their experiences. Prior to and after teaching the tasks, we sought teacher perceptions on strategies to encourage persistence on challenging tasks.

Examples of our challenging tasks

Each lesson has what we have come to call a *main task*, and is often accompanied by an *introductory task* and *consolidating tasks*. An important feature of the documentation is the inclusion of *enabling prompts* (for students who have difficulty making a start on the main task) and *extending prompts* (for students who find the main task quite straightforward).

To give a further sense of the kinds of tasks in these lessons, we include the main task from two other lessons:

- The volume of a rectangular prism is 600 cm^3. What might be the surface area?
- Some websites say that 1 mm of rain on 1 m^2 of roof is 1 L of water. The roof of a building is 12 m long and 6 m wide. Assume that 60 mm of rain falls each month. Design a tank, in the shape of a rectangular prism (like this one), that could hold that amount of rain water for one month. 1 L is the same as 10 cm × 10 cm × 10 cm. 1000 L is 1 m^3.



Following the first two day meeting in February, teachers were asked to teach as many of these ten tasks as possible, before returning to share their experiences and student work samples with the larger group in June. Teachers were discouraged from telling the students how to solve the problems, and asked to ensure that students had plenty of time to work on the tasks.

Insights from secondary teachers

In February, before any professional learning input from the research team and the opportunity to trial challenging tasks, teachers were asked to respond to a question, framed as follows:

> Sometimes when students struggle with a mathematics task, they choose not to persist. What kinds of things do you believe a teacher could do in the planning stage of a lesson and during the lesson that would help those students to persist? *Please record as many as you can.*
> In the planning stage, teachers could …
> During the lesson, teachers could …

Teachers were given seven lines for each stem, with a verbal encouragement to put one thought on each line, for as many of the lines as they wished to complete. Twenty secondary teachers responded with 94 suggestions for

Table 1. Most common strategies in the planning stage for encouraging persistence on challenging tasks.

Strategy for the planning stage	**Number of comments**	**Percentage of all comments (n=94)**	**Sample comments**
Differentiation	18	19.1%	• Plan according to their level • Have extensions for those who get it easily • Plan for different abilities
Nature of tasks	13	13.8%	• Use open-ended tasks so that each student can start • Use games that require skill but chance element means all can safely attempt • Choose tasks that connect to students' lives, culture
Teacher knowledge of students	11	11.7%	• Identify students who may struggle • Investigate data available to get to know the students • Plan tasks that link to students' prior knowledge
Explicit teaching	11	11.7%	• Use examples beforehand in class that have similar approaches to those that could be used for the task • Brainstorming a range of ways of approaching a problem before starting on the task • Provide terminology/definitions

Table 2. Most common strategies during the lesson for encouraging persistence on challenging tasks.

Strategy for during the lesson	**Number of comments**	**Percentage of all comments (n=88)**	**Sample comments**
Discussion/questioning/sharing	23	26.1%	• Allow for individual discussion to allow students to clarify thoughts • Have a student explain their thinking • Support students by asking questions
Explicit teaching	18o	20.5%	• Redefine the procedure to individuals/ whole class if necessary • Assist with basic skills • Provide them with more explanation to help their understanding
Differentiation	13	14.8%	• Assist and show students how to do a question and sit with them to give them support for the next one(s) • Try explaining in another way for strugglers • Intervene where necessary to extend or enable
Teacher enthusiasm/encouragement	5	5.6%	• Encourage students to persist through positive language • Encourage students to begin and have a go • Embrace and acknowledge attempts

the planning stage and 88 suggestions for during the lesson, an average of 4.7 and 4.4 respectively per teacher. These were grouped into categories by two members of the research team. In Tables 1 and 2, the most frequently occurring categories are listed, with sample comments to elaborate the kinds of responses for each category, for the planning stage, and during the lesson, respectively.

It is clear that the categories are not necessarily mutually exclusive, and that distinguishing the 'planning stage' from the 'during the lesson stage' was not clear cut for some teachers. The major differences in comments between the two stages were the emphasis on careful choice of tasks in the planning stage, and discussion and questioning during the lesson to support students with challenging tasks.

Secondary teachers' insights after teaching up to ten tasks

In June, following the chance to try out up to 10 challenging tasks, two different prompts were given, as follows:

> In this project, you have trialled a number of challenging mathematics tasks and encouraged students to persist when working on them. We are interested in what you believe is the most important change in your practice that contributes to students persisting, both in the planning stage and during the lesson.
>
> 1. In terms of your planning: please describe *one* aspect of your planning for these lessons that is *different from the way you planned previously*, and which you believe has helped some students to persist.
> 2. In terms of your teaching: please describe *one* aspect of your teaching behaviour during the lessons, that is *different from the way you taught previously*, and which you believe has helped some students to persist.

The teachers were given a verbal encouragement to provide only one thought, that is, their *most important change in practice* that was different from the way they planned and taught previously. Fifteen secondary teachers responded, each providing one comment, although some of these comments were coded into two or more categories, when two somewhat distinct thoughts were contained in the one statement. Once again, these were grouped into categories by two members of the research team.

Table 3. Most common new strategies in the planning stage for encouraging persistence.

Strategy in the planning stage	Number of teachers out of 15	Sample comments
Differentiation	8	• Planning for enabling prompts • Having the enabling prompt and extending prompt ready to go • Planned a whole range of enabling prompts particularly physical manipulatives
Solving the task	2	• I worked through the tasks completely before teaching • I completed each task before taught—consciously trying to do so in multiple ways to predict student approaches

Table 4. Most common new strategies during the lesson for encouraging persistence.

Strategy during the lesson	Number of teachers out of 15	Sample comments
Holding back from telling	5	• I am a facilitator of the students thinking, more teaching 'behind' than a teacher of explicit and closed activities • Not giving in and telling them—instead giving hints and questioning students when they are stuck • I have changed from helping the students to encouraging their thinking. The students are then going back to try and work through [the task]
Think time	2	• The launch phase—asking students to work in silence for the first five minutes • Use the 1–5 minute individual think time more consistently now

In Tables 3 and 4, the most frequently occurring category is listed, with sample comments to elaborate the kinds of responses for this category, for the planning stage and during the lesson, respectively. Only two categories are mentioned in each case, because the request for just one response led to the number of responses being small.

Discussion

In the initial survey in February, some teachers mentioned the use of enabling and extending prompts, but by June, after the experience of using the lessons which contained them, not surprisingly, there was a greater emphasis on this strategy. Two teachers mentioned that solving the tasks prior to teaching the lesson was the most important change to their practice in the planning stage. However, no teacher mentioned this in February.

In the February survey, no teacher made a comment that they should hold back from telling or hold back from explicitly teaching, but this was implied in a number of the comments in June. Also, only one teacher in February commented that giving students time to think was helpful. In the June survey however, 7 out of the 15 teachers suggested the most important change in their practice during the lesson was doing one of these two things.

Although not among the most frequent comments, during focus group discussions in June, several teachers mentioned the importance of clarifying new terms to students. In the case of the *One Hectare Park* lesson (see Appendix), for example, teachers indicated that this was an example of one of the times when clarification or the provision of a definition is a requirement for students to genuinely engage with the mathematics. Two such terms were 'hectare' and 'internal angles'. Jackson, Garrison, Wilson, Gibbons and Shahan (2013) emphasised the importance during the 'setup' of lessons of developing a common language, as this was directly related to the opportunities for students to learn during concluding whole class discussions.

Teachers also indicated that they sought to introduce a more personal context to some tasks. One teacher used Google maps to investigate the question: "How big is our school in area?" as a means of clarifying the unit hectare. In a survey which teachers completed on each of the lessons they tried, the One Hectare Park lesson was rated in the top three lessons for student engagement by all seven teachers who taught it, and rated in the top three for student learning by five of those seven teachers.

At the February professional learning days, the term "zone of confusion" was introduced as something which some teachers might find helpful in discussions with students about the different stages they might move through as they work on genuinely challenging tasks. It is clear that this term resonated with both teachers and students in the project. From responses to other survey items in June, 9 out of 15 teachers claim to now use the term "zone of confusion" and all of them either agree or strongly agree that it had the desired effect of assisting students. Fourteen out of 15 claimed that they explained the benefits of persistence to their students and 8 of the 14 either agreed or strongly agreed that this assisted students.

As indicated, the greatest change in the kinds of strategies offered by teachers after the experience of teaching the challenging tasks appears to be a focus on holding back from telling students how to solve problems and giving them more time to think about the tasks.

Conclusion

As a project team, we draw upon the insights of primary and secondary teachers as recorded in questionnaire responses and audio-taped focus group discussions, and from our own observations in developing the following list of strategies which appear to support students to persist when working on challenging tasks:

- some attempt is made to connect the task with students' experience;
- the ways of working are explained to students, including the type of thinking in which they are expected to engage and what they might later report to the class;
- the teacher communicates enthusiasm about the task, including encouraging the students to persist with it, but holds back from telling students how to do the task;
- classroom climate encourages risk taking, teachers expect students to succeed, errors are part of learning, and students can learn even if they do not complete the task;
- the lesson is structured to ensure that students have adequate time to work on the challenging task;
- processes and expectations for recording are made clear, including encouraging students to make appropriate notes along the way;
- the teacher moves around the class, predominantly observing students at work, selecting students who might report and giving them a sense of their role, intervening only when necessary to seek clarification of potential misconceptions, to support students who cannot proceed, and to challenge those who have completed the task; and
- there is time allowed for lesson review so that students see the strategies of other students and any summaries from the teacher as learning opportunities.

For worthwhile learning in mathematics, students need mathematically appropriate, engaging and cognitively demanding tasks. At the same time, the decisions which the teacher makes (in planning and 'on the run') can make a considerable difference in how the task plays out, the level of persistence shown by students, and the resulting learning, cognitively and affectively. This article has provided some insights from teachers into the kinds of decisions which they make, during planning and during teaching, which appear to maximise the potential of the tasks for worthwhile learning.

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Appendix: One hectare park

A park is enclosed by a fence that has exactly 6 internal right angles.

The total area of the park is 1 hectare.

What might be the perimeter of the park? (Give two different answers)

Rationale for the lesson

A key insight for students is to see that the length of some of the sides of rectangular shapes influences the lengths of the other sides. This lesson also connects a problem related to angles, hectare as a unit of measurement, and perimeter.

Year level

7–8

Particular pedagogical considerations

There is a variety of shapes that have six internal right angles (see below). Note that there are possible shapes that do not consist solely of 90° and 270° angles but calculating perimeters of such shapes is not expected at this stage.

Explain that 1 hectare is the same as 10 000 m (that is, the same as a square 100 m × 100 m). Have a discussion of a space locally that has an area of about a hectare.

Note that a common misconception arises when multiplying large numbers (2 thousand times 3 thousand is *not* 6 thousand).

For the students

The meaning of hectare as a unit of area, internal angles and finding the perimeter of a shape. For one area you can have many different perimeters.

Introductory task

A park is enclosed by a fence that has exactly six internal right angles. What might the park look like?

Enabling prompt

A park is enclosed by a fence that has exactly four internal right angles. The area of the park is 100 m^2. What might be the perimeter of the park?

Extending prompt

If a park is enclosed by a fence that has exactly seven internal right angles and the total area is 1 hectare, what might make it hard to calculate the lengths of the various sides?

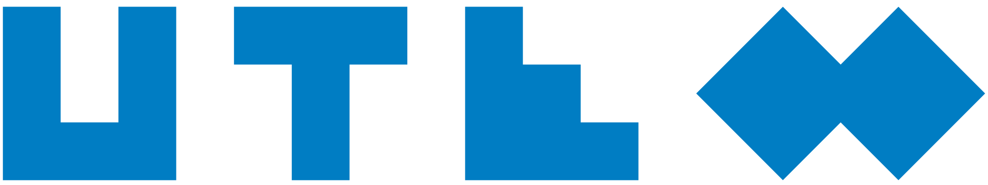
Consolidating task(s)

A park is enclosed by a fence that has exactly eight internal right angles. The area of the park is 2 hectares. What might be the perimeter of the park?

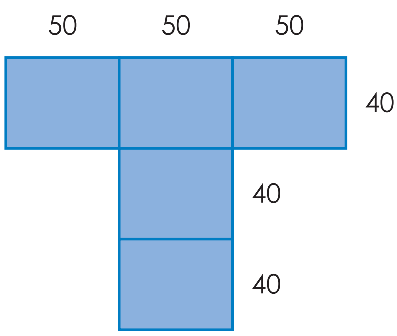
Some possible student solution strategies

There is a variety of shapes that have 6 internal right angles, although the process of calculating the lengths of the sides is similar (so long as the internal angles are either 90° or 270°).

Some of the possible shapes that have six internal right angles are:



Most students will convert the hectare to square metres. One possible solution is to see the T shape made from 5 rectangles, each of which has an area of 2000 m^2. Assume that the dimensions are 50 m × 40 m, the diagram might look like the following.



So the perimeter is 540 m.