Teacher actions that encourage students to persist in solving challenging mathematical tasks

Naomi Ingram
University of Otago College of Education
<naomi.ingram@otago.ac.nz>

Marilyn Holmes
University of Otago College of Education
<marilyn.holmes@otago.ac.nz>

Chris Linsell
University of Otago College of Education
<chris.linsell@otago.ac.nz>

Sharyn Livy
Monash University
<sharyn.livy@monash.edu>

Peter Sullivan
Monash University
<peter.sullivan@monash.edu>

As part of a project exploring the use of challenging mathematical tasks, data from New Zealand teachers and their students were analysed to explore teachers' actions that encouraged students to persist. Rather than rescuing the students when they needed help, the teachers' actions included arranging for and encouraging students to work independently and cooperatively, asking questions, providing materials, and getting students to reflect on the process. When the teachers performed these actions, they reported students persisted and were better able to navigate through the zone of confusion.

This paper reports on an iteration of the Encouraging Persistence Maintaining Challenge (EPMC) project, which examines what happens when teachers give students the opportunity to work on challenging mathematical tasks with minimal input from the teacher (described in more detail in Sullivan, Holmes, Ingram, Linsell, & Livy, this issue). In this iteration, students (aged 9-11) in New Zealand and Australia were given challenging angle tasks to work on. This paper specifically reports on the New Zealand teachers' actions that encouraged students to persist.

Teachers' actions are informed by their intentions, which are, in turn, influenced by their own relationships with mathematics and teaching. These relationships include teachers' beliefs about the nature of mathematics, teaching and learning, their knowledge of mathematics and pedagogy, and the opportunities and constraints they anticipate that they might experience when teaching (Clark & Peterson, 1986). One of these constraints in the context of the project is the extent to which teachers will allow students to struggle when confused. Teachers may take action to reduce the complexity of the task and scaffold the students' mathematical understanding (Sullivan et al., 2015). This constraint is therefore a potential barrier to teachers' implementation of challenging tasks.

This understanding of the intentions that lead to teachers' actions resulted in two important elements of the EPMC project. Firstly, teachers are provided with a suggested lesson structure as well as a set of tasks. Described further in (Sullivan et al., in press) a challenging task is *launched*, the students *explore* the task with minimal input from the teacher, and the teacher selects students' work to highlight in a *summarise* phase. There may be several iterations of launch-explore-summarise within a lesson. The lesson structure may also include the planning and implementation of enabling and extending prompts and consolidation tasks. Enabling prompts are designed to be given to individual students when they need support during the explore phase. This proposed lesson structure was found to be helpful and sufficient for supporting students when engaging in challenging tasks (Sullivan et al., 2015).

Secondly, rather than minimise challenge, teachers are encouraged to maintain it by explicitly encouraging students to persist, to reinforce the connections between persistence and learning, and to highlight student persistence when they see it (Sullivan et al., 2015). Teachers

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were encouraged to allow students to enter a *zone of confusion* (Sullivan and Davidson, 2014), a state of confusion before a pathway for solving the problem has been identified.

This is consistent with effective pedagogy. It is well known, if not necessarily practiced, that, to ensure a strong mathematical focus within a classroom, students need to think for themselves, and teachers need to avoid the kind of caring relationships that encourage dependency (Anthony & Walshaw, 2009). When a student seeks help from a teacher for example, this can mean the student is highly engaged in the problem, but it can also be evidence of on-going dependency on the teacher (Ingram, 2011).

Method

This paper uses data from ten New Zealand teachers and their students to answer the research question: What actions did the teachers take to encourage their students to persist when exploring challenging angle tasks? This study can be considered 'design research' because, by giving suggestions for the content and structure of lessons, a particular form of learning is being engineered and systematically studied. The intent of design research is to provide increasingly workable and effective interventions which are widely received, relevant and useful (van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). Thus, the iterative nature of the EPMC project is consistent with this intent.

Similarly to other iterations of the EPMC (e.g., Cheeseman, Clarke, Roche, & Wilson, 2013), teachers were given a set of challenging tasks, and were provided with a lesson structure that included launch, explore, and summarise phases. Prior to the intervention, the teachers were given an overview of the project and pedagogies for encouraging persistence were suggested, including using the zone of confusion as a metaphor for the initial stages of exploration. A poster for doing mathematics was also suggested, which included advising students 'not to give up when they got stuck' and to 'expect to get confused' (poster adapted from Ingram, 2013).

The data is drawn from the progressive feedback ten teachers gave after teaching each task and their general comments about the project during a feedback day. Student data was drawn from their responses to an open question given before and after the intervention: *'What does your teacher do to make you feel good about learning mathematics?'* Pseudonyms have been used to protect the identity of teachers. Student data has not been identified individually.

Results and Discussion

The suggested pedagogy of the EPMC project was very different to the teachers' normal practice.

> This was a new approach to teaching and I, and the children, weren't used to it. [The children] sat back and waited for a bit of help. So the zone of confusion went on for longer than it needed to. Initially I struggled as a teacher because I wanted to go over and sit down with them and work with them (Sally).

Indeed, it highlighted for the teachers "just how much some children expect to be rescued" (Martha). The students were "dumbstruck" and "didn't know where to start" (Mary). The teachers took a series of actions during the exploration phase. They arranged for learning by setting the children up to work both individually and cooperatively, they asked their students questions, and they provided materials to scaffold the students' understanding. They also suggested a further, reflection phase to improve the students' persistence.

Arranging for learning

After initial independent thinking time, the teachers encouraged the students to work individually or cooperative by naturally forming pairs or supportive groups.

There was so much freedom compared to what I would have [normally] done (Marg).

In this way, the students used each other as resources, resulting in discussions of "pleasing quality" (Sally), and "less teacher talk and more student talk" (Cathy).

Asking questions

All of the teachers found the designed enabling prompts useful, however sometimes the students were still "locked" in the zone of confusion for some time, usually because of their limited knowledge of the context or geometric properties. For example, in Task One, students needed to be familiar with semaphore and needed to know what a right angle was. If the student had prior knowledge, they were unable to make the connections required. Further, probing questions were needed, such as "What do you need to find out?" (Martha). Rather than "rescue" the students when they got stuck, the teachers carefully considered what questions they might pose, and when they might do so.

This change in teaching approach is apparent from the students' responses. Before the intervention, 75 of the 200 students said they felt good about learning mathematics when their teacher helped them. The teachers made it "easier" for them. They "broke the problem down into small steps". They explained the problem "very thoroughly". Only three of the students specified in their answers that the teacher helped them to do the mathematics for themselves. After the intervention, this result was different. 88 of the 200 students described the importance of the teachers' help in making them feel good about learning mathematics. 26 of those students, however, now specifically described how the teacher helped them to do the mathematics *themselves.* The teacher gave them "advice about how to do the problem". The teacher "doesn't tell me the answer but helps me to figure it out myself". The teacher "encourages me to keep going".

Using materials

Sometimes students used concrete materials or other objects to support their learning. During the explore phase, students used the classroom door, their own bodies, popsicle sticks, pattern blocks, geometric shapes, unifix cubes, and coloured paper cut into circles, triangles and strips. For Task 3, which related to the angles made with hands of a clock, Fiona gave her class paper circles to fold and cut. Later, she converted a circular tablecloth into a clock to represent this problem and used unifix cubes to represent the hands. Others used actual clocks. In Task 5, which related to compass bearings, Pat drew a grid on the whiteboard and provided the children with magnetic counters, which "helped them a lot".

Getting students to reflect on their time in the zone of confusion

Outside of the launch, explore and summarise phases, the teachers described an "equally valuable" (Martha) phase – reflection. Teachers developed the students' reflection skills by first establishing that being persistent in the zone of confusion was a normal part of what doing mathematics was. It was evident that the students were familiar with the zone of confusion and the need to persist because there was some re-voicing by students of language related to the EPMC project.

I need to persist.

Everyone is expected to get confused.

[My teacher] tells me to keep trying and don't give up because maths is thinky.

The teachers allocated time for reflections on the students' persistence, often using the poster provided as a guide.

Conclusion

The angles iteration of the project was deemed successful in terms of student outcomes (Linsell, Holmes, Ingram, Livy, & Sullivan, in press). In addition to the design of the tasks and lesson structure, the teachers' actions, described in this paper, perhaps contributed to this success. The teachers arranged for the students to work cooperatively, they asked the students probing questions, as well as providing them with the enabling and/or extending prompts. They provided students with materials, and they normalised confusion, asking the students to reflect on their engagement. By these actions, the teachers did more than enable their students to persist when confronted with challenging tasks. They enabled their students to navigate within, and even thrive, within the zone of confusion.

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