Teaching Strategies for Building Student Persistence on Challenging Tasks: Insights Emerging from Two Approaches to Teacher Professional Learning

Doug Clarke
Australian Catholic University

Anne Roche
Australian Catholic University

Jill Cheeseman
Monash University

Stephanie van der Schans
St James Catholic College

In recent years, the mathematics education research community has given increased focus to the use of cognitively demanding, challenging tasks and the demands placed on students and teachers by their use. In particular, there is evidence that a major issue is students' lack of persistence when working on such tasks. In this article, we report on two approaches to teacher professional learning in which the use of challenging tasks was the focus. In the first case, two full days of professional learning were followed by the opportunity to teach up to ten challenging tasks. In the second case, teachers observed three lessons built around challenging tasks taught by members of the project team. In both cases, teachers completed questionnaires about their perceptions of promising strategies for encouraging persistence on challenging tasks, prior to any professional learning input and following the teaching of the tasks and the observation of the lessons, respectively. Both groups also participated in focus group discussions about their experiences and insights that had emerged. Data from written responses and focus group discussions were analysed for themes. There was considerable similarity in teachers' suggestions prior to the two professional learning experiences, but also interesting differences afterwards. In this paper, we describe the professional learning approaches, illustrate the kinds of tasks involved, and discuss similarities and differences in the data within and between the two groups of teachers. We also discuss affordances and limitations of the two professional learning approaches.

Keywords · challenging tasks · persistance · professional learning· teaching strategies

Problem Solving, Challenging Tasks, and Persistence

The important place of problem solving in mathematics education has long been well recognised (National Council for Teachers of Mathematics, 1980; Polya, 1945). As Thompson, Battista, Mayberry, Yeatts, and Zawojewski (2009) noted,

> "Good problems challenge students to develop and apply strategies, serve as a means to introduce new concepts, and offer a context for using skills. Problem solving is not a specific topic to be taught but permeates all mathematics" (Thompson et al, p. 2).

In recent years, there has been a greater emphasis in research papers and curriculum documents on the important role played in problem solving by *cognitively demanding tasks* (Stein, Smith, Henningsen, & Silver, 2009). Also, most curriculum guidelines in mathematics education stress the need for teachers to extend students' thinking, and to pose extended, realistic and open-ended problems (see, for example, City, Elmore, Fiarman, & Teitel, 2009).

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 students begin to grapple with problems, but Pogrow asserted that this "controlled floundering" is essential for students to begin to think at higher levels.

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" (Thomson, Hillman, & Wernert, 2012, p. xxi). They claimed 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. (p. xxi)

Further, noted "a syndrome of shallow teaching, where students are asked to follow procedures without reasons" (Hollingsworth, Lokan, & McCrae, 2003, p. xxi). Other researchers have agreed:

> Principles of effective teaching recommend that teachers communicate high expectations to students, which involves posing challenging tasks, and adopting associated pedagogies such as encouraging students to task risks in their learning, to justify their thinking, to make decisions, and to work with other students (Stein, et al., 2009; 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.

Sullivan, Cheeseman, Michels, Mornane, Clarke, Roche, and Middleton (2011) characterised challenging tasks as those that require students to:

- plan their approach, especially sequencing more than one step;
- process multiple pieces of information, with an expectation that they make connections between those pieces, and see concepts in new ways;
- engage with important mathematical ideas;
- choose their own strategies, goals, and level of accessing the task;
- spend time on the task;
- explain their strategies and justify their thinking to the teacher and other students; and
- extend their knowledge and thinking in new ways (p. 34).

Two 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). Stein and Lane (1996) also found that teachers had an orientation to reducing the cognitive demand of tasks.

The *Encouraging Persistence Maintaining Challenge* project[1] (EPMC) is researching a range of issues including the kinds of teacher practice that might encourage students to persist when working on challenging tasks in mathematics. It is a complex project with many aspects of data collection, including teacher interviews, focus group discussions, teacher and student observations, and survey instruments completed by teachers and students.

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 institutions. We acknowledge gratefully the contribution and insights of teachers with whom we are working.

A Framework of Task Use

Data collection in this project is exploring, among other things, teacher actions during planning and during teaching that might maximise the effectiveness of the use of challenging tasks in mathematics, through encouraging students to persist in working on these tasks.

A framework (see Figure 1) that guided our thinking in the project about using challenging tasks to build student persistence was proposed by Stein, Grover, and Henningsen (1996).

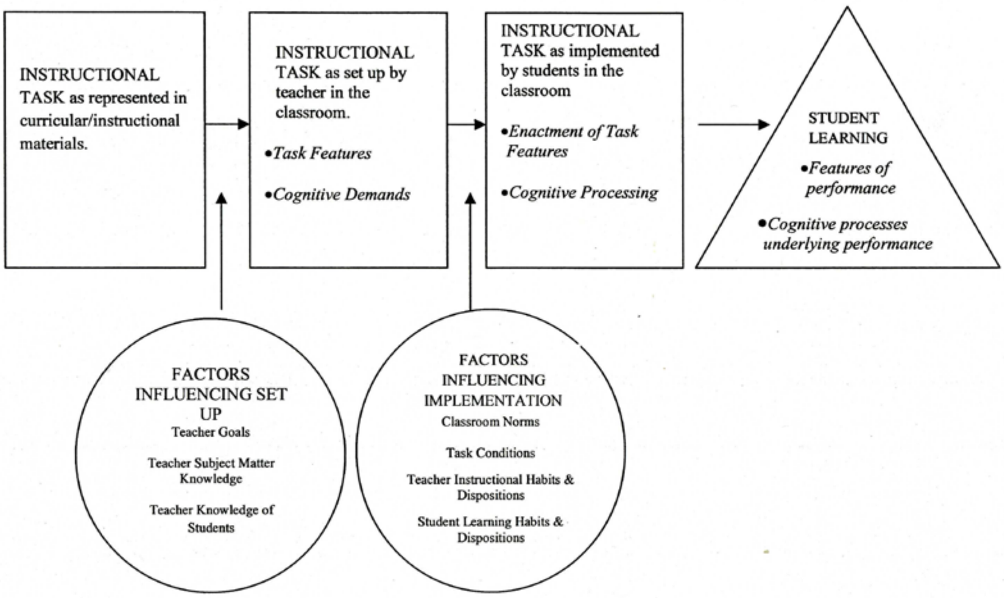

Figure 1. Relationship among various instructional task-related variables and student learning (Stein, Grover, and Henningsen, 1996, p. 496).

Smith and Stein (2011) explained that teachers make decisions, both in planning and in teaching, the effect of which is either to maintain the challenge or to reduce the cognitive demand of the tasks for the students. They argued that actions that assist in maintaining the challenge of tasks include scaffolding student thinking, allowing students to monitor their own learning, modelling high level performance, pressing for justification and argumentation (e.g., Wood, 2002), making conceptual connections, and allowing time. Actions that result in a decline of the cognitive demand include routinising approaches to tasks, emphasis on completion rather than comprehension, inadequate time on the task, inappropriate choice of tasks, and expectations for high-level performance not being communicated. We would add concerns about over use of teacher modelling. By this we mean demonstrating to students how to solve the problem. Tzur (2008) argued that the two key times that teachers modify tasks are at the planning stage if they anticipate that students cannot engage with the tasks without considerable assistance, and once they see student responses if these are not as intended.

The timing of this project in our country is important in light of the current implementation of the *Australian Curriculum: Mathematics* (Australian Curriculum, Assessment and Reporting Authority, 2013), and, in particular, 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.

Teacher Professional Learning

As indicated earlier, there are many challenges involved when teachers seek to use cognitively demanding tasks with students, including the challenge of encouraging persistence. For many teachers, substantial changes in their role may be required.

A framework that has guided our thinking about teacher professional learning is that of Clarke and Hollingsworth (2002). They suggested that the process of "teacher growth" or learning could be usefully modelled as cyclic with multiple entry points and "growth pathways". They argued that teacher change is motivated by more considerations than just student outcomes, and broadened what they called the Domain of Consequence to changes in salient outcomes, acknowledging that "individuals (teachers) value and consequently attend to different things (they consider different things salient)" (p. 954). They claimed that teacher change is personal and situated and "the support of teacher growth must offer teachers every opportunity to learn in a fashion that each teacher finds most useful" (p. 965).

The Clarke-Hollingsworth model identified not only the four change domains, but proposed the two key mechanisms—"enactment" and "reflection"—as mediating change between domains (see Figure 2). Most importantly, the individuality of teacher learning was acknowledged in the multiple growth pathways possible within the model.

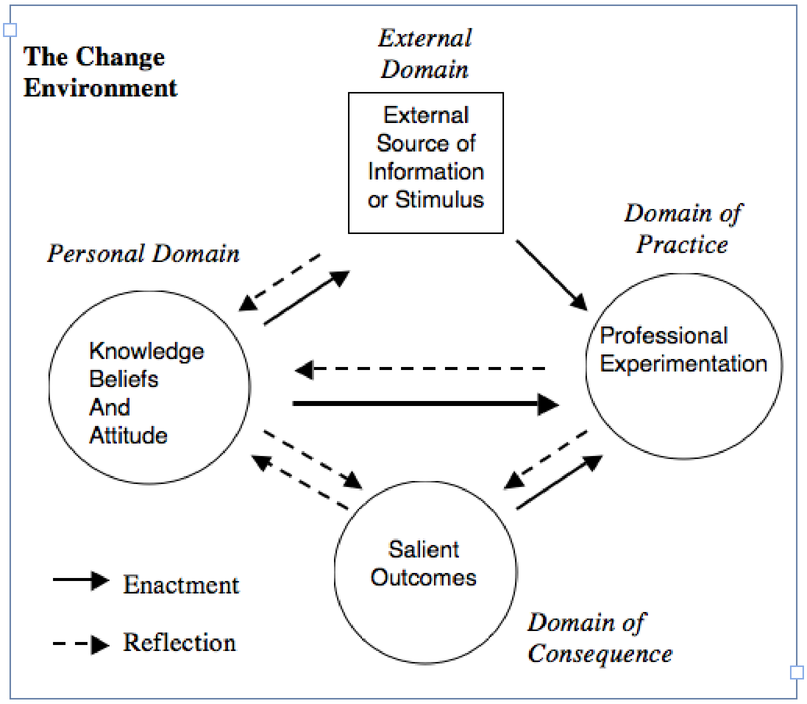

Figure 2. The interconnected model of teacher growth (Clarke & Hollingsworth, 2002, p. 951).

In the two professional learning approaches that are discussed in this paper, each of the four different domains in the Clarke and Hollingsworth model come into play, as will be discussed later.

Approaches to Teacher Professional Learning

Borko (2004), building on her previous work with Putnam (see Putnam & Borko, 2000), mapped the terrain of research on teacher professional learning, and identified the key elements of any professional learning system as:

> … the professional learning program; the teachers who are the learners in the system; the facilitator who guides teachers as they construct new knowledge and practices; and the context in which the professional learning occurs. (p. 4)

Borko raised important issues about whether materials and resources developed for use in one setting can maintain integrity with the designer's intentions when made available to multiple users in other diverse settings, discussing the trade-offs between fidelity and adaptation that are necessary to ensure program effectiveness across multiple settings.

Garet, Porter, Desimone, Birman, and Yoon (2001) surveyed a national probability sample of 1027 mathematics and science teachers to identify "three core features of professional development activities that have significant, positive effects on teachers' self-reported increases in knowledge and skills and changes in classroom practice" (p. 916). They claimed these to be a focus on content knowledge, opportunities for active learning with collective participation of groups of teachers from the same school, and coherence of programs with other activities. Desimone (2009) added the importance of *duration* of professional learning programs to these core features, noting that both span of time over which the activity is spread and the total hours spent on the activity, are important.

In her review of the literature on the mathematics education and development of teachers, Sowder (2007) emphasised the importance of "professional communities" in supporting teachers to acquire "knowledge-in-practice" (p. 185). She argued that, "learning often takes place in settings in which teachers join with other teachers—making learning a communal process" (p. 185). The notion of communities of practice finds harmony with Garet et al.'s (2001) collective participation.

Sowder also nominated six key teacher needs from professional development, by grouping them into goals:

> a shared vision of mathematics teaching and learning; a sound understanding of mathematics for the level taught; an understanding of how students learn mathematics; deep pedagogical content knowledge; an understanding of the role of equity in school mathematics; and a sense of self as a mathematics teacher. (p. 161).

Timperley and Alton-Lee (2008), in their attempts to reframe the notion of teacher professional learning, brought the focus back to the need to strengthen value outcomes for diverse learners. They also noted possibly the greatest challenge of teacher professional learning, that of *scale*, in order to produce "sustainable rather than siloed and transitory developments in education" (p. 361)

In a later section, we consider two approaches to teacher professional learning, and the extent to which they incorporate the desired features above.

Research Design

In working with the teachers in the EPMC project, we adopted a design research approach, which "attempts to support arguments constructed around the results of active innovation and *intervention* in classrooms" (Kelly, 2003, p. 3). The characteristics of design research were further elaborated by van den Akker, McKenney and Neiveen (2006) as:

- Interventionist: the research aims at designing an intervention in the real world;
- Iterative: the research incorporates a cyclic approach of design, evaluation and revision;
- Process oriented: … the focus is on understanding and improving interventions;
- Utility oriented: the merit of a design is measured, in part, by its practicality for users in real contexts; and
- Theory oriented: the design is (at least partly) based on theoretical propositions, and field testing of the design contributes to the theory building (p. 5).

Our intervention was that we suggested particular tasks and lessons for the teachers to pose to the students, as well as recommending particular pedagogies that they might use. The innovation refers to the types of tasks and lesson structure we suggest, which are different from those commonly used by the teachers. We suggested lessons based on challenging tasks to teachers to match content they were intending to teach, we offered suggestions about ways of encouraging students to persist, and we gathered data from teachers and students on their experience.

In what follows, we describe two different approaches to teacher professional learning used within the project. The first, "the Victorian professional learning approach" (Victoria, Australia) was true to the key elements of design research. The second, "the Tasmanian professional learning approach," (Tasmania, Australia) involved a single set of experiences on one day. The design of each of these approaches is now described, followed by a discussion of the data that emerged from each.

Our major research question was as follows: What are the kinds of strategies which teachers can employ when using challenging mathematics tasks, during the planning and teaching stages, respectively, which have the potential to encourage students' persistence?

The Victorian Professional Learning Approach

Fifty-five primary and secondary teachers met with the project team for two full days in February, 2013, with four or five teachers attending 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. The data and tasks discussed in this paper involve only the primary teachers in the study. For the 36 primary teachers, the focus was on tasks involving the content areas of multiplication and division at Years 5 and 6. All lessons were written using the structure shown in Appendix 1 for the lesson, *How Many Blocks?*

Feedback from teachers, reported elsewhere, indicated that the elements of the lessons suggested to teachers were both necessary and sufficient for supporting students in engaging in the challenging tasks (see Sullivan, Askew, Cheeseman, Clarke, Mornane, Roche, & Walker, in press).

Each lesson has what we have come to call a *main task*, and this 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) (see Sullivan, 2011).

To give a further sense of the kinds of tasks in these lessons, we include below the main task from two other lessons (see Figures 2 and 3).

I did a division question correctly for homework, but the printer ran out of ink.
I remember it looked like

__ __ 4 ÷ __ = __ 4

What might be the digits that did not get printed?
(Give as many answers as you can)

Figure 3. From "Missing Number Division".

Work out which card is better value. Do this in two different ways.
Explain your thinking clearly.

Figure 2. From Music Cards (Roche & Clarke, 2013, p. 225)

Following the meeting in February, teachers were asked to teach as many of the 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.

Prior to and after teaching the tasks, we sought teacher perceptions of strategies to encourage persistence on challenging tasks.

The Tasmanian Professional Learning Approach

A quite different approach professional learning was taken in Tasmania. Following the apparent success in using demonstration lessons to stimulate conversations around strategies for encouraging persistence in one school in Melbourne (see Cheeseman, Clarke, Roche, & Wilson, 2013), it was decided to use demonstration lessons as the main stimulus for Tasmanian teacher reflection on strategies that might prove helpful in encouraging students to persist with challenging mathematics tasks. These teachers were from local primary and secondary schools, and were part of an active network which met regularly to explore issues related to improving mathematics teaching in the schools.

Demonstration lessons, when situated within a professional development or coaching program, have been shown to hold the potential to promote teacher change and raise the quality of the teaching and learning in a classroom (Grierson & Gallagher, 2009; Joyce & Showers, 1980; Saphier & West, 2010). Many factors about professional development and coaching programs have been suggested to contribute to this change. These include the presentation of theory within the professional learning program, professional support embedded in the workplace, the coach's or demonstration teacher's interpersonal skills and on-going support, structured feedback, the examination of evidence of student learning, collaborative planning and reflection on practices, with demonstration lessons or modelling being a key component (see, for example, Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003).

It was agreed that three lessons would be taught at St James Catholic College in Cygnet, Tasmania, with 12 teachers observing the lessons. The lessons were taught by two members of the project team (the first two authors) and a teacher participant in the project (the fourth author). All three teachers were quite experienced at teaching demonstration lessons, with other teachers observing.

A summary of the three lessons follows.

Fitness Fest (Year 7). After an introduction to athletic events in general (e.g., the Olympics), students were provided with data on 15 Year 6 students' athletic performances on 100 m run, 800 m run, high jump, and a fitness test. Using these data, their challenge was to work in pairs to come up with three teams of five students from this group, such that the three teams could be expected to compete in an upcoming athletics carnival, where the three teams are of similar overall standard to each other. (See Thompson et al., 2009, for the original source of this task.)

Sandy Point Fun Run (Year 5). While displaying a map of Sandy Point, Tasmania, an introductory discussion included important features of maps, such as compass directions, keys/legends, grid coordinates, and scale. After the students had shared their experiences with fun runs, they used the map provided to work in pairs to design a fun run. Instructions for the design were: the route must begin at the gate of Sandy Point Primary School and end at the school gate; it must be between 1 and 2 kilometres long, and must stop at exactly five checkpoints along the way. The students also recorded the progressive distance along the route, and the location of the checkpoints, including street names and grid references. (See Roche, 2013, for a full description of this task.)

Mathematical Tug of War (Year 6). In this task, students were presented with two situations, one in which four equally strong footballers and five equally strong band members (from the band *One Direction*) draw in a tug-of-war competition. A second draw occurs when a combination of one footballer and two band members competes against an Ewok from Star Wars. The students were then told of a third proposed contest, where the Ewok and three band members combine to compete against the four footballers. Students were asked to consider what might happen in this latter contest, justifying their decision.

Because of scheduling difficulties and the need to limit the number of teachers observing a given lesson, not all teachers observed all lessons. The three lessons were observed by six, eight, and seven teachers, respectively. Prior to the demonstration lesson day, the teachers had completed the same initial survey as the Victorian teachers.

The demonstration lesson day was structured as follows. Before each lesson, for about ten minutes, the teacher of the lesson broadly outlined how the lesson was intended to play out. Observing teachers asked clarifying questions as necessary. During each lesson, the teachers were asked to make notes in provided exercise books, in response to the following prompt:

(a) Make a note of anything the teacher does that encourages students to persist.

Immediately following the lesson, before any discussion, teachers provided written responses to a further two questions:

(b) Make a note of anything else the teacher could have done which you believe might have led to greater persistence.

(c) What aspects of the task make it challenging for students?

Once teachers had written their responses to these questions, a focus group discussion was held about the lesson that had just been observed. These discussions were audiotaped and transcribed. As part of the focus group discussions, teachers were asked to check their notes, and share the most important strategy for supporting persistence that they had observed in action.

Data Analysis

All survey responses and transcribed focus group discussions were read through by the first two authors, independently. Each coded the data for themes. Following this initial coding, differences were discussed and agreement found, yielding the final set of codes discussed below.

Results

Data from the two professional learning approaches are now considered separately, to be followed by a discussion of the similarities and differences.

Insights from Victorian Teachers

As indicated earlier, at different points in the project, we collected information from teachers on their experiences. 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. They were also asked to "tick" any strategy that they currently used.

The 36 primary teachers responded with 172 suggestions for the planning stage and 164 suggestions for during the lesson, an average of 4.6 and 4.4 respectively per teacher. These were grouped into categories by two members of the research team. In Tables 1 and 2 below, the most frequently occurring categories are listed, with illustrative comments to elaborate the kinds of responses for each category, for the planning stage, and during the lesson, respectively.

For both the planning and during the lesson stages, many teachers focused on differentiating the tasks provided to students by the preparation of prompts, and by grouping arrangements. Interestingly, grouping suggestions of some teachers focused on mixed ability, while others suggested groups of similar ability. Differences between the comments in the two stages were the emphasis on careful choice of tasks and resources, taking into account the teachers' knowledge of individuals in relation to the content in the *planning* stage; and encouraging students to share their thinking, the development of a classroom culture, providing encouragement and enthusiasm, and monitoring students while they are working on the task, *during the lesson*. Of course, there are some strategies that are more appropriately addressed during planning (e.g., choice of tasks), and during the lesson (e.g., the teacher monitoring students), respectively.

Table 1
*Most Common Strategies in the Planning Stage for Encouraging Persistence on Challenging Tasks (*n=172*)*

Strategy	Number	Percentage	Illustrative comments
Differentiation	46	26.7%	Make variations to tasks to suit the needs of the children
			Differentiate the task to suit ability
			Consider extending/enabling prompts
Nature of tasks	25	14.5%	Develop a task that is open ended
			Relate to real life experiences
			Careful task selection
Grouping	18	10.5%	Ensure working groups are mixed ability
			Group children according to ability
			Small focus group work with me
Resources	18	10.5%	Concrete materials
			Plan and collect all equipment needed
			Organise a range of resources for students to access
Teacher knowledge - Content	18	10.5%	Understand the curriculum above and below level
			Be aware of misconceptions
			Know prior knowledge students should have
Teacher knowledge - Students	11	6.4%	Understand student learning styles
			Predict student difficulties
			Ensure s/he knows where students are at

The strategies listed in Tables 1 and 2 relate clearly to the *Factors influencing set up* and *Factors influencing implementation* in Figure 1. In relation to set up, the latter two categories (Teacher subject matter knowledge and Teacher knowledge of students) were clearly present in the data, while Teacher goals could be argued to have been provided in the lesson notes, albeit as a starting point. In regards to implementation, Classroom norms and Teacher instructional habits and dispositions link to Culture and Teacher enthusiasm/ encouragement, and Task conditions to Differentiation. Data on Student learning habits and dispositions are not discussed in this paper.

Primary teachers' insights after teaching up to ten tasks

In June, following the chance to try out up to ten 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 most common strategies listed by the Victorian teachers are set out in Table 2.

Table 2
Most Common Strategies during the Lesson for Encouraging Persistence on Challenging Tasks (*n*=164)

Strategy	Number	Percentage	Illustrative comments
Discussion, Questioning, Sharing	38	23.2%	Encouraging students to discuss mathematics
			Encourage students to listen to other strategies
			Question students to investigate their thinking
Differentiation	21	12.8%	Use enabling prompts
			Make changes to the activity to best suit each child
			Make activities multi-entry
Grouping	20	12.2%	Have a small focus group
			Allow students to work with a partner to share strategies
			Use flexible groupings, kids learn from each other
Culture	16	9.8%	Build a positive relationship with the children
			Discuss persistence when it gets tough
			Reinforce that taking risks/making mistakes is a normal part of learning
Teacher enthusiasm, encouragement	13	7.9%	Provide encouragement to persist
			Praise, encourage students by focusing on what they do know
			Present positively – enthuse students
Teacher monitoring students	13	7.9%	Monitor progress of each student/group closely
			Check in with all students
			Rove around chatting to student to check understanding

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. Thirty-five primary teachers responded, each providing one comment. Once again, these were grouped into categories by two members of the research team. In Tables 3 and 4, the most frequently occurring categories are listed, with illustrative comments to elaborate the kinds of responses for this category, for the planning stage and during the lesson, respectively. Of course, the request for just one response led to a smaller number of responses than earlier in the year. For this reason, percentages are not used here. Table 3 shows strategies used effectively at the planning stage, while Table 4 shows strategies used during teaching.

Table 3

Most Common New Strategies in the Planning Stage for Encouraging Persistence (n=35)

Strategy	Number	Illustrative comments
Differentiation	10	Have the prompting questions already to use during the session, rather than waiting for a particular misunderstanding to occur
		Actually including enabling and extending prompts in my planning
		I have planned what I will say to enable/challenge. This has been a change as previously I would do this as I am working with students on tasks
Nature of tasks	7	More problem solving activities. Plan more tasks that they need to think about instead of telling them what was wanted
		Providing tasks which focus on a particular concept, but in the problem solving format
		I would probably now give much harder tasks so that everyone had a level of confusion
Holding back	3	Not telling them what to do
		Not planning to 'teach' the concept first but waiting for the need to arise. Purposeful learning
		Not over planning and planning for too much content in the lesson

Table 4

Most Common New Strategies during the Lesson for Encouraging Persistence (n=35)

Strategy	Number	Illustrative comments
Discussion, questioning sharing	11	• Asking lots more questions e.g. so where could you go from there? Can you explain how you got here? What could you do next? Are you sure that's correct?
		• Students share more of their thinking more of the time. Students are learning more from sharing with each other, rather than listening to me.
		• More emphasis on sharing strategies
Holding back	10	• I model less at the beginning of lessons.
		• I probably don't 'over teach' during working time and share time - I allow for students to discover the mathematical concepts and strategies
		• I am more careful to hold back and not give the strategy which could help in the initial stage of the maths task.

Culture	9	• I am a lot more willing to say to a student "I know this is hard, I want it to be hard you need to go and think a bit more about (some specific context). • Using phrases such as yes this is hard, zone of confusion, I want you to have a go first, I'm not going to help you for 10 minutes, prove it to me, how do you know it is correct? • Convince them that it is OK to not know immediately

Possibly the most interesting difference in the data from before the teaching of the lessons (February) and after (June) was the emphasis on "holding back" during the lesson. In February, only two comments out of 164 mentioned that "teacher talking less" was a helpful strategy. These were "Resist talking too much" and "Pause." Only three out of 164 comments mentioned "Allowing students time to think." These were "Allow thinking time," "Provide opportunities for gradual release," and "Give time to sit and think." One comment out of 164 mentioned "Allowing students to struggle."

However, in the June survey, 10 comments related to the teacher talking less, teaching less, or allowing students to struggle. We summarised these comments as "Holding back." Although this number is not large, it is important to remember that it represents a large proportion of responses out of 35.

At the February professional learning days, the term "zone of confusion" was introduced by the research team as something which other teachers had found helpful in discussions with students about the different stages they might move through as they work on genuinely challenging tasks. The intention in mentioning this term to students was to acknowledge that if genuine learning is to take place, there will be times of student confusion. It is clear that this term resonated with both teachers and students in the project. From responses to survey items in June, 23 out of 34 teachers claimed to now use the term "zone of confusion" with their students and 18 either agreed or strongly agreed that it had the desired effect of assisting students. Thirty-two out of 34 claimed that they explained the benefits of persistence to their students and 29 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 and work on the tasks.

Insights from Tasmanian Teachers

As mentioned earlier, prior to the demonstration lesson day, the Tasmanian teachers had completed the same initial survey as the Victorian teachers, including being asked to "tick" any strategy that they currently used. The most common themes for the planning stage and during the lesson, respectively, are shown in Tables 5 and 6.

There were several themes evident in both the *planning* stage and *during the lesson* stage. These were: the need to cater for the different abilities in the class, possibly by differentiating tasks or providing prompts; grouping arrangements; the explicit ways of modelling or explaining the task to the students; and preparing and asking students questions to elicit their thinking.

Themes evident only in the planning stage were the emphasis on careful choice of tasks and preparing and providing helpful resources. Themes evident only during the lesson were monitoring students while they are on task and providing encouragement and enthusiasm.

Comments that were made by the teachers that were similar to those strategies made in the initial survey (see Tables 5 and 6) were focused on the nature of the tasks, classroom discussions, teacher questioning and sharing of ideas, differentiating the task for different abilities, and monitoring students' progress during the lesson. Examples of these comments are shown in Table 7.

In summary, the teachers in the focus groups noted in all lessons that the tasks presented to the students were engaging and provided a context or story to which students could relate. They identified the use of enabling prompts to help students who might be "stuck" and the use of an extending task for those students who finished quickly (Sullivan, 2011). They indicated that asking students to share their ideas and listen to others, and value what others said were positive and engaging classroom experiences for the students. One teacher noted an occasion when, in her opinion, an opportunity for students to share their thinking at the end of the lesson was missed.

> Or there's other kids that turn around and say, "Oh what did you guys do; what did you guys just say up there? Show me your map". So maybe having a pair share at the end of each presentation about what they thought about what the kids just presented, how it compared to theirs … like that maybe.

Table 5
Most Common Strategies in the Planning Stage for Encouraging Persistence on Challenging Tasks (n=64)

Strategy	Number	Percentage	Illustrative comments
Differentiation	11	17.2%	Cater for all abilities
			Look to extend some students
			Think about how the task can be differentiated
Nature of tasks	11	17.2%	Plan engaging tasks
			Plan open ended tasks
			Plan hands on activities
Grouping	7	10.9%	Group work based on ability
			Plan for group activities
			Pair a more able student with a lower child
Explicit teaching	6	9.4%	Make sure you model what is expected
			Teacher demonstration of task, then students do, then discussion
			Provide clear examples to follow
Resources	6	9.4%	Prepare visual aids
			Think about concrete materials that could be used
			Provide tools, visual text, calculators, charts etc.
Discussion/	6	9.4%	Ask students to try another way
questioning/			[Prepare] questions to ask
sharing			Question what they are doing to understand

Many of the comments (89.1%) made by these teachers in the initial survey were 'ticked' (indicating they were behaviours the teacher claimed to regularly try). It is therefore not surprising that they may then look for and identify these behaviours by the teacher in the demonstrations lessons, where they existed. There were nevertheless a number of themes made by teachers in the focus groups that had not been evident in the initial survey. It is likely therefore that these may be new ideas for these teachers and something that may influence their practice in the future. These are now discussed.

Table 6
*Most Common Strategies During the Lesson for Encouraging Persistence on Challenging Tasks (*n=*55)*

Strategy	Number	Percentage	Illustrative comments
Explicit teaching	10	18.2%	Model how to solve a problem Help students to get set on tasks Explain the process step by step
Discussion/ questioning/ sharing	8	14.5%	Ask students to explain their thinking Ask students questions- is there another way? Question, listen
Differentiation	6	10.9%	Provide prompts Provide different levels of questions so all kids can complete the tasks Extend
Teacher monitoring students	6	10.9%	Identify those struggling Monitor Check for understanding- questioning, observing
Grouping	5	9.1%	Grouping, pairing students Work with smaller groups Encourage group answers
Teacher enthusiasm/ encouragement	5	9.1%	Encourage, support, praise Encourage each step Praise and celebration

There were three categories of strategies that were mentioned predominantly in the focus group discussions as arising from their observations of the demonstration lessons, and yet were rarely mentioned in the survey. These were creating a classroom culture (e.g., thinking is valued; persistence on challenging tasks is discussed with the students); the teacher making goals and intentions explicit to the students; and holding back from telling.

In the initial survey, only one comment was made about developing a culture of persistence in the classroom. However, some of these strategies were noted by the teachers as occurring in the demonstration lessons.

> [The teacher] explained to the students the importance of having a go at challenging tasks.
>
> "I'm confident you can do it" and "I want you to persist with this" so getting them used to the language, I think, of persistence and not just the language of maths, which was a nice meshing of the two.

Only two comments out of the 119 made in the survey about making the aim of the lesson clear (to the students and for the teacher themselves). However, in the focus groups, there were several teachers who mentioned aspects of this behaviour, which included: making the task clear by using the visualiser so that all students could clearly see what the teacher was referring to; getting the students to demonstrate what they already know; the teacher using the students' language when responding to their comments; and restating their words in a different way for clarification.

> I thought you were quite explicit in what you saw as most important, just like you did all that tuning in and then getting them to show you what they already knew. But then just before they went and sat down, you actually said what you thought was most important, which I think was calculating the numbers, working out the distances.

> You stated them another way to make sure that you're on the same path, that you're saying what the child was saying. … saying it in another way to make sure that you were understanding what they were saying. So if they said "organising this data," you'd say "The data about the high jump."

Table 7

Strategies Noted by Observing Teachers that were Similar to Categories in the Initial survey

Strategy	Illustrative comments
Nature of the task	They started to think about sports and Olympics and started to talk about some popular athletes or popular events and that sort of thing. So [the teacher was immediately engaging their thinking so that they were already warmed up, I suppose, before the activity was introduced to them. And I think that would help anybody to persist longer with whatever the activity is if they're already feeling engaged and warmed up.
Differentiation	After a while, somewhere in the middle there, [the teacher] was circulating for those groups that needed it, question cards……which were prompting them to refocus, to maybe look at it in a different way. … So those prompts, I thought, were a great way to keep them engaged in the activity and then to retain their focus.
Discussion/ questioning/ sharing	The whole time everyone could have their say and everyone could voice their thinking. And then the sharing time was really great too because they were really engaged.
Teacher monitoring students	[The teacher] really enforced how important all of their ideas are and that not to press that delete button, but to keep all of those ideas, write them all down, because they could come in, they could be useful later. And I just liked it at the outset, and then, when you came back to it and reinforced it once or twice, I thought that was really powerful.

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. The strategies that the teachers observed seem to align closely with what Jackson, et al. (2013) referred to as one of the aspects of a high quality setup. They describe this aspect as, "Common language is developed to describe contextual features, mathematical ideas and relationships, and any other vocabulary central to the statement that might be confusing or unfamiliar to students" (p. 652).

None of the Tasmanian teachers commented in the initial survey that holding back from telling students how to solve a problem might be a teacher behaviour that could help students to persist with challenging tasks. However, in the focus group discussions, some teachers noticed this behaviour. For example, in the Tug of War lesson, the demonstration teacher chose not to tell the class at the end of the lesson the "right" answer, leaving the students to go home not knowing if they were correct. The teachers' comments suggested that they felt this encouraged the students to continue thinking about the task (a form of persisting).

> Yeah, I loved that. I love that it wasn't resolved in that way. And it kind of encourages kids' curiosity and persistence maybe to go and work on it a bit more themselves.
>
> I like it because it keeps them thinking.
>
> But they were still sort of thinking "No, I want to work this out. I don't want to let that go".

During the Sandy Point Fun Run lesson, the demonstration teacher provided the students with some half metre lengths of string. This occurred part way through the lesson when she noticed some students were struggling with calculating the distance along a curvy road. A teacher in the focus group discussion noted that not telling the students what to do with the string was a motivator to get the students to work it out for themselves.

> One of the things was the use of the string, so providing the scaffold, or another option of solving it, yeah. I saw that as a scaffold or another prompt, and a chance to refocus their attention too, sort of in the middle of the lesson, "If you're getting stuck, here's another way of doing it, see what you can do with this", and refocusing their attention on that. And just to add on that, to that point, how you said "But I'm not going to show you or tell you how to use it, you've got to think about that" .

It is clear that the teachers gained a number of insights about teaching for persistence from the process of demonstration lessons. In the next section, we discuss the two different approaches to professional learning outlined in this paper, aspects of teacher learning which appeared to be evident from each, and outline their affordances and limitations.

Reflecting on the Two Different Approaches to Professional Learning

In the earlier discussion of the research literature on teacher professional learning, several important elements of effective programs were identified. These are now considered in Table 8, and the extent to which they were present in the two approaches discussed in this paper. It is also appropriate to consider the two approaches of professional learning, in relation to the model of teacher change proposed by Clarke and Hollingsworth (2002).

In the case of the Victorian teachers, their initial written responses to the questions about their recommended strategies for encouraging persistence are likely to be reflective of their *knowledge, beliefs, and attitude* in the personal domain. The *external source of information or stimulus* was the professional learning program in February. The *professional experimentation* was the opportunity to teach up to ten of the challenging lessons, and observe the *salient outcomes*. This in turn influences their knowledge, beliefs and attitude, as reflected in the written responses after the teaching experience.

For the Tasmanian teachers, prior to the observation day, their recommended strategies for encouraging persistence are also likely to be reflective of their *knowledge, beliefs, and attitude* in the personal domain. The *external source of information or stimulus* was the professional opportunity to observe demonstration lessons, and to discuss these observations in a focus group. The teachers were thus vicariously observing *professional experimentation* (as, in one sense, every lesson is at one level, professional experimentation), and noting the *salient outcomes*. This in turn had the potential to influence their knowledge, beliefs and attitude, as reflected in the focus group discussions after the three lessons.

Table 8
A Consideration of Important Elements of Effective Professional Learning Programs (Garet et al., 2001; Deismone, 2009; Sowder, 2007) in Relation to the Victorian and Tasmanian Professional Learning Approaches

Key element	Victorian approach	Tasmanian approach
Focus on content knowledge	Tasks taught had the potential to enhance teachers' content knowledge	Tasks observed and discussed had the potential to enhance teachers' content knowledge
Opportunity for active learning	The opportunity to teach ten lessons and reflect on the experience involved active learning	Observing the teaching of lessons was less active, but data suggest the observation and subsequent discussion involved participants actively
Coherence with other activities	Tasks were deliberately developed to match the content which the teachers were to teach in their regular programs	The "one-off" nature of the approach meant that no attempt was made to cohere with other professional learning activities
Duration of program	The spaced professional learning program took place over approximately nine months	The single day approach obviously was inadequate in respect of this element
Professional communities	Teams of teachers who were used to working together were able to participate in a collaborative activity over a period of time	Although only a one-day experience, the teacher participants were all part of a local professional learning network

In both cases, professional communities were established (Sowder, 2007), although in the case of Tasmanian teachers, the demonstration lesson day was a single event in the experience of a previously-established network of teachers.

Teacher Learning in the two Approaches

In considering what the teachers learned about encouraging persistence, we drew upon questionnaire responses in the case of the Victorian teachers, and on focus group discussions in the case of the Tasmanian teachers. Before the two interventions, both groups of teachers, for the planning stage, emphasised differentiated tasks, careful choice of tasks, grouping approaches, and the use of resources. Differences of note were that Tasmanian teachers gave more emphasis to explicit teaching, while Victorian teachers focused on the teacher's knowledge of the content. During the lesson, the common strategies involved discussion, questioning and sharing, differentiation, monitoring students, grouping, and teacher enthusiasm and encouragement, while the differences between the two groups were the emphasis on explicit teaching by Tasmanian teachers, and a focus on building the classroom culture by Victorian teachers.

Following the interventions (observing demonstration lessons in the case of the Tasmanian teachers and teaching up to ten provided lessons between professional learning days in the case of the Victorian teachers), there was an increased emphasis in the responses of both groups on discussion, questioning and sharing, the development of a classroom culture, and holding back from telling students what to do. The major differences were that the Tasmanian teachers now placed greater emphasis on the careful monitoring of students during the lesson, and the Victorian teachers emphasised "time" in a wide range of aspects.

The extent to which the word "time" was mentioned in Victorian teachers' statements about their teaching behaviour during the lessons, is reflected in Figure 3. The software *Wordle* has been used to provide a visual image of the relative frequency of words used in teachers' responses. (The word "students" was omitted from the database prior to the use of the software, as this word occurred most frequently, and would have been a distraction). The word "time' was used within statements which were coded in a range of categories. For example, "time" was linked to strategies such as giving students more time to work on tasks, more thinking time, time to share with other students and teachers spending less time telling students what to do.

Figure 3. A visual illustration of most common words used in describing changes in teaching practice.

It is clear from the written and verbal responses that the two models provided different but important learning for most teacher participants.

Affordances and Limitations of the two Professional Learning Approaches

The demonstration lesson approach in Tasmania, with a prebrief session, structured written feedback, and focus group discussion gave the opportunity for the project team to provide an image of a mathematics classroom environment which attempts to encourage persistence on challenging tasks. Although a video of the same classrooms could offer similar opportunities, the choice given to the observing teachers to move and watch particular events of their choosing adds benefit, potentially. At the same time, the "one-off" nature of the demonstration lesson day, without planned follow up in the teachers' own classrooms, has obvious limitations—given that change can be a gradual, difficult and often painful process, and one that needs ongoing support (Clarke, 1994). In terms of the features of design research mentioned earlier (van den Akker, et al., 2006), the approach's lack of a cyclic approach is its major weakness. Despite the limitations of this approach, in light of teacher comments during focus group discussions in Tasmania, it would appear that the investment of one full day provided worthwhile benefits to the participating teachers.

The Victorian professional learning "sandwich model" (Owen, Johnson, Clarke, Lovitt, & Morony, 1989) had the advantage of the teachers working through all the tasks, in the role of students, in a professional community, prior to trying them out with their students. This, together with the detailed notes that accompanied each lesson, enabled the teachers to anticipate likely student responses to challenging tasks, an important precursor to orchestrating productive mathematical discussions, in the view of Smith and Stein (2011). The extended process of the approach, where teachers had several months to consider ideas suggested in the initial two days of professional learning in February, to discuss with colleagues the most suitable times to teach the lessons, and the opportunity to share their experiences with colleagues from their own and other schools once more in June, acknowledged the complexity of the change process and the time needed for it. Most schools received at least one visit from a project team member or members, and this provided the opportunity for teachers to share their experiences, and, in some cases, for project team members to observe teachers in action. All of the previously mentioned features of design research were present in this approach. A disadvantage of this approach is the very limited opportunity to see what actually happened in the teachers' classrooms, in order to gauge the extent to which teachers' self-reports of their changed practice were in fact a true measure of what happened. The fact that all teachers were able to identify one aspect of their teaching that had changed in their attempts to encourage students to persist is an indication that this model too can be regarded as potentially helpful.

It is important to emphasise that in neither approach did we collect data on student persistence, as a result of the professional learning. We did however collect data on students' perceptions of the kind of classroom environment in which they believed they worked best on challenging tasks, as well as data on their preferred level of difficulty of tasks in mathematics. These data will be reported in future publications.

Conclusion

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, effort, and persistence 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.

For worthwhile learning in mathematics, students need mathematically appropriate, engaging and cognitively demanding tasks. At the same time, the decisions that 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 study has made a small but important contribution to understanding and elaborating the role of the "instructional task as set up by the teacher" in the Stein et al. (1996) model of task use. This article has provided some insights from teachers into the kinds of decisions that they made during planning and during teaching—decisions that might maximise the potential of challenging tasks for worthwhile learning. We have also outlined two quite different approaches to supporting teachers in their professional learning around the use of challenging tasks, both of which appear to have benefit.

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Authors

Doug Clarke
Faculty of Education, Australian Catholic University, 115 Victoria Pde, Fitzroy, VIC, 3065, Australia.
Email: doug.clarke@acu.edu.au

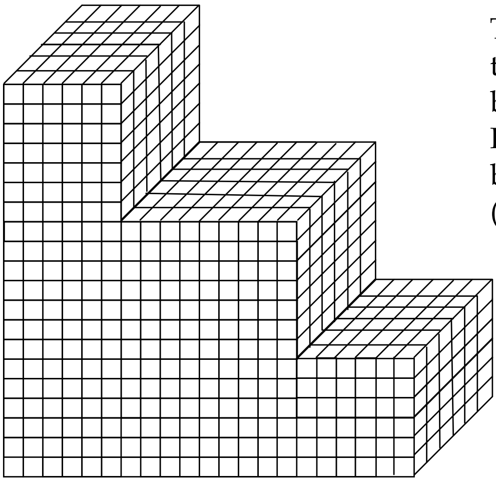
Anne Roche
Faculty of Education, Australian Catholic University, 115 Victoria Pde, Fitzroy, VIC, 3065, Australia.
Email: anne.roche@acu.edu.au

Jill Cheeseman
Faculty of Education, Monash University, Peninsula Campus, McMahons Road, Frankston, VIC, 3199, Australia.
Email: jill.cheeseman@monash.edu

Stephanie van der Schans
St James Catholic College, 25 Mary Street, Cygnet, TAS, 7112, Australia.
Email: stephanie.vanderschans@catholic.tas.edu.au

Appendix 1: A sample task of the ten used in the Victorian approach

HOW MANY BLOCKS?



This is a plan for some steps that are to be built from small blocks.
How many small blocks would be needed to make this?
(Do this in two different ways.)

Rationale for the lesson:

Mathematics is about patterns and connecting ideas. This lesson connects the volume (the number of cubic units) with the process of imagining (the cubic units we cannot see) and the process of calculating (multiplication).

Year level:

Year 5- 6

Particular pedagogical considerations:

Explain that there are two challenges with this task: One is imaging the blocks that cannot be seen, and the other is finding a more efficient way of calculating than counting all the blocks one by one.

For the students:

There is a range of strategies to work out the number of blocks without counting them one by one.

Enabling prompt:

How many blocks have been used in making this shape?

Extending prompt:

I want to cover the steps with square tiles. How many tiles do I need? (Explain your answer)

Consolidating Task(s):

I want to make a set of steps that has a cross section (the side) that looks like this. I need to use 882 blocks altogether. How deep should be the steps?

Some possible student solution strategies:

- One approach is to treat the tiers separately, and calculate the volume of each. For example, the lowest tier is 21 x 6 x 6
- It is also possible to calculate the towers separately. For example, the highest tower is 20 x 6 x 7
- It is also possible to move the top tier to the missing section on the bottom tier, creating a single prism that is 20 x 13