Mathematics Teacher Education and Development 2017, Vol 19.1, 30 - 46

How does lesson structure shape teacher perceptions of teaching with challenging tasks?

James Russo
Monash University

Sarah Hopkins
Monash University

Received 5 October 2016 Accepted 9 February 2017

Despite reforms in mathematics education, many teachers remain reluctant to incorporate challenging (i.e., more cognitively demanding) tasks into their mathematics instruction. The current study examines how lesson structure shapes teacher perceptions of teaching with challenging tasks. Participants included three Year 1/2 classroom teachers who observed the researcher (first author) deliver two units of mathematical work. Teacher-participants were given an opportunity to observe the use of challenging tasks to both launch lessons (Task-First Approach) and extend student thinking (Teach-First Approach). It was revealed that teacher-participants perceived both the Task-First Approach and the Teach-First Approach to teaching with challenging tasks to have particular strengths. Specifically, the Task-First Approach was viewed as engaging and empowering for students, providing an opportunity to build student persistence whilst fostering student mathematical creativity. Teachers also placed value on the quality of the mathematical discussion which emerged, and the value of the Task-First Approach for supporting an authentic assessment of student mathematical knowledge. By contrast, the Teach-First Approach was viewed as highly focussed, and an efficient approach to learning. It was also perceived as providing an opportunity for lower-achieving and less confident students to be successful. Although there appear to be distinct advantages to both the Task-First and Teach-First Approaches, the study revealed that the most dramatic shift in teaching practice for some teachers may be the incorporation of more cognitively demanding tasks into their mathematics instruction in any capacity.

Keywords · cognitively demanding tasks · teacher perceptions · lesson structure · instructional approaches · mathematical knowledge for teaching

Introduction

In the past, students in Australian classrooms have tended to complete a high volume of mathematical tasks, however spent relatively little time engaged in deep problem solving (e.g., Hollingsworth, McCrae, & Lokan, 2003). Consequently, a key aspect of reform in mathematics education has been encouraging teachers to utilise cognitively demanding tasks, in part as an avenue to engage students better in rich mathematical discussions (Cheeseman, Clarke, Roche, & Wilson, 2013; Stein, Engle, Smith, & Hughes, 2008). Teaching with such tasks is thought to facilitate opportunities for students to exercise higher level mathematical thinking; what Stein, Smith, Henningsen and Silver (2009) described as 'Doing Mathematics'.

One interpretation of developing a cognitively demanding and mathematically meaningful task has been the notion of challenging tasks (Sullivan, Clarke, Michaels, Mornane & Roche, 2012). Challenging tasks are complex and absorbing mathematical problems with multiple

solution pathways, whereby the whole class works on the same problem. The task is differentiated through the use of enabling and extending prompts (Sullivan & Mornane, 2013), the former of which are sometimes referred to as the 'hint sheet' (Russo, 2016a). Generally teaching with cognitively demanding tasks involves a three-stage process: launch, explore, discuss (with summary) (Stein et al., 2008). Such a lesson structure can be viewed as an example of problem-based, or inquiry-based, learning (Alfieri, Brooks, Aldrich & Tettenbaum, 2011).

Arguments for and against the Task-First Approach

There is some support for the notion that this launch-explore-discuss lesson structure has distinct strengths which may lead to improvements in student learning outcomes. There are at least three arguments in support of this position. First, there is empirical evidence to suggest that higher-order mathematical goals, such as the ability to reason and think critically and creatively, are more likely to be realised when students are given an opportunity to explore concepts prior to instruction (Leikin, 2009; Marshall & Horton, 2011; Sullivan & Davidson, 2014), and subsequently discuss these concepts as a class (Forman, Larreamendy-Joerns, Stein, & Brown, 1998; Woodward & Irwin, 2005). Second, it has been argued that students are more engaged in the learning material when tasks are perceived as more cognitively demanding (Sullivan et al., 2012), which is likely to be the case when the task is presented first. Indeed, there is some evidence that teaching with cognitively demanding tasks generates high levels of student engagement (e.g., Roche, Clarke, Sullivan, & Cheeseman, 2013; Russo & Hopkins, in press; Sullivan et al., 2014). Third, building a lesson around students first tackling a cognitively demanding task may improve student persistence, as students work through the "zone of confusion" (Sullivan et al., 2014, p. 11). The contention is that through participating in a classroom culture that normalises struggle and identifies it as an integral aspect of doing mathematics (Sullivan et al., 2013), students are oriented to see this state as a prompt for action (e.g., pursuing a particular solving strategy, such as trial and error), rather than as a sign of failure.

By contrast, perhaps the strongest claim against the launch-explore-discuss structure is the notion put forward by some cognitive load theorists that such problem-based approaches to learning are not optimally efficient, in part because they generate unnecessary cognitive load (Kirschner, Sweller & Clark, 2006; Sweller, Kirschner, & Clark, 2007). Specifically, it is contended that without prior instruction in a concept, novice learners are unlikely to benefit from working on a challenging, or cognitively demanding, task. The argument is that the number of interacting elements within the set task is too high, thereby increasing the number of items the learner has to process simultaneously in working memory to unsustainable levels, in turn impeding learning (Sweller, 2010). Although cognitive load theory itself has substantial empirical support (Sweller, 2010), this argument critiquing problem-based approaches specifically is not uncontroversial and the claim remains in dispute (for counter arguments, see Hmelo-Silver, Duncan, & Chinn, 2007; Kuhn, 2007; Schmidt, Van der Molen, Te Winkel & Wijnen, 2009).

Examining teachers' reluctance to incorporate more cognitively demanding tasks

Despite the apparent benefits of teaching with more cognitively demanding tasks, teachers are frequently reluctant to pose such tasks to students (Cheeseman et al., 2013; Darragh, 2013; Tzur, 2008). Part of this reluctance appears to relate to teachers anticipating negative student reactions to being challenged to think (Sullivan et al., 2014). However, it has also been argued that a lack of pedagogical content knowledge, and mathematical content knowledge more generally, leads

to some teachers focussing more on routine and procedural tasks, at the expense of deep problem solving and conceptual understanding (Charalambous, 2008; Forrester & Chinnappan, 2010). This lack of content knowledge can be framed as some teachers feeling they lack the confidence and/or competence to teach with cognitively demanding tasks.

Reluctance to teach with cognitively demanding tasks may be exacerbated if teachers are faced with the expectation that they deliver an entire lesson around such a task. Although the launch-explore-discuss structure which characterises a typical lesson built around a cognitively demanding task is relatively straightforward to explain, it requires a substantial amount of skill to successfully orchestrate (Stein et al., 2008; Ridlon, 2009; Sullivan, Clarke, Clarke & O'Shea, 2010; Thomas & Monroe, 2006). The fact that such lessons are extremely complex and carefully thought through is often masked by the tendency in the literature to present models for these lessons based on the practice of expert facilitators, which may provide little practical guidance for non-experts (Stein et al., 2008).

Given these issues, it may be that teachers would be more comfortable incorporating cognitively demanding tasks to further extend student thinking, rather than having such tasks serve as the core of the lesson. Specifically, teachers may prefer to teach with cognitively demanding tasks using a Teach-First Approach (i.e., a teacher-facilitated discussion of the relevant mathematics, followed by consolidating work, followed by the cognitively demanding task), rather than a Task-First Approach (i.e., the aforementioned launch, explore, discuss structure; followed by some consolidating work). Although it may be argued that using cognitively demanding tasks in this manner undermines their learning potential, such a conclusion warrants evaluation. Indeed, a related study has found that students' mathematical performance improved substantially regardless of whether challenging tasks were used to extend student thinking (Teach-First Approach), or launch a lesson (Task-First Approach) (Russo & Hopkins, 2017a).

The current study

Clearly the issue of whether teacher confidence and competence with developing and using cognitively demanding tasks is impacted on by lesson structure justifies empirical examination. In addition, given the substantial interest in encouraging teachers to incorporate such tasks into their mathematics instruction, there is a need to more broadly investigate the respective strengths of both the Task-First Approach and the Teach-First Approach from the perspective of practising classroom teachers. Such an investigation should also consider how perceptions influence these teachers planned use of such tasks in future instruction. These issues are the focus of the current study.

Research questions

1. What advantages did teachers perceive a Task-First Approach to have when teaching with challenging (i.e., cognitively demanding) tasks?
2. What advantages did teachers perceive a Teach-First Approach to have when teaching with challenging (i.e., cognitively demanding) tasks?
3. When it came to considering their own teaching practice, did teachers have a preference for one particular approach?

Method

Participants

Participants included the three Year 1/2 classroom teachers who taught at a primary school in the Shire of Yarra Ranges, Victoria, Australia. In Victoria, students typically turn seven years of age during Year One, and eight years of age during Year Two. These classroom teachers became involved in the program in a teaching capacity, after their principal agreed to the researcher (first author) teaching two units of work built around challenging tasks as part of all Year 1/2 students' regular mathematics instruction in number and algebra. The teachers also consented to being involved in the study as participants.

The three teacher-participants varied notably in terms of their teaching experience. Whereas Polly (Class B) had been teaching for over 25 years, and Sally (Class C) was in her ninth year as a classroom teacher, Rachel (Class A) was a recent graduate, in her first full year of teaching.[1]

Procedure

Teacher-participants observed the researcher deliver two units of work across Terms 2 and 3 of 2016: one unit of work relating to number patterns (Patterning Unit), and another unit of work relating to addition and missing addend problems (Addition Unit). Examples of some of the challenging tasks included in the units of work have been published elsewhere (e.g., Russo, 2015, 2016a, 2016b, 2016c; Russo & Hopkins, 2017b).

The current study adopted a quasi-experimental design, whereby naturally occurring groups (i.e., a class of students and their respective teachers) were initially randomly allocated to one of three intervention conditions: Task-First Approach, Teach-First Approach or the Alternating Approach (two lessons Task-First, two lessons Teach-First, two lessons Task-First etc.). Within the Patterning Unit, Class A participated in the Task-First condition, Class B in Teach-First condition and Class C in the Alternating condition, with the respective classroom teachers observing. For the Addition Unit, Class A and Class B were deliberately inverted, such that Class B participated in the Task-First condition and Class A the Teach-First condition. Class C remained in the Alternating condition. This cross-over approach ensured that the three teacher-participants observed their students experience both the task-first and teach-first conditions. This description of the program structure is summarised in Table 1.

[1] Note that all teacher and student names have been replaced with pseudonyms.

Table 1
Structure of the Overall Research Program.

Unit of Work	Task-First	Teach-First	Alternating
Patterning: Term 2 (20 lessons)	Class A (Rachel)	Class B (Polly)	Class C (Sally)
Addition: Term 3 (16 lessons)	Class B (Polly)	Class A (Rachel)	Class C (Sally)

Overview of a lesson: Task-First versus Teach-First

Figure 1 provides an overview of the two different lesson structures, and the approximate time allocated to each phase of the lesson. A brief summary of each of the two approaches is provided. Note that, for the purposes of the current study, 'routine tasks' is a term intended to reflect simpler mathematical tasks which exist in juxtaposition to more cognitively demanding (challenging) tasks. Generally, routine tasks can be solved by the student following one (or several) established steps, the application of which has been demonstrated during prior instruction and discussion.

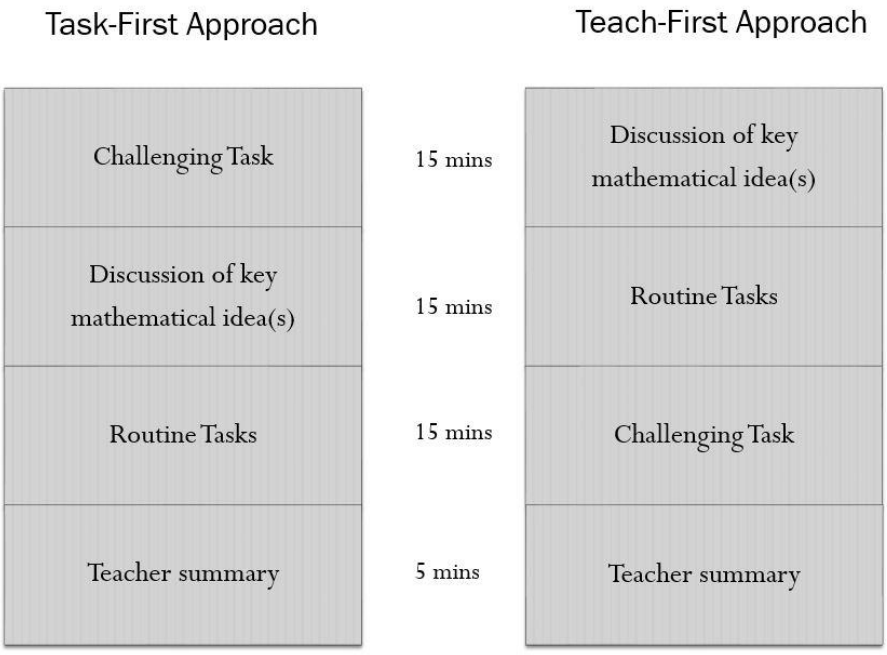

Figure 1. Alternative lesson structures: Overview.

Task-First Approach

The structure of the task-first session largely mimicked Sullivan et al.'s (2014) suggested structure, with work on a challenging task beginning the lesson (incorporating both its launch

and exploration by students), followed by a discussion of the key mathematical ideas, and an opportunity for students to consolidate their learning. To expand, the task-first session began with the launch of the challenging task by the researcher. Students were then provided with an opportunity to explore the task, either individually or collaboratively, with an emphasis placed on students being able to explain their own mathematical reasoning. The class then came back together to discuss the key mathematical ideas, and examine potential solutions to the challenge. Students were then exposed to several more 'routine' mathematical tasks, designed to consolidate their understanding. The researcher concluded the session with a brief summary, clearly stating the learning objective and inviting two or three students to very briefly present their responses to some of the routine tasks that reinforced this objective.

Teach-First Approach

By contrast, the Teach-First Approach began with what can be considered a student-centred 'mini-lesson', where the teacher introduced the learning objective, and proceeded to facilitate a discussion of the key mathematical ideas to be explored in the session. Students were then given a series of 'routine' mathematical tasks to establish their understanding of the concepts introduced. The class then briefly came back together, and the challenging task was launched and subsequently explored by students. Again, the researcher concluded the session with a brief summary. This involved restating the learning objective and calling upon one or two carefully selected students, whose approach to the challenging task aligned with the learning objective, to very briefly explain how they approached the challenging task.

Data collection and analysis

One week after the completion of both the Patterning Unit and the Addition Unit, semi-structured interviews were undertaken by the researcher (first author) with each of the teacher-participants individually. Teacher-participants had been encouraged to informally record their reflections and observations (in the form of a journal) following each of the lessons. They were then invited to spend some time reflecting on these experiences prior to their interviews with the researcher.

The key question asked of participants during the second interview of particular relevance to the current study was as follows.

> You have now seen challenging tasks used to both launch lessons and extend understanding. How do you think you would utilise challenging tasks in the future? Why?
>
> When answering this question, the interviewee was encouraged to consider a range of issues, including student learning outcomes, classroom management issues, encouraging student persistence, building intrinsic motivation to learn mathematics, the skills and knowledge required by the teacher, and the quality of the mathematical discussion.

With regards to the data analysis, each of the three transcriptions were read repeatedly, until a distinct understanding of the particular narrative capturing each teacher-participants experience with the program emerged. The three narratives were then compared and contrasted, in order to generate sets of themes that could meaningfully address the research questions. This approach to analysing qualitative data mirrors that of Interpretative Phenomenological Analysis (Smith & Osborn, 2008).

Results

The results section has been organised around the three research questions. Sub-headings under each research question highlight key themes to emerge from the analysis of teacher-participant narratives, and essentially serve to summarise study findings. In an attempt to illustrate and further flesh out each theme, particularly compelling quotes from the interviews have also been included.

What advantages did teachers perceive a Task-First Approach to have when teaching with cognitively demanding tasks?

Task-First Approach: Encourages creativity and empowerment.

There seemed to be a consensus amongst the three teachers that beginning a lesson with the challenging task appears to foster more creative forms of mathematical thinking. Sally clearly placed considerable value on the freedom given to students in the Task-First Approach.

> You know sometimes we can stifle kids' creativity, if we are teaching this strategy, and this way of thinking… When you are saying this is the challenge, go and tackle it, you are not stifling that thinking that they already have going on. So I loved that element of it. I think that was probably my favourite part of the lesson – hearing them explain their thinking. *Sally, Patterning Unit.*

Similarly, Rachel emphasised the importance of students being empowered to develop their own solutions to problems.

> And they had to think of it themselves. And I think that is a really important skill to learn – that you find your own way to solve it. I mean, I always found you get taught a certain way and you're thinking "that doesn't make any sense to me". Whereas if you had of had a different strategy, then it could have made a lot more sense… Yeah I think there was some pride. That they had achieved it. They all wanted to share their ideas. *Rachel, Patterning Unit.*

However, this greater creativity, empowerment and freedom was also accompanied by greater uncertainty and some discomfort, particularly when students were first exposed to the previously unfamiliar experience of beginning a lesson with a challenging task. As Rachel noted:

> I think to start off with, as I said, some of them didn't know what to do. And they are not used to that style of teaching. They are used to "We talk about this first, then we get an idea, and then we go off and do our work". *Rachel, Patterning Unit.*

By contrast, the perception was that beginning with the teacher-facilitated mini-lesson first directed students in a specific direction, and led to many students attempting to apply teacher-demonstrated strategies. Rachel emphasised how the different lesson structure completely changed the tone of the lesson, and the type of mathematical thinking demonstrated by students.

> Yeah. It was a big difference for me I think. The challenge first, you were getting to see how their brains ticked a lot of the time, because they were sent off and they had to find their own way to work out the challenge, based on previous lessons, and what they thought might be the best strategy to use. This time I guess I found it different because they were getting the lesson first, and they had to go off and do what was taught in the lesson, and apply that strategy. Some of them still did try and use a different strategy, even though they had the lesson first, but the majority of them were just using that strategy that you had taught to them in that lesson, which was a huge difference I think. *Rachel, Addition Unit.*

Task-First Approach: Engages students.

Similarly, there also seemed to be a consensus amongst teachers that having the challenge first was a highly engaging way in which to begin the lesson. As Rachel and Sally outlined, many students seemed to eagerly await the challenge.

> I think there was a certain buzz when they came in and had to do the challenge first. I think I noticed that in my class. They were a bit excited: "I wonder what the challenge is going to be today?". *Rachel, Addition Unit.*

> You know, being set a challenge each week and there was some kids like… You know Josh and Neo, and Liam… they were looking at the challenge when you put it up on the board and they wanted to be first, and they wanted to work it out. You know, they were doing that in their head. *Sally, Patterning Unit.*

Task-First Approach: Builds persistence.

There was also a perception amongst teachers that the Task-First Approach helped to build student persistence. According to Rachel, this opportunity to persist was directly a result of the greater uncertainty students experienced with regards to how to proceed with the task. By contrast, because students had a clearer idea of what they were required to do under the Teach-First Approach, there was less of a need for students to demonstrate persistence.

> I think a lot of them showed a lot of persistence in the challenge first. Even though a lot of them, sometimes, didn't know what was going on, I think they showed persistence in wanting to work it out… And I guess it was different with the lesson first. I had a few that weren't catching on, but a lot of them were catching on to what was going on, so they were able to get the work done. *Rachel, Addition Unit.*

Polly placed more emphasis on the psychological aspect of having to undertake the challenge first in building persistence. She essentially concluded that if students could get through the challenge, they knew that the rest of the lesson would be manageable, providing them with an incentive to persist through the challenging task. In juxtaposition, the prospect of having to work through the challenging task towards the end of the lesson could become overwhelming for students in her view, a consequence of both fatigue and perhaps anxiety brought about by anticipating difficulties with the task.

> I think they persisted more with the challenge first… I don't know whether it was the structure of having the challenge first, or because they come in and they are not as tired. They come in, ready to learn, and they hit the task. They've done the hardest bit first, and then it's kind of downhill from there. And then when they get to the (consolidating) task at the end, well that was easy-peasy… Whereas what happened last term was we did the worksheet, and that was very hard for them, and then it just got harder again… I don't know whether psychologically, subconsciously, whether "ok the hard bit is done now, now I have got the easy bit" and you sort of think "oh good, I can do this". I mean as humans, when we know something is easier we sort of relax a little bit more, whereas when we know something hard is coming up, we kind of brace ourselves for it. *Polly, Addition Unit.*

Task-First Approach: Provides an authentic assessment opportunity.

Related to the notion that the Task-First Approach prompts students to demonstrate both more creative mathematical thinking and considerable persistence is the idea that beginning a lesson with a challenging task provides an authentic assessment opportunity. Sally noted how working within this structure allowed her to observe students in their capacity to apply their knowledge without direct scaffolding from a teacher.

> I got a chance to see what they knew before you had planted anything in their brain. And I thought that was really fantastic. *Sally, Patterning Unit.*

Elaborating on this idea in more detail following the second unit of work, Sally discussed her recent experience of teaching an open-ended lesson on data.

> It was fascinating, fascinating. I really just said to them "Here is a paint pot. How can we decide what is the most popular colour in our classroom". And the maths thinking that came out of that was about 50 times greater than if you said to them "Here's graph paper. We're making a graph on our favourite colour". Because all of a sudden you get all this information that you didn't know you would. *Sally, Addition Unit.*

Rachel concurred with Sally that the Task-First Approach provided valuable insight into student mathematical thinking, relative to more conventional teaching approaches.

> But I really liked that I got to see how they could solve the problem, what strategies they already knew, what strategies they could learn to do themselves... they could show their own thinking, without having to have that lesson first. *Rachel, Patterning Unit.*

Task-First Approach: Generates meaningful discussion and reflection.

Both Sally and Polly acknowledged the value in having students work on a task prior to a teacher-led discussion. Polly perceived that having the mini-lesson after engaging with the challenging task meant that students were more invested in the class discussion, and receptive to listening to peers describe different ways of approaching the task. She also emphasised the importance of students then being able to put these learnings into practice through undertaking the consolidating task.

> And I think it made coming back and discussing the teaching – or the reflection on what just happened – more meaningful because they tried it out first. And they came back and they thought "Ah ok, so I could have done it like this. Oh gee, I didn't do it like that, but I could have". I think that was actually more beneficial in many ways than giving them everything that they needed to do a task, and then sending them off... I think it was great to have that reflection after. It gave them the opportunity to then apply that knowledge to the easier work. And it made a lot more sense with the easier work. *Polly, Addition Unit.*

Sally also placed considerable value on the post-task discussion with students.

> That is the thing that I said to you that I miss when you flip-it. Where there is no time for that really in-depth discussion. *Sally, Addition Unit.*

However, Sally also noted one of the shortcomings of a lesson being reliant on an effective, teacher facilitated discussion; that is, the physical and psychological availability of the classroom teacher. It was clear that Sally perceived the Task-First Approach as being quite demanding on a teacher as the lesson unfolds in real-time.

> In the day-to-day of the classroom as well, you need to consider the fact that you can't always be that available during a maths class either… Sometimes, when you are on your own, they come in from lunch and this argument has happened, or that argument has happened… So you have to be really engaged and really involved to be able to then do that (coordinate the discussion) effectively. And I know for me in my classroom this year, with all the behavioural issues I have, that I would really struggle with that. *Sally, Addition Unit.*

What advantages did teachers perceive a Teach-First Approach to have when teaching with cognitively demanding tasks?

Teach-First Approach: Creates greater focus.

Rachel noted that students appeared more focussed and on task when the lesson began with the teacher facilitated discussion. She linked this more focussed behaviour to the contrasting sense

of ambiguity and discomfort students experienced when they began the lesson with the challenging task.

> With the structured lesson first, it seems more pulled together. They are more focussed on the floor: they come in, sit down and get their lesson, and then they go off and get their work done, because they are not sort of distracted from not knowing what to do… I think they were more on task in the lesson first scenario. I think some of them, with the challenge first, when they didn't know what to do, they just got distracted, and just started mucking around a little bit. *Rachel, Addition Unit.*

Teach-First Approach: Provides a more efficient approach to learning

Rachel also suggested that the Teach-First Approach, in part because students were more on-task, appeared the more efficient approach to instruction in terms of student learning. By contrast, the Task-First Approach seemed more time intensive, as students had to work through the aforementioned ambiguity before making progress with the task.

> I think that one of my concerns the first time (Task-First Approach) is that some of them had just started to work out a way to solve the problem, and the time was up. And they had to come to the floor, and they didn't find any success because they didn't have the time. Whereas with the lesson first, they had that time to sit there and go "Ok I know how I have to do this". And they used it (the time) quite well I think… They went off, and knew what they had to do, and decided to try it straight away. *Rachel, Addition Unit.*

Teach-First Approach: Allows less confident and lower performing students to be successful.

Rachel and Sally also offered the perspective that beginning with the lesson tended to better support less confident and lower achieving students, who benefitted from greater teacher scaffolding and support. By contrast, many of the more confident and higher achieving students appeared to thrive when the lesson was launched with the challenging task.

> I think generally the weaker, less confident kids responded to the lesson first, and then building to the challenge. And then I think that the kids who had the confidence, and the willingness to have a go, loved having the challenge first. *Sally, Patterning Unit.*

> I had more concerns with kids in the first unit of work, when the challenge was first, than I did this term… I think with the lesson first, it made the challenges much easier… because they had had the lesson, then they'd practiced it, and then they can apply it. So I think a lot of them found it much easier, which I guess is good, because then they felt like they could do it – they felt successful. *Rachel, Addition Unit.*

When it came to considering their own teaching practice, did teachers have a preference for one particular approach?

This question considered the beliefs of the three teacher-participants in terms of how they might teach with challenging tasks in the future. The key finding is that teacher-participants differed considerably in their conclusions as to how they would consider teaching with challenging tasks. These perspectives are elaborated on below.

Sally: Conceptualises lesson structure as the 'best fit' for a given student, rather than 'best practice'.

Sally perceived that different students responded differently to the different lesson structures. According to Sally, whereas some students thrived when engaging with the Task-First Approach, other students responded better to, and seemed to have a preference for, the Teach-

First Approach. In her view, such diversity makes the emergence of any form of 'best practice' in relation to lesson structure somewhat unlikely.

> Look I really struggle with this one, because I actually think there is a percentage of the grade who respond best to each… I feel like having seen the difference in the way the kids tackled those problems and how they coped differently, it actually really opens my eyes to the fact that, as teachers, it is really important to mix things up. *Sally, Addition Unit.*

Moreover, Sally concluded that it becomes the responsibility of the teacher to look past her own individual preferences for a particular learning approach and ensure she provides a variety of different learning experiences for students.

> It is easy to do what comes naturally to you, but you might not be aware of the impact that's having on your students. And I think that was what was really powerful about this for me, was that sometimes, in the teaching of it, one way may have felt more unnatural – I don't know if one felt easier or more normal for you? But typically speaking we would go lesson-first, then challenge. But it really opened my eyes to the fact that maybe when we take that closed off view, we're actually kind of disabling some of those kids, and, you know, holding them back. *Sally, Addition Unit.*

Although Sally suggested that generally the students she perceives as more mathematically capable demonstrated a relative preference for the Task-First Approach, in her view this was not exclusively the case.

> I am just looking at my notes here. "Surprised by the fact that those students who most enjoyed being challenged weren't necessarily the strongest students". So Liam, who finds maths really challenging, approached the (challenging) task in a really focussed way. And Jake quit when things got difficult, even though he is more than capable. And you look at those two kids. Jake is probably more capable than Liam. And he just threw in the towel. *Sally, Patterning Unit.*

Rachel: Preferred teach-first for supporting lower-achieving students and managing the classroom.

Despite acknowledging the strengths of the Task-First Approach, particularly with regards to engaging students, building persistence and the opportunity for authentic assessment, overall Rachel indicated a preference for the Teach-First structure. In part this was related to her perception that the Teach-First Approach was more efficient.

> It is a tricky one. I think they learn more when the lesson's first, but I like to see what they can do when they don't have the lesson first, because it is challenging them a lot... I would probably feel more comfortable having the lesson first myself as a teacher. *Rachel, Addition Unit.*

Additional reasons for Rachel preference for the Teach-First Approach related to her capacity as a teacher to provide sufficient support to those students who required it, and to manage the classroom accordingly.

> I find then, especially when you are on your own… because in here we've got the two of us and we can roam around. But when it is just you in the classroom, if you are giving out a challenge first and there are a lot of kids who don't know what they are doing and need that support, I think it can be quite tricky to get around to all of them, to manage that… Whereas, when you have the lesson first, the majority of them will catch on, and be able to do the work independently, and you just have to have a small group who you just work with. *Rachel, Addition Unit.*

Polly: Apparent preference for the Task-First Approach, however difficult to analyse the impact of lesson structure independently of a 'practice effect'.

It was apparent during the teacher interviews that teaching with challenging tasks was powerfully different from how the study teachers typically approached a mathematics lesson. Consider, for example, Polly's comments during her interview after her class undertook the Patterning Unit, which her class experienced through the *more scaffolded* Teach-First Approach.

> Well I think initially when they first started off from the very first lesson they had absolutely no clue about what to do! I was thinking "oh no, they've got no idea". They were wandering around, they just sat there, and they didn't have any idea about how to even approach the subject. I don't think they even really knew what you were asking of them. They were completely like… it was like they were in this cloud of mist, and they didn't know where they were. By the end… I mean each day it got better and better, so that by the end, they knew what they had to do. They knew how to use the tools that were there like the counting chart and the abacus… More and more kids switched into what the actual problem was… *Polly, Patterning Unit.*

Consequently, there is a risk of overstating the impact of lesson structure, as compared to a 'practice effect', whereby students became accustomed to the higher expectations and greater autonomy typically encountered during a lesson involving challenging tasks. Polly indicated that, although she perceived the second unit of work, which was structured such that the task was first, to be more effective, she was uncertain whether to attribute this to the structure of the lesson or prolonged exposure to challenging tasks.

> I think this term worked better than last term… I think they were more settled with the challenge first… But once again, it is hard to know isn't it, because of them having had the term before. They were more used to the whole format of everything… They already came to it with a better frame of mind because of understanding the expectations. And they were ready to work right from the beginning, instead of floundering from the beginning. They understood what the hint sheet was all about more – and even I understood more what the hint sheet was all about… I felt that more of them were on task and they seemed to get a grasp of what was happening more. They might not have come to the right answers, but I think one of the good things was that they were grappling with the problem. *Polly, Addition Unit.*

Interestingly, despite Polly commenting positively about the program, particularly the Addition Unit involving the Task-First Approach, she remained reluctant to teach with challenging tasks in any capacity.

> Nup, I just don't have the know-how… You know, if someone else planned it, and I had to administer it, I would be more inclined to do that. But no, there is no way in the world… I wouldn't know what to do... *Polly, Addition Unit.*

Discussion

Analysis of the teacher interviews revealed that teachers perceived each of the two lesson structures to offer distinct benefits. Although no specific hypotheses were put forward with regards to how teacher-participants may perceive the two different lesson structures to impact on student learning, it is worth noting that the teacher perceptions uncovered in the current study were highly consistent with the arguments and evidence contained within prior research. Specifically, it was found that the Task-First Approach was perceived by teachers as better able to: foster mathematical creativity as students had the opportunity to 'discover' idiosyncratic, and often more than one, solution methods (e.g., Leikin, 2009; Sullivan & Davidson, 2014); promote meaningful discourse amongst students (e.g., Forman et al., 1998; Woodward & Irwin, 2005); build student persistence (Sullivan et al., 2014); and effectively engage students through challenge (Sullivan et al., 2012). Conversely, there was also some support for the postulation put

forward by some cognitive load theorists that a lesson which begins with some form of explicit teaching, such as the Teach-First Approach, constitutes a more focussed, efficient approach to instruction (e.g., Kirschner, et al., 2006; Sweller et al., 2007). Indeed, even the belief that a Teach-First Approach may be more appropriate for lower-achieving students, not mentioned in our brief literature review, has precedence (e.g., Westwood, 2011). Overall, this implies that framing the Task-First Approach or Teach-First Approach as an either/or proposition is perhaps overly simplistic, as both approaches appear to have distinct strengths in terms of student learning outcomes, at least as construed by observing teachers. This conclusion is perhaps contrary to conventional wisdom. For example, Sullivan et al., (2014) argued that traditional lesson structures, characterised by some form of teacher explanation preceding student practice (equating to the Teach-First Approach in the current study), can inhibit the possibility of even well-designed tasks facilitating opportunities for students to engage in higher level mathematical thinking.

The central tension identified by teacher-participants in the current study between wanting students to discover and subsequently own their personalised solution method and teachers leading students towards the most efficient (or mathematically important) solution method is not novel, and has been revealed in previous research. For example, Star and Rittle-Johnson (2008) found that encouraging year six students to discover their own methods for solving linear equations led to them demonstrating a broader variety of problem solving strategies, however directed teaching in how to solve such equations resulted in students incorporating more efficient strategies. This tension has been described elsewhere by Baxter and Williams (2010) as "managing the dilemma of telling", and is the central theme of their paper which observes the classroom practice of two teachers who are attempting to employ problem-based approaches to learning mathematics (Baxter & Williams, 2010, p. 7).

A corollary of the finding that the Task-First Approach and the Teach-First Approach have distinct strengths is that a particular teacher's preference for one approach over another will likely depend in part on what student learning outcomes she prioritises as a teacher. For example, a teacher who is strongly focussed on meeting the needs of the three or four students in her classroom who have severe difficulties with mathematics may be inclined to embrace the Teach-First Approach. By contrast, a teacher who views mathematics learning as being principally about struggle and discovery will likely embrace a Task-First Approach. The notion that the idiosyncratic values that teachers hold regarding what they believe should be the primary learning objective impacts on their subsequent approach to instruction has been raised in a variety of other primary education contexts, including foreign-language learning (e.g., Pichon, 2014) and the use of technology in classrooms (e.g., Warwick & Kershner, 2008).

Interestingly, Sally put forward an equity-based argument as to why teachers need to suspend their own preferences for a particular lesson structure, and consider incorporating a mixture of approaches in their classrooms. Sally noted that, anecdotally, it appeared some students responded better to, and had a preference for, the Task-First Approach, whilst other students responded better to, and had a preference for, the Teach-First Approach. She implied that such diversity in student reactions makes the emergence of any form of best practice somewhat unlikely. Sally's position is consistent with the proposition that one size is unlikely to fit all within the context of mathematics education (Ridlon, 2009), although others may argue that preferring the Teach-First Approach reflects such students having not yet developed a mastery orientation towards mathematics. For example, Dweck (2000) contended that students who are more willing to take risks and less concerned about social affirmation, are more inclined to both embrace, and persist with, a challenge. In any case, a related study by the current authors found that Sally's contention that students have a distinct preference for either a

Task-First Approach or a Teach-First Approach is in fact corroborated empirically (Russo & Hopkins, in press).

Finally, there was some support for the notion that the Task-First Approach may allow less confident and experienced teachers to experiment with incorporating more challenging tasks into their mathematics lessons. Specifically, Rachel, a first-year graduate teacher, noted that part of her reason for preferring the Task-First Approach was the less demanding classroom management aspect. Although it may be argued that using challenging tasks in this manner undermines their learning potential, such a conclusion may warrant further evaluation. For example, it may be that mastering the use of challenging tasks to extend student thinking enables the development of the requisite skills, knowledge and confidence for teachers to subsequently use such tasks to launch lessons. Having said this, it is noteworthy that, at least in Polly's case, a teacher who self-identified as having (relatively) limited content knowledge in the area of mathematics was still reluctant to incorporate challenging tasks, even when such tasks were used to extend student thinking, following a more traditional lesson structure (i.e., Teach-First Approach).

Concluding Thoughts

To summarise, there are two key findings to emerge from the current study. The first key finding is that teacher-participants perceived both the Task-First Approach and the Teach-First Approach to teaching with challenging tasks to have distinct strengths. The Task-First Approach was viewed as engaging and empowering for students, providing an opportunity to build student persistence whilst fostering student mathematical creativity. Teacher-participants also placed value on the quality of the mathematical discussion which emerged, and the value of the Task-First Approach for an authentic assessment of student mathematical knowledge. By contrast, the Teach-First Approach was viewed as highly focussed and an efficient approach to learning. It was also perceived as providing an opportunity for lower-achieving and less confident students to be successful.

The second key finding to emerge is that, notwithstanding these important differences, it appears that the type of tasks incorporated into lessons and the overall pedagogical approach may be perceived by teachers as at least as important as the specific lesson structure adopted. For Polly in particular, it is likely that incorporating challenging tasks regularly into lessons in any capacity would represent a significant change in her teaching practice. Therefore, at least for teachers like Polly, whether the task is used to launch a lesson or extend student thinking may be secondary to the presence of challenging tasks themselves. As a corollary of this, when comparing the two units of work, practice with challenging tasks may have been as important as lesson structure, as the class adapted to learning with challenging tasks. Consequently, although there appear to be distinct advantages to both the Task-First and Teach-First Approaches, the most dramatic shift in teaching practice for some teachers may be the incorporation of more cognitively demanding tasks into their mathematics instruction in any capacity.

References

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? *Journal of Educational Psychology, 103*(1), 1-18.

Baxter, J. A., & Williams, S. (2010). Social and analytic scaffolding in middle school mathematics: Managing the dilemma of telling. *Journal of Mathematics Teacher Education, 13*(1), 7-26.

Charalambous, C. Y. (2008). Mathematical knowledge for teaching and the unfolding of tasks in mathematics lessons: Integrating two lines of research. In O. Figueras, J. Cortina, S. Alatorre, T. Rojano & A. Sepúlveda (Eds.), *Proceedings of the 32nd conference of the International Group for the Psychology of Mathematics Education* (pp. 281-288). Morelia, Mexico: PME.

Cheeseman, J., Clarke, D. M., Roche, A., & Wilson, K. (2013). Teachers' views of the challenging elements of a task. In V. Steinle, L. Ball & C. Bardini (Eds.), *Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 154-161). Melbourne, Australia: MERGA.

Darragh, L. (2013). Sticking with it or doing it quickly: What performances do we encourage in our mathematics learners? In V. Steinle, L. Ball & C. Bardini (Eds.), *Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 218-225). Melbourne, Australia: MERGA.

Dweck, C. S. (2000). *Self-theories: Their role in motivation, personality, and development*. Philadelphia, United States: Psychology Press.

Forman, E. A., Larreamendy-Joerns, J., Stein, M. K., & Brown, C. A. (1998). "You're going to want to find out which and prove it": Collective argumentation in a mathematics classroom. *Learning and Instruction, 8*(6), 527-548.

Forrester, P. A., & Chinnappan, M. (2010). The predominance of procedural knowledge in fractions. In L. Sparrow, B. Kissane & C. Hurst (Eds.), *Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia* (pp. 185-192). Fremantle, Australia: MERGA.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*(2), 99-107.

Hollingsworth, H., McCrae, B., & Lokan, J. (2003). *Teaching mathematics in Australia: Results from the TIMSS 1999 video study*. Camberwell, Australia: Australian Council for Educational Research.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75-86.

Kuhn, D. (2007). Is direct instruction an answer to the right question? *Educational Psychologist, 42*(2), 109-113.

Leikin, R. (2009). Exploring mathematical creativity using multiple solution tasks. In R. Leikin, A. Berman & B. Koichu (Eds.), *Creativity in mathematics and the education of gifted students* (pp. 129-145). Rotterdam, the Netherlands: Sense Publisher.

Marshall, J. C., & Horton, R. M. (2011). The relationship of teacher-facilitated, inquiry-based instruction to student higher-order thinking. *School Science and Mathematics, 111*(3), 93-101.

Pichon, C. (2014). What do teachers value and perceive to be the purpose of Foreign Languages in Key Stage Two–a multi-case study. *Language Issues: The ESOL Journal, 25*(2), 59-60.

Ridlon, C. L. (2009). Learning mathematics via a problem-centered approach: A two-year study. *Mathematical Thinking and Learning, 11*(4), 188-225.

Roche, A., Clarke, D.M., Sullivan, P., & Cheeseman, J. (2013). Strategies for encouraging students to persist on challenging tasks: Some insights from work in classrooms. *Australian Primary Mathematics Classroom, 18*(4), 27-32.

Russo, J. (2015). Teaching with challenging tasks: Two 'how many' problems. *Prime Number, 30*(4), 9-11.

Russo, J. (2016a). Teaching mathematics in primary schools with challenging tasks: The Big (not so) Friendly Giant. *Australian Primary Mathematics Classroom, 21*(3), 8-15.

Russo, J. (2016b). Teaching with challenging tasks: Baskets and boundaries. *Prime Number, 31*(3), 7.

Russo, J. (2016c). Teaching with challenging tasks: Hopping with Fiona the Frog. *Prime Number, 31*(2), 10-11.

Russo, J., & Hopkins, S. (2017a). *Does lesson structure matter for student mathematical performance when teaching with challenging tasks in the early primary years?* Manuscript submitted for publication.

Russo, J., & Hopkins, S. (2017b). CLASS Challenging Tasks: Using Cognitive Load Theory to inform the design of challenging mathematical tasks. *Australian Primary Mathematics Classroom, 22*(1), 21-27.

Russo, J., & Hopkins, S. (in press). Student reflections on learning with challenging tasks: "I think the worksheets were just for practice, and the challenges were for maths" *Mathematics Education Research Journal*.

Schmidt, H. G., Van der Molen, H. T., Te Winkel, W. W., & Wijnen, W. H. (2009). Constructivist, problem-based learning does work: A meta-analysis of curricular comparisons involving a single medical school. *Educational Psychologist, 44*(4), 227-249.

Smith, J. A., & Osborn, M. (2008). Interpretative phenomenological analysis. In J. A. Smith (Ed.), *Qualitative psychology: A practical guide to methods* (pp. 53-80). London: Sage.

Star, J. R., & Rittle-Johnson, B. (2008). Flexibility in problem solving: The case of equation solving. *Learning and Instruction, 18*(6), 565-579.

Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning, 10*(4), 313-340.

Stein, M. K., Smith, M., Henningsen, M., & Silver, E. A. (2009). *Implementing standards-based mathematics instruction*. New York, United States: Teachers College Press.

Sullivan, P., Askew, M., Cheeseman, J., Clarke, D. M., Mornane, A., Roche, A., & Walker, N. (2014). Supporting teachers in structuring mathematics lessons involving challenging tasks. *Journal of Mathematics Teacher Education*, 1-18.

Sullivan, P., Aulert, A., Lehmann, A., Hislop, B., Shepherd, O., & Stubbs, A. (2013). Classroom culture, challenging mathematical tasks and student persistence. In V. Steinle, L. Ball & C. Bardini (Eds.), *Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 618-625). Melbourne, Australia: MERGA.

Sullivan, P., Clarke, D. M., Clarke, B., & O'Shea, H. (2010). Exploring the relationship between task, teacher actions, and student learning. *PNA, 4*(4), 133-142.

Sullivan, P., Clarke, D. M., Michaels, D., Mornane, A., & Roche, A. (2012). Supporting teachers in choosing and using challenging mathematics tasks. In J. Dindyal, L. Cheng & S. Ng (Eds.), *Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia* (pp. 688-695). Singapore: MERGA.

Sullivan, P., & Davidson, A. (2014). The role of challenging mathematical tasks in creating opportunities for student reasoning. In J. Anderson, M. Cavanagh & A. Prescott (Eds.), *Proceedings of the 37th annual conference of the Mathematics Education Research Group of Australasia* (pp. 605-612). Sydney, Australia: MERGA.

Sullivan, P., & Mornane, A. (2013). Exploring teachers' use of, and students' reactions to, challenging mathematics tasks. *Mathematics Education Research Journal, 25*, 1-21.

Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. *Educational Psychology Review, 22*(2), 123-138. doi: http://dx.doi.org/10.1007/s10648-010-9128-5

Sweller, J., Kirschner, P. A., & Clark, R. E. (2007). Why minimally guided teaching techniques do not work: A reply to commentaries. *Educational Psychologist, 42*(2), 115-121.

Thomas, J. A., & Monroe, E. E. (2006). Self-study of a teacher's journey toward standards-based mathematics teaching. *Studying Teacher Education, 2*(2), 169-181.

Tzur, R. (2008). A researcher perplexity: Why do mathematical tasks undergo metamorphosis in teacher hands? In O. Figuras, J. Cortina, S. Alatorre, T. Rojano & A. Sepulveda (Eds.), *Proceedings of 32nd conference of the International Group for the Psychology of Mathematics Education* (pp. 139-147). Morelia, Mexico: PME.

Warwick, P., & Kershner, R. (2008). Primary teachers' understanding of the interactive whiteboard as a tool for children's collaborative learning and knowledge-building. *Learning, Media and Technology, 33*(4), 269-287.

Westwood, P. (2011). The problem with problems: Potential difficulties in implementing problem-based learning as the core method in primary school mathematics. *Australian Journal of Learning Difficulties, 16*(1), 5-18.

Woodward, J., & Irwin, K. (2005). Language appropriate for the New Zealand numeracy project. In P. Clarkson, A. Downton, D. Gronn, M. Home, A. McDonough, R. Pierce & A. Roche (Eds.), *Proceedings of the 28th annual conference of the Mathematics Education Research Group of Australasia* (pp. 799-806). Melbourne, Australia: MERGA.

Authors

James Russo
Monash University
Wellington Rd
Clayton, 3800
Australia
email: james.russo@monash.edu

Sarah Hopkins
Monash University
Wellington Rd
Clayton, 3800
Australia
email: s.hopkins@monash.edu