

Student Attitudes Towards Learning Mathematics Through Challenging, Problem Solving Tasks: “It’s so Hard—in a Good Way”

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Abstract

Despite a focus on teaching mathematics through challenging, problem solving tasks, there has been limited research into student attitudes towards these learning experiences. To address this gap in the literature, we asked 52 Australian primary students who had recently experienced mathematics taught in this manner to convey their feelings about learning through problem solving. Adopting a qualitative, exploratory, research design, student participants completed a brief questionnaire, and a sub-set also contributed to follow-up focus groups. Thematic analysis of the questionnaire data revealed that three-quarters of students reported unambiguously positive attitudes towards problem solving, most others were ambivalent, and no students expressed negative attitudes. Younger students (Year 3/4) were more likely to express positive attitudes than older students (Year 5/6) and boys more likely to express positive attitudes than girls. Positive attitudes arose from students enjoying learning through problem solving, the perception that it supported their learning, and students thriving on challenge. Follow-up focus groups also reinforced the power of working collaboratively, particularly the importance of learning through discussions with peers, and opportunities to explore authentic and purposeful tasks. The findings help explain why students frequently have positive reactions to learning mathematics through problem solving.

Keywords:

Challenging Tasks, Mathematics Education,
Problem Solving, Student Attitudes, Student Enjoyment

Introduction

The quality of tasks that students engage with in the classroom has been widely acknowledged as critical to supporting student mathematical learning (Anthony & Walshaw, 2010). Consequently, “selecting, designing, and modifying tasks for teaching” is central to the practice of all teachers of mathematics (Tekkumru-Kisa et al., 2020, p. 3). Indeed, teaching with more cognitively demanding tasks through problem-based learning approaches has been an important aspect of efforts to reform mathematics education in many countries, including: Australia (Sullivan et al., 2016, 2020), Indonesia (Siagan et al., 2019; Simamora



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& Saragih, 2019), Sweden (Samuelsson, 2010), Turkey (Bulut, 2007), Portugal (Viseu & Oliveira, 2017), the United Kingdom (Boaler 1998, 2000), and the United States (Stein & Lane, 1996; Stein et al., 2008), to name but a few. On occasion, teaching mathematics through problem solving has been augmented by efforts to simultaneously develop students' meta-cognitive problem solving skills, so that they can engage more productively in cognitively demanding tasks (Özsoy & Ataman, 2009). Teaching mathematics through challenging, problem-solving tasks has been shown to support student learning through: encouraging students to connect mathematical ideas (Loibl et al., 2017); promoting the transfer of problem solving skills (Kapur, 2010); cultivating critical thinking skills and mental flexibility (Leikin, 2014); supporting mathematical creativity and discourse (Russo & Hopkins, 2017a); and developing problem solving skills (Karatas & Baki, 2013).

Despite evidence for their impact on student learning, there have been relatively few studies examining student experiences with challenging, problem solving tasks (Tekkumru-Kisa et al., 2020). Although some teachers are hesitant to introduce such challenging, problem solving tasks to all students regardless of their perceived mathematical ability (Ingram et al., 2019; Leikin et al., 2006), there is evidence that many students' embrace struggle and thrive on challenge (Russo & Hopkins, 2017b; Sullivan & Mornane, 2014). Previous studies that have discussed student attitudes to problem solving in an Australian educational context have focused on early primary (i.e., Year 1, Year 2; Russo & Hopkins, 2017b) or secondary (i.e., Year 8; Sullivan & Mornane, 2014, Year 10; Wilkie, 2016) contexts. The current research-practice partnership endeavoured to add to this existing literature through examining the attitudes of middle and upper primary students (Years 3 to 6) to learning mathematics through challenging, problem solving tasks.

Background Literature

Attitudes refer to ways in which individuals may act, feel, or think as a means of expressing their view (positive or negative) about a particular topic. They are considered more enduring and cognitive than emotions, but less enduring and cognitive than beliefs (Philipp, 2007). Student attitudes have been an increasing focus of research into mathematics education over the past two decades. Relevant to the current study, there is a growing body of literature connecting instructional approaches focused on learning mathematics through problem solving with positive attitudes towards mathematics learning (Chen et al., 2015; Chew et al., 2019; Hendriana et al. 2018; Higgins, 1997; Ni et al., 2018). However, as many

of these studies have adopted quantitative methods, they have tended to not probe the specific reasons for these positive attitudes, nor to delve into the experience of learning mathematics in this manner from the perspective of the student. By contrast, three recent studies have focussed on student reactions to learning mathematics through challenging, problem solving tasks in an Australian context in particular, and have incorporated some qualitative methods to explore explanations for these reactions.

Russo and Hopkins (2017b) interviewed 73 Year 1 and Year 2 students following their engagement in a unit of work (16 lessons) built around challenging, problem solving tasks. The associated classroom teachers involved in the study confirmed that students certainly experienced the tasks as cognitively demanding, and students frequently worked on the tasks for periods of 20 minutes or more without identifying any solutions (Russo & Hopkins, 2019; Russo, 2019). During the interviews, students were encouraged to sort through the work artefacts they created during the unit to prompt reflection. The authors concluded from their analysis of student responses that these young students embraced struggle and persisted when engaged in mathematics lessons involving challenging tasks, and moreover that many students enjoyed the process of being challenged.

Sullivan and Mornane (2014) led a design-based research project that supported five junior secondary teachers (Year 8) to deliver a unit of work built around challenging, problem solving tasks. This support included a workshop where the pedagogical approach was discussed and unpacked, a booklet of task ideas, and a demonstration lesson in the classroom. Part of the data collection process involved gathering student affective responses to the demonstration lesson in particular, and learning mathematics through challenging tasks more generally. The most frequently chosen words to describe how students felt working on such tasks were: challenged, interested and confused. Combining specific student reactions to two particular tasks, the authors noted that most students (53%) felt that working on these tasks was the 'same as usual', with some students (22%) responding that they liked/ preferred these tasks more than usual, and some students responding they liked/ preferred these tasks less than usual (24%). Sullivan and Mornane (2014) concluded from their study that "teachers' possible fears of widespread negative student reaction to challenge are unfounded" (p. 207).

Wilkie (2016) undertook a similar design-based project with 87 high-achieving senior secondary students (Year 10) and their respective teachers aimed at supporting teachers teach mathematics through challenging,

problem solving tasks. Following observing a particular lesson involving a quadratics task, the researcher had students complete a questionnaire to describe their reactions to the task. Wilkie's analysis revealed that most student descriptions of their reactions tended to emphasise affect (i.e., how they felt about their learning) rather than cognition (i.e., level of perceived challenge and the effectiveness of the task to support learning). Moreover, the vast majority of affective reactions to the task were positive (e.g., interesting, engaging, enjoyable, fun, good), and almost all the remaining reactions neutral (i.e., okay, alright). Only one student responded negatively to the task (i.e., being confused).

Theoretical Framework

Despite teacher concerns to the contrary, there is evidence to suggest that students often have positive attitudes towards learning mathematics through problem solving, particularly when enabling and extending prompts are used to augment the level of challenge (Russo & Hopkins, 2017b; Sullivan & Mornane, 2014; Wilkie, 2016). Enabling prompts make the task more accessible to students who require further support through: simplifying the problem, changing how the problem is represented, helping the student connect the problem to prior learning and/or removing a step in the problem (Sullivan et al., 2006, 2009). Extending prompts extend the task, or expose students to a similar task, that is more challenging, often to prompt generalising (Sullivan et al., 2006, 2009).

Self-determination theory can be used to help us understand why many students might enjoy learning mathematics through challenging, problem solving tasks, more than through more traditional instructional approaches (e.g., teacher explanations, followed by practice of more routine problems). Advocates of self-determination theory contend that there are three fundamental psychological needs that motivate behaviour: autonomy, competence and relatedness (Deci & Ryan, 2012). It can be argued that lessons involving challenging, problem solving tasks can support students in meeting all three of these needs.

First, working on challenging tasks promotes autonomy. Students have a choice over how they approach a task (Sullivan & Mornane, 2014), are frequently invited to solve a task in multiple ways (Russo et al., 2019), and, in many contexts in which these tasks are used (including the current study), are able to access enabling and extending prompts of their own volition (Russo et al., 2020). Second, working on challenging tasks promotes competence. Students have a strong sense that challenging, problem solving tasks are simultaneously

more demanding, yet more worthwhile and authentic than more routine mathematical work. Consequently, students who make progress with challenging tasks frequently experience a sense of pride and accomplishment (Russo & Hopkins, 2017b). Third, working on challenging tasks promotes relatedness. In lessons involving challenging tasks, inviting students to collaborate when exploring a task tends to be an important component of the overall lesson structure (Russo, 2020). Allowing students to collaborate after spending some initial time working individually on the task was indeed how challenging tasks were used with students in the current study.

The current qualitative, exploratory, study investigated the attitudes two classes of primary school students (Years 3 to 6) had towards learning mathematics through challenging, problem solving tasks. We were interested in exploring the reasons underpinning these attitudes, as well as whether differences existed in attitudes across grade level and gender. Our study adds to the existing literature, due to both the qualitative methodology adopted, and the age group of the students.

Method

Participants

Two classes of students ($n= 52$) from one particular school completed a questionnaire after participating in a lesson involving problem solving. Participating students included one Year 5/6 composite class (26 students), and one Year 3/4 composite class (26 students). The school was a medium size primary school (approximately 300 students) situated in outer North-Western Melbourne. Its demographic profile was comparable to Australia as a whole, with most students being classified into the middle quartiles on the measure of community socio-educational advantage (67%). All students completed the questionnaire, which was returned anonymously.

School Context

According to the National Assessment Program – Literacy and Numeracy Assessment (NAPLAN) data, the school can be classified as an average-performing school in terms of its academic achievement, which is consistent with its demographic profile being reflective of Australia as a whole in terms of its relative advantage. Anecdotally, it is worth noting that there was relatively limited parental involvement in student learning at the school, and no specific initiatives to address this issue. Class sizes were between 25 and 30 in the middle and upper primary years.

Over the previous two years, most of the professional development that the school engaged with was focussed on a “visible-learning” approach, loosely based on John Hattie’s work (Hattie, 2012). This meant that significant emphasis was placed on areas such as learning intentions, success criteria, goal setting and growth mindsets.

As a result of this focus on “visible-learning”, there had been comparatively little time devoted to professional development in the area of mathematics. The school was a member of a Number Intervention project run by Catholic Education Melbourne. The program targets a small section of students from Year 1 to 4 to participate in an intervention program designed to address specific learning needs. However, only two staff members were directly involved in its implementation, therefore, it did not have an impact on the wider student population or the pedagogical approach of the bulk of the classroom teachers.

At the time of this study, the school had recently appointed a new mathematics leader (second author). The focus of his work was in getting teaching staff to pay more attention to the proficiency strands of understanding, fluency, reasoning and problem solving (i.e., how mathematics was being taught), rather than almost exclusively focussing on the content of the curriculum (i.e., what needed to be taught).

Both classroom teachers involved in this study were graduates. The Year 3/4 teacher was in her first year working as a teacher, after graduating from university at the end of the previous year. At the time of the study, she was planning in a team with two other colleagues, both considerably more experienced. Prior to her involvement in this coaching cycle, she felt that her students had few opportunities to work as genuine problem solvers in her mathematics lessons. She was pleasantly surprised both at how engaged her students were during the problem solving lessons, as well as their capacity to make good choices in relation to their learning when given the opportunity to do so (e.g. choosing when to access enabling prompts, selecting peers to collaborate with).

The Year 5/6 teacher was in her second year working as a classroom teacher at the time of the study. She actively requested to be included in the school’s mathematics coaching program, as many of her students had expressed to her that they were finding mathematics boring. She was also aware that she was having difficulty catering for the diverse range of student performance in her class, with some students complaining that the work her team was planning was too easy, while others were finding it so

challenging that they were becoming disengaged from the subject. While her self-confidence in her ability as a mathematics teacher was somewhat low in the current context, she was open to new ideas and willing to trial different approaches in order to improve her practice.

Procedure

The second author was tasked with working once a week in multiple classrooms across a school term, with the objective being to model (for the classroom teachers) how to teach with challenging tasks using a task-first approach. Specifically, the lesson structure being modelled resembled the launch-explore-discuss/summarise structure that is often adopted when teaching mathematics in this manner (Stein et al., 2008).

Students were asked to provide a written response to the following question directly after such a problem solving lesson: How do you feel about learning mathematics through problem solving? In addition, six students (3 boys, 3 girls) from Year 5/6, and six students (3 boys, 3 girls) from Year 3/4, also participated in focus groups designed to explore in more depth students’ feelings about learning mathematics through problem solving. Each focus group consisted of two students identified as relatively low-performing in mathematics, two students identified as average-performing in mathematics, and two students identified as high-performing in mathematics (as indicated by their classroom teacher).

In the Year 5/6 Case Study classroom, at the time of completing the questionnaire, students had experienced six lessons involving challenging, problem solving tasks: three modelled lessons led by the second author, and three lessons led by the classroom teacher. By contrast, in the Year 3/4 Case Study classroom, at the time of the questionnaire being administered, students had experienced approximately 25 lessons involving challenging, problem solving tasks: 10 modelled lessons led by the second author, and approximately 15 lessons led by the classroom teacher.

In both classrooms, this task-first approach differed greatly from what the vast majority of the students had previously been exposed to. In the past, the school favoured a more ‘traditional’ approach, where each lesson begins with the teacher modelling what the students will be working on, before the students are given time to apply the skill or concept independently.

Examples of Challenging, Problem Solving Tasks from The Study

The lesson that immediately preceded the administering of the questionnaire to the Year 3/4 class was based on a task developed by the second author. The main problem (see below) was launched with a brief story about a family vacation at a resort that had a large chess set. It was also accompanied with a picture of one of the children in the problem playing chess at the resort, which was placed on the classroom’s television during the launch phase.

Main task: Nash, Isaiah, Genevieve, Rhia, Megan and Ava decided to play a round robin chess tournament during the week that they stayed at Paradise Resort. How many matches will they have to play for each person to play each other player once?

The enabling prompt (see below), was placed on the teacher’s chair, the same spot where it was placed during all problem solving lessons in this particular room. At the conclusion of a five minute period where students had to work both silently and independently, they were free to access this prompt at any time that they felt it would be helpful and to collaborate with others (note that this same basic protocol was followed in the Year 5/6 classroom).

Enabling prompt: Can you draw a diagram to show how many matches Nash plays, so that he played each of the other kids once? Can you do the same for Isaiah?

The extending prompt (see below) for this particular lesson, asked students to extend their thinking from the initial problem, to see if they could make a generalisation about this particular type of problem.

Extending prompt: If there were 10 kids wanting to play a round robin tournament, how many matches will they have to play for each person to play each other player once? What if there were 20 kids? How about 100?

The lesson that preceded the questionnaire in the Year 5/6 classroom was a modified version of Adding and Subtracting Fractions, a task found in Challenging Mathematical Tasks by Peter Sullivan. The main problem (see below), was identical to the original version.

Main task: Some parts of my equation below did not print. What might the missing numbers be?

$$2 \frac{\square}{4} + \frac{\square}{8} = 3 \frac{\square}{\square}$$

Give as many answers as you can

However, both the enabling and extending prompts (see below) were modified, in order to include

specific direction for students to draw diagrams to match the equations they found. This was based around assessment information gathered from previous lessons, which indicated that the students needed more focus on building their conceptual understanding of fractions.

Enabling prompt: What might the missing numbers be?

$$\frac{\square}{4} + \frac{\square}{8} = \frac{\square}{8}$$

Draw a matching diagram for each equation to prove that it is correct.

Extending prompt: Choose 3 of your equations and record matching diagrams to prove that they are correct. Can you record your answers in a way that proves you have found all the possible combinations?

Analytical Approach

Data was analysed thematically, following the process put forward by Braun and Clarke (2006). The process began by deeply immersing ourselves in the data, reading and rereading questionnaire responses and focus group transcripts to develop an overall impression. Following this familiarisation, we began our first level of coding by classifying each student questionnaire response according to the participants’ overall attitude towards problem-solving: positive, ambivalent, negative, or a descriptive response – that is, no attitude could be gleaned from the text (see Table 1 and Table 2).

We then returned to the questionnaire data to begin our second level of coding, which involved identifying specific themes to explain these attitudes (see Table 3 and Table 4). These themes were then further refined, for example, in some instances two themes were combined when they were deemed conceptually closely related (e.g., persistence and confidence). Following this refining process, themes were then elaborated and more clearly defined through selecting a particular participant response that accurately captured that theme. The final list included nine themes, with many participant responses being coded to multiple themes. Finally, focus group transcripts were then reread, and selected quotations which connected to a particular theme were extracted and classified when relevant.

Results

Results of our analysis are presented below. Illustrative quotes from both the questionnaire text and the focus groups’ are included in order to further illuminate key themes.

Table 1
Attitude to Problem Solving by Gender

	Positive	Ambivalent	Descriptive	Negative
Boys	21 (84%)	2 (8%)	2 (8%)	0 (0%)
Girls	18 (67%)	9 (33%)	0 (0%)	0 (0%)
Total	39 (75%)	11 (21%)	2 (4%)	0 (0%)

Table 2
Attitude to Problem Solving by Year Level

	Positive	Ambivalent	Descriptive	Negative
Year 3/4	23 (88%)	2 (8%)	1 (4%)	0 (0%)
Year 5/6	16 (62%)	9 (35%)	1 (4%)	0 (0%)
Total	39 (75%)	11 (21%)	2 (4%)	0 (0%)

Three-quarters of students described learning mathematics through problem solving in positive terms, whilst around one-fifth of students felt ambivalent. Boys were somewhat more likely to hold unambiguously positive attitudes (84% vs 67%) and girls somewhat more likely to be ambivalent (33% vs 8%; see Table 1). In addition, there was evidence that the Year 3/4 groups held more positive attitudes than the 5/6 group (88% vs 62%), and older students were more likely to be ambivalent (35% vs 8%; see Table 2).

Reasons for Positive Attitudes towards Problem Solving

As previously noted, 39 out of the 52 students held unambiguously positive attitudes towards learning mathematics through problem solving. As is apparent from Table 3, the reasons why students held these positive views varied considerably. It is worth reiterating that some student responses were coded to multiple themes (mean= 2.2 themes).

As is apparent from Table 3, two-thirds of students who held positive attitudes towards learning mathematics through problem solving indicated that they found the process enjoyable or fun; corresponding to half of students who completed the questionnaire. Ostensibly, in contrast, the third most prevalent theme identified was the notion that learning through problem solving is challenging or hard. However, further analysis revealed that 12 out of the 39 students with positive attitudes towards learning mathematics through problem solving (equating to 23% of all students) had their responses coded to both the themes enjoyable/ fun and challenging/ hard. The implication is that these students enjoyed learning mathematics through problem solving precisely because it was challenging. Here are some selected quotes from students who felt that it was the challenging nature of the tasks which made them enjoyable:

"I love it! It is so hard (in a good way) fun and interesting. I also love it because it is always true! Sometimes it's funny. Super duper fantastic." (Year 3/4 student).

"It is really fun but sometimes it is a bit tricky and that's how math is. It is a bit of a challenge for me and I love a challenge." (Year 3/4 student).

"I think that problem solving is really fun because it challenges me with my math - and because it is always different." (Year 5/6 student).

"The problems are fun and a good challenge. I like it when I get stuck, but try something and it works. I like the problems with more than one answer to it..." (Year 5/6 student).

"Problem solving is a lot of fun because it's not so easy and I like hard things." (Year 5/6 student).

By contrast, here is an example of a quote classified to the challenge/ hard theme, but not enjoyment/ fun, for a student who held a positive attitude towards problem solving. In this example, it seems that the student values problem solving because they view it as good for their learning ("Supports mathematical learning"), rather than enjoyable/ fun:

"I like problem solving because it gives you a challenge and makes you think really hard - and I think that it is good for my learning." (Year 5/6 student).

The idea that it is the challenging nature of this approach which makes it both an enjoyable and effective way to learn was a theme that also appeared in the focus group discussions. Below are some quotes from these discussions that illustrate how challenge contributed to the positive attitudes displayed by the students:

"I reckon today's session was actually pretty good because it was a bit confusing at the start, and then once you got the hang of it and started figuring out patterns, and it was really cool how it worked actually." (Year 3/4 student)

"I felt like it was actually good because my brain keeps stretching every time I do problem solving, so I enjoy it." (Year 3/4 student)

"I've learned more...because problem solving's actually hard." (Year 5/6 student)

The second most prominent reason identified through the questionnaire responses as to why students were positive about learning mathematics through problem solving was the belief that this instructional approach supported their mathematical learning. During the focus group discussions, this theme was frequently raised in connection with the idea that students enjoyed working on problems with connections to real-world scenarios and that they also felt that these links to the outside world made the mathematics easier to understand.

"I like doing problem solving because it's like a scenario and there's a background story to the actual problem and it's not just like three times four, it's actually giving you a problem that's in a background story." (Year 3/4 student)

"[Having a real-world scenario for the problem] makes it a bit more fun and a bit more easy to understand." (Year 3/4 student)

Table 3*Reasons for Positive Attitudes towards Problem Solving: Summary of Thematic Analysis*

Theme	N	Percentage of students with positive attitudes to problem solving	Percentage of all students
Enjoyable/ fun	26	67%	50%
Supports mathematical learning	16	41%	31%
Challenging/ hard	15	38%	29%
Opportunities to collaborate with other students	7	18%	13%
Relevant to real world and other curriculum areas	5	13%	10%
Interesting/ novel way of learning mathematics	5	13%	10%
Builds confidence/ persistence	5	13%	10%
Value the learning contexts in which the tasks presented	4	10%	8%
Opportunities to work independently and be autonomous	2	5%	4%

"It also helps, all the questions are things that could happen in real life. Like the problem that we had today." (Year 5/6 student)

Another theme linked to positive attitudes towards this learning approach was the freedom to collaborate with peers. This was the fourth most frequently identified theme to emerge from our analysis of free text student questionnaire responses to their feelings about problem solving, after: "enjoyable/ fun", "supports mathematical learning" and "challenging/ hard". Moreover, this feedback was reported on many occasions to the second author through informal discussions with students and it also came up repeatedly in the focus groups. It seemed that allowing, or in some cases actively encouraging, students to work collaboratively with whomever they wanted was notably different to regular practice in each of the classrooms, and particularly valued amongst students in Year 5 and Year 6. Below are some quotes from the focus groups relating to collaboration:

"I think it's better how it is now sort of, because instead of Miss X taking students and sort of showing them how to do it... we're allowed to work collaboratively so each person sort of gives in an idea as well. So, you're thinking like, instead of Miss X thinking with your thinking, you're thinking with people who are the same age, same sort of thinking." (Year 5/6 student)
"I like how it is now because when we got called to the floor I always feel like a bit self-conscious about where my learning was at with some of the things

and I felt like I was sort of missing out on collaborating with people and friends and just trying to work out another problem. So, I like how it is now." (Year 5/6 student)

"I kind of find it better when my friend's showing me something than like a teacher, because my friends kind of show me how it's done, but I I kind of listen to them more than a teacher." (Year 5/6 student)

"We learn best off each other." (Year 5/6 student)

Reasons for Ambivalent Attitudes towards Problem Solving

By contrast, 11 out of the 52 students held ambivalent feelings about problem solving. Table 4 indicates the themes to which these student responses were coded. Again, some student responses were coded to multiple themes (mean = 1.9 themes).

It was interesting to note that challenging/ hard was the major reason why some students felt ambivalent about learning mathematics through problem solving. Here are some quotes from students classified as ambivalent who noted challenge as a contributing factor:

"I think that some of the problems that we get are a little bit too hard sometimes, because they are a little bit too challenging. At the same time, they are also good because it really helps us learn more and challenges us." (Year 5/6).

Table 4*Reasons for Ambivalent Attitudes towards Problem Solving: Summary of Thematic Analysis*

Theme	N	Percentage of students with ambivalent attitudes to problem solving	Percentage of all students
Challenging/ hard	8	73%	15%
Sometimes it is enjoyable, other times it is not	5	45%	10%
Sometimes interesting, but too much problem solving can become boring	3	27%	6%
Opportunities to collaborate with other students	3	27%	6%
Builds confidence/ persistence	2	18%	4%

"I'm not very good with problem solving so I find them a bit tricky. I get a little bit stressed about it - that I'm not going to work it out." (Year 5/6)

"When our class does problem solving, I say I don't want to do it - but when we get into it, I find it really fun... But when we do fraction problem solving I get frustrated because I don't get it." (Year 5/6)

"Problem solving makes me feel happy, sad, good, annoyed. Sometimes I feel like quitting but I don't" (Year 3/4)

However, it is important to note that although challenge/ hard was the most prevalent theme explaining students' ambivalence, students who indicated that learning through problem solving was challenging/ hard were more likely to hold positive attitudes towards problem solving (15/23; 65%) than be ambivalent (8/23; 35%).

Discussion and Conclusions

Consistent with our theoretical framework linked to self-determination theory (Deci & Ryan, 2012), the current study found that most primary school students (75%) conveyed unambiguously positive attitudes towards learning mathematics through challenging, problem solving tasks. Moreover, approximately half of students indicated that they found learning mathematics in this manner enjoyable and/ or fun. This is consistent with prior research. For example, 28 out of the 73 (38%) students in the Russo and Hopkins (2017b) study indicated that they valued work on challenging mathematics tasks because they enjoyed it. Moreover, in a similar manner to Russo and Russo (2020), around one quarter of our study participants indicated that they enjoyed learning mathematics through problem solving tasks precisely because it was challenging and hard. This supports the claim that working on such tasks helps to meet students' need for competence (Deci & Ryan, 2012).

Other prominent themes included the notion that this instructional approach supported students' mathematics learning, in part through providing meaningful problem contexts to make mathematical ideas more salient. Students also valued the opportunity to work collaboratively with peers, with several focus group participants in particular noting that peer explanations were often clearer and more comprehensible than teacher explanations. The emphasis on the value of peer collaboration suggests that learning mathematics through challenging, problem solving tasks also supports students' need for relatedness (Deci & Ryan, 2012).

Conversely, slightly less than one quarter of students were ambivalent about learning mathematics through challenging, problem solving tasks. Most students with these ambivalent attitudes indicated that they felt this way because learning mathematics

through problem solving was challenging and/ or hard. It is noteworthy, however, that a student who reported learning in this manner to be challenging and/ or hard was still approximately twice as likely to have an unambiguously positive attitude towards problem solving than be ambivalent. Moreover, perhaps surprisingly, no students in our study reported unambiguously negative feelings towards learning mathematics through challenging, problem solving tasks. Although replicating this finding in other contexts with larger and more diverse samples of students is necessary, this suggests that it is relatively unusual for primary-aged students to hold negative attitudes towards problem solving.

There were some differences in the propensity to report positive attitudes towards problem solving between grade level and gender that are worth drawing attention to. Previous studies have discussed how younger students have tended to report higher levels of enjoyment and intrinsic motivation to learn mathematics compared with older students (Lepper et al., 2005; Russo & Russo, 2019). Our findings suggest that this claim can be extended to learning mathematics through challenging, problem solving tasks. In relation to gender, some previous studies have found that boys have more positive attitudes towards learning mathematics than girls (Skaalvik & Skaalvik, 2004), however other studies have failed to find meaningful overall differences across gender (Mata et al., 2012). We found that boys were more likely to hold unambiguously positive attitudes towards learning mathematics through challenging, problem solving tasks than girls. It might be interesting to attempt to replicate this finding with a larger sample, and explore the underlining mechanisms in more depth (e.g., Are boys more likely to report enjoying mathematics learning experiences that are challenging or hard than girls?).

Our study has particular limitations that need to be acknowledged. First, the study needs to be considered exploratory in nature, as the school and student participants were selected on a convenience basis. Future studies intending to examine the issue more systematically may consider different sampling procedures (e.g., random sampling). Secondly, it is possible that the second author's pre-existing relationship with the school and students may impact student responses, particularly during the focus groups (e.g., social desirability bias). However, it should be noted that having a pre-existing teacher-student relationship can also be considered a strength of the current study design, as this established trust might encourage students to be more candid and thoughtful with their responses.

To conclude, despite teacher concerns to the contrary (e.g., Ingram et al., 2019), the current study

affirms the idea that primary students embrace learning mathematics through problem solving tasks; at least in a context where such tasks are augmented by enabling and extending prompts (Sullivan et al., 2009), and students are afforded opportunities to work collaboratively. These overwhelmingly positive student attitudes should embolden teachers to experiment with such approaches in their own classrooms.

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