How can mathematical tasks support students' confidence and motivation, particularly in a mixed prior attainment setting?

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Teaching students with low confidence and motivation in mathematics can be challenging. I teach mathematics in a secondary school where students are grouped based on a wider range of prior attainment than has previously been the case. Some of my students report that they "cannot do maths" and I believe they have not yet experienced enough joy in their mathematics classrooms. One way to consider my teaching practice in relation to these challenges has been through a focus on task design and by exploring the elements of mathematical tasks that can help support students' confidence and motivation. In this study, students were asked to evaluate two mathematics tasks based on a theoretical framework of design elements. It was found that students' confidence is increased when the structure of the task is familiar, and that classroom culture needs to be carefully considered to support confidence and motivation.

Keywords: keyword; keyword; keyword; keyword

Introduction

The motivation for this paper came from Holzapfel et al's 2019 paper which concluded that often teachers do not recognise the differentiation potential of mathematical tasks and sometimes write tasks off as "too hard" based on elements such as the task's layout. In reading this paper, I wondered how my students would react to the mathematical tasks used in that study; how each task would affect their confidence and motivation.

This study will explore how a group of Year 9 students from one class in the United Kingdom respond to two mathematical tasks. The school I work at, as a secondary mathematics teacher, has recently introduced classes with a greater breadth of prior attainment in Year 9 (age 13/14 years). The students' benchmarks ranged from a grade 2 to a grade 5 (on a scale of 1-9 where 9 is highest, 1 is lowest and 5 is consider a 'strong pass'). My aim is to create a classroom that instils confidence and motivation in these students despite the varying levels of apathy towards mathematics that I have encountered. Therefore, this research will address the following research question:

(1) What elements of mathematical tasks help to support students' confidence and motivation?

Theoretical framework

In this paper, when referring to a mathematical 'task' I will be referring to any question or prompt which promotes mathematical thought (Christiansen and Walther, 1986). Mathematical tasks can be used by teachers to support differentiation within mixed prior attainment classrooms (Holzapfel et al., 2019). Holzapfel et al (2019) found that teachers are not always aware of how tasks can be adapted to meet the varying needs of students. Their paper talks about ‘adaptive’ tasks; I take this to mean tasks which are more open and flexible; they can be adapted by the teacher to meet a student’s needs. These tasks are rich, meaning they have a low access point and high ceiling. Recently I have been working on using more ‘adaptive’ tasks in my own classroom to support my classes especially those with a greater breadth of prior attainment.

The students of mine have had almost 10 years of mathematical experiences in school and from their anecdotes some of them really believe that they will never be able to “do maths”. This aligns with the common misconception that some people can do mathematics and some people cannot (Boaler, 2009). This cultural norm along with people’s experiences in mathematics classrooms has led to many people finding it difficult to engage in mathematical tasks, to the point where they feel fear doing so and attempt to avoid tasks which involve mathematical thinking; this is Mathematical Anxiety (Ashcraft, 2002). There are students in my class who I have known to avoid engaging with mathematical tasks even when they have contributed positively to the class discussion beforehand. They present a fear of working independently, a fear of making mistakes and this in turn can then begin to affect their behaviour in the classroom.

Johnston-Wilder and Lee (2010) defined the construct of ‘Mathematical Resilience’ to help change mindsets and overcome these challenges. This is no easy task; it needs a cultural shift within schools and classrooms. Mathematical resilience comes hand in hand with a student’s confidence and motivation with mathematics. In one of Johnston-Wilder and Lee’s (2010) studies in a school, students fed back that they appreciated having a different way of working on mathematics. The students were referring to working on more open tasks and working in teams. Johnston-Wilder and Lee (2010) noted the impact of communicating mathematical ideas and of the task choice on both the student’s mathematical resilience and their learning. Watson (2021) notices a similar improvement to both confidence and subject progress when students are working on interesting tasks.

Many ways in which students interact with mathematics in schools is unexciting and depressing (Ahmed, 1987; Boaler 2009). This does not increase their confidence and motivation of learning mathematics. In many classrooms, students who present Mathematical Anxiety spend most of their time reproducing teachers’ examples with different numbers. This does not support students in building Mathematical Resilience (Ahmed, 1987; Boaler, 2009; Johnston-Wilder and Lee, 2010). At times, students need to find their own strategies rather than following teacher’s methods and algorithms; this could only make the students less confident and motivated with their mathematics and feel less success when they cannot remember a taught process (Ahmed, 1987). Carefully designed and implemented tasks can help to improve students' confidence, and motivation. Ahmed (1987) gives a list of design features a task should have to achieve this which Foster (2018) distils into three main elements which will give us the framework for this study:

Enticing – tasks should have immediate appeal to learners.

Accessible yet challenging – students should be able to begin immediately but the solution must not be obvious.

Naturally extendable – the task should not lead to a dead end of resolve itself too neatly too soon.

The naturally extendable element here could support the teacher with differentiation in a mixed prior attainment classroom, as discussed by Holzapfel et al (2019).

Foster (2018) developed the notion of the convergent and divergent model for task design. Where a convergent task "has a single, correct answer, which may be arrived at by a range of different methods" and a divergent task "is more open-ended and provokes a more diverse range of outcomes" (Foster, 2018, p14). To meet the three main design elements above Foster suggests using this model where first a convergent task is explored which naturally leads to a divergent task.

The notion of using the convergent and divergent model for task design does not mean that procedure tasks do not have their place. A well-designed set of similar procedures can lead to insights about mathematical structure when facilitated by the teacher in such a way (Watson and Mason, 2006). However, procedural tasks must not be used in a way where students struggle repeatedly to do a list of questions requiring purely the use of memory without understanding as this is known to produce the mathematical anxiety discuss above (Johnston-Wilder and Lee, 2010). In fact, even seeing a worked example and then working on a very similar problem, which is common practice in many mathematics classrooms, can be demotivating for students as they are not having the opportunity to solve the problems (Watson, 2021).

Methodology

This study is a form of design-based research as I have taken two tasks from Holzapfel et al's 2019 paper and used them for teaching fractions to a small group of my students. This has enabled me to test the design elements of the tasks from a student perspective based on the theoretical framework discussed above. This forms part of my continual work on designing and improving the tasks that I am using to support my students. The first of the two tasks is a list of procedural questions to practice adding and subtracting fractions; there is no deliberate variation of these questions. The second task could be considered to follow the convergent-divergent model (Foster, 2018) as it is a task where students need to add and subtract fractions to fill in four number pyramids (see figures 2 and 3). The final pyramid with solely one half at the top could have multiple solutions.

The research involved a small group of eight students from a class with a cross-section of prior attainment. Some of these students I suspect to have mathematics anxiety, low mathematical resilience, and mathematics avoidance. There was no other specific selection of students, the group was partly determined by those whose consent was given to participate.

The students were taught how to add and subtract fractions in a way akin to my usual practice; they saw an example and practiced a few questions on mini whiteboards. The students were then given the first of the two tasks to engage with. This task was then stopped and marked, and they were given the second task. The students were told that they can work with the person next to them on both tasks. I audio recorded the students working on the tasks to capture any partner talk.

Once students had engaged with the tasks, I asked the students to fill out a questionnaire prompting them to compare the tasks. The questionnaire was written to be aligned to the theoretical framework. I asked the students to assess the tasks on a Likert scale based on the criteria: enticing, accessible yet challenging, and naturally extendable. However, the language was altered to make this more accessible for the students. For example, students were asked 'How easy did you find it to start each task?' to assess the accessibility of the tasks and 'How did you feel when we stopped task 1?' was used to assess the naturally extendable element. I collected in the responses to the questionnaire and the students' worksheets and analysed the results against the theoretical framework alongside the audio recording.

Findings and analysis

The presented analysis is structured based on the theoretical framework which aligned to the questionnaire. You can find a summary of the questionnaire results below:

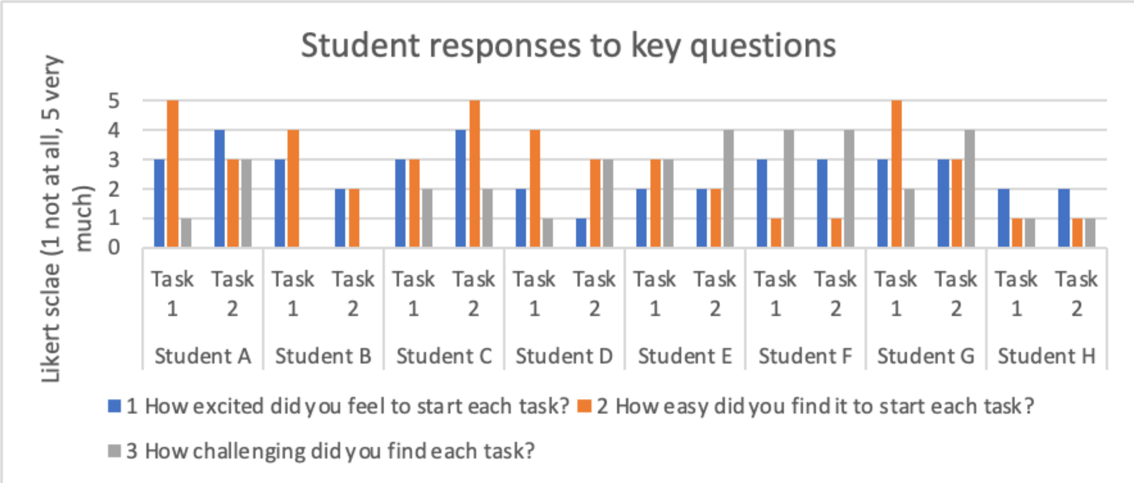

Figure 1: Graph to show student responses to key questions.

Enticing

The results for how excited the students felt to begin each task were the same for half the students. Three of these students have particularly high levels of apathy for mathematics and so I suspect they would have struggled to answer this question. The other half of the students all had one difference between each task with two students being more excited to begin each of the tasks. Therefore, there was no distinction between how enticing each task was for students.

When the questionnaire asked what could make either of the tasks better some students commented on the layout. For example, for task 1 one student commented "more space and bigger numbers". Another student commented that they would have liked "times/dividing fractions" included in task 1 but they did not say the same for task 2. I wonder if this is because they felt they had mastered adding and subtracting in task 1.

Two of the three students who said they preferred task 2 gave reasons that it was "more fun" or "more enjoyable". These students were the students who got on to the final part of the task so this could have been why they found it more enjoyable.

Accessible yet challenging

Five of the eight students marked task 1 higher in question 2, with two giving it the same score and only one marking task 2 higher. This could be seen to agree with the teachers from Holzapfel et al's (2019) paper as many of them said that task 2 would be "too hard" for their students. Most students consistently marked task 2 as more challenging. This could be due to the students needing to decide whether they need to add or subtract the fractions before doing the calculation itself. This was further supported by a moment within the audio recording where one student asked another "So do we need to just add them?".

Furthermore, when the students were asked which task, they preferred half of them preferred task 1. All the students who preferred task 1 mentioned finding task 1 “easier”. During the analysis, I began to question what the students meant by the word ‘easier’. Did they think the task was easier because it was a more familiar layout to them? I had not used pyramids with this class before and on reflection could have used a version of the pyramid task with easier numbers to get them familiar with the structure of the task before asking them to complete task 2. I believe task 2 was accessible for them as every student had begun the task. Some students had less calculations completed on task 2 but the need to think more deeply could lead to enhanced learning. Some students responded in the survey that they felt confused while doing task 2 however, they had correctly completed at least one pyramid, so this appears to be perception and lack of confidence.

Naturally extendable

From my perspective, task 2 was the more naturally extendable of the two tasks. Task 2 supported me to differentiate for the class by simply asking “Is there another way you could answer pyramid 4?” Two of the students got to this stage. One of them had put their hand up to say that they were finished. When I looked at their sheets, I found it interesting that these two students, who were working together, had written the same answer for pyramid (3) and (4) and one of them had left pyramid (2) incomplete (see figure 2 and 3).

Teacher: Why didn’t you complete this pyramid?
Student C: because pyramid (3) and (4) were easier.
Teacher: Why did you find them easier?
Student C: I don’t know they just were.
Teacher: For this one (pyramid 2), what would you need to do?
Student C: One quarter take away one fifth?
Teacher: Yes! That’s right. You can do that.

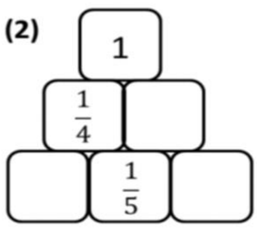

Figure 2: image of pyramid 2 on task 2

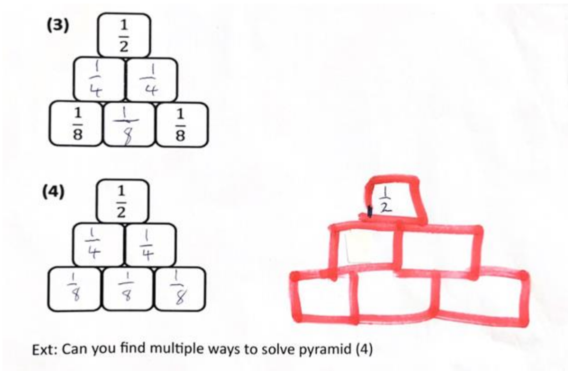

Figure 3: image of student work on pyramid 3 and 4.

I wonder if this student found pyramid (3) “easier” because working with ½ may be more familiar to them, perhaps working with fraction walls using ¼ + ¼ = ½ is something the student was used to seeing.

I then invited the students to find another solution for (4). With my direction, student A made another copy of the pyramid and then wrote ½ in the top (as seen in the picture above). However, the students struggled to figure out how to begin this but seemed motivated to do so. Unfortunately, we ran out of time to explore this further.

On reflection, I could have given the students one more pyramid to scaffold them to find a different solution and even placed 3/8 in one of the boxes in the middle row. This could have deepened their understanding of fractions while still enabling the students to practice adding and subtracting fractions. These were the two of the three students who preferred task 2. I wonder if this is because they got to the more interesting mathematics at the end of the task. This led me to question the purpose of the first pyramids and whether they were needed at all. Could every student have started with the final pyramid?

Conclusion

This study highlights student responses to mathematical tasks. Having familiarity with the structure of a task seems to add to the feeling of accessibility for some students. The naturally extendable element, however, can help build students resilience and confidence to find multiple solutions and question their own solutions however, this does need to be built into the culture of the classroom so that students build this resilience over time and are able to independently begin this work.

All students attempted both tasks and were successful in both tasks. Some students stated they felt more "confused" with task 2 and that they found task 1 "easier". This seems to be more about the students feeling less comfortable and leads me to consider how I can build a classroom culture where students feel comfortable and safe working on unfamiliar problems such as tasks using the convergent and divergent model. A classroom culture like this could lead to higher student confidence and motivation. This could then in turn would lead to greater progress and outcomes for students.

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