Using TIMSS items to develop mathematics with meaning – but whose meaning matters?

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We report on an exploration of how we might repurpose TIMSS assessment items for classroom use to promote meaningful mathematical engagement. During this work, we uncovered a tension between pupils' and teachers' beliefs about the purposes of mathematics learning, leading to some unexpected outcomes. Working with Year 5 and Year 9 teachers and pupils in England, we selected and adapted TIMSS tasks for integration into regular lessons and collated data from classroom observations, pupil dialogue, and teacher interviews. Thematic analysis, identifying patterns in engagement and value orientations, indicated that pupils often approached tasks through procedural lenses, prioritising correctness and assessment-related practices, whereas teachers sought to foster reasoning and process-focused learning. This misalignment of priorities sometimes led to counterproductive engagement, highlighting tensions between policy-driven assessment cultures and aspirations for mathematics with meaning.

Keywords: primary & secondary mathematics; meaning-making; TIMSS; assessment

Introduction: repurposing TIMSS for meaningful mathematical engagement

The Trends in International Mathematics and Science Study (TIMSS) is designed to monitor and compare achievement in grades 4 and 8 (in England, years 5 and 9) across education systems. It is primarily seen as assessing performance or benchmarking attainment. However, we were interested in how its released items might serve as catalysts for teaching mathematics with meaning and sought to explore what happens when tasks originally intended for large-scale assessment are repurposed for everyday classroom use. The work reported here forms part of that wider study, with a focus on the values and priorities that shaped pupils' and teachers' engagement with TIMSS tasks, and the extent to which these align – or misalign – with aspirations for meaningful mathematics learning.

Mathematics with meaning

In our usage, 'mathematics with meaning' moves beyond rote procedures to engage learners in reasoning, exploration, and sense-making. As Mason (2001) and Howson (2005) argue, mathematics often feels disconnected when presented as isolated techniques rather than as a coherent way of thinking. Meaningful mathematics invites learners to explore patterns, relationships, and structures in purposeful ways, connecting ideas to their experiences and fostering curiosity. This approach emphasises reasoning, problem-solving, and communication alongside conceptual understanding. Learners need to grasp not only how to carry out a procedure but why

it works, when to apply it, and how it links to broader concepts (McCallum, 2023). Robust conceptual knowledge, defined by Hodgen et al. (2018, p.16) as "the connections and relationships between mathematical facts, procedures and concepts," is central to this vision.

Developing mathematics with meaning aims to cultivate learners as thinkers who can reason, generalise, and find purpose in their learning. This involves creating opportunities for abstraction, discussion, and multiple representations, enabling learners to see connections across ideas and contexts. As Su (2020, p.42) notes, "abstraction enriches meaning ... when you see that two things have similar structures or behaviour, then those similarities create a connection, a new meaning for you." Our goal is to help learners experience such insights, moving beyond surface relevance toward deep engagement with mathematical ideas. Teaching for meaning therefore values inquiry, creativity, and perseverance, while avoiding "rules without reasons" (Skemp, 1976). It positions mathematics as a human endeavour – cultural, historical, and purposeful – so that learners can see it as a living discipline that offers new ways of understanding the world (Kilpatrick, Swafford & Findell, 2001; Howson, 2005).

Methods

The data presented in this paper arose from a larger study exploring how TIMSS assessment items could be adapted for classroom use to promote meaningful mathematical engagement. As part of this study, we were interested in understanding the values underpinning pupils' and teachers' approaches and how these manifested in the classroom. We adopted a qualitative design involving collaborative work with primary (Year 5) and secondary (Year 9) teachers and their classes in England.

Teachers – who had elected to be part of the study and who were willing to trial items with their classes – selected tasks from the 2019 released TIMSS items for Grades 4 (Year 5) and Grade 8 (Year 9) based on their cognitive and content domains (e.g., measurement, geometry, number) and benchmark difficulty levels. While we provided initial 'didactic notes' (suggestions for use), they used these tasks in ways they saw fit with their classes over one or more lessons. We observed such use, focusing on pupil interactions, strategies, and discourse. Following each lesson, we conducted interviews with the class teachers and focus groups with small groups of learners to better understand their approaches to the tasks.

We conducted thematic analysis of observation notes and interview transcripts, coding for evidence of reasoning, procedural approaches, collaboration, and value statements. Comparative analysis examined (mis)alignment pupils' and teachers' priorities (e.g., emphasis on correctness vs. reasoning, enjoyment vs. assessment-driven practices).

Findings: patterns in engagement and value orientations

It is important to keep in mind the small-scale nature of the work reported in this paper (from one primary school and two teachers in one secondary school); also, that the teaching observed might not have been entirely typical for all participating teachers, although participating teachers say it was consistent with their usual approaches. Further the findings discussed here may be specific to the contexts in which the study schools and classes were located. For example, the primary school in this study was in an area where education at 11+ was selective and several pupils were being tutored for related tests: this may have impacted on how pupils perceived the importance of different approaches and tasks.

We were interested to see what value statements and priorities for mathematics learning were shared, either by pupils in different year groups (primary and secondary), by teachers in different year groups, or across pupils and teachers (between and within years). These are illustrated in Figure 1.

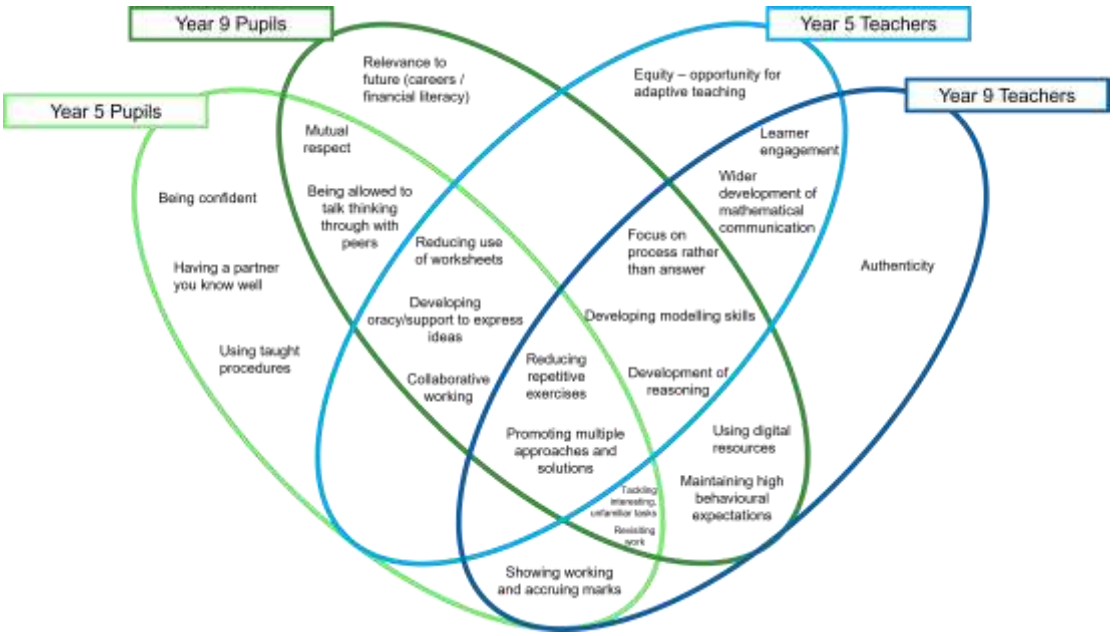

Figure 1: Alignment / misalignment of what was important to Year 5 and Year 9 teachers and pupils in learning mathematics.

Our observations showed us that the released TIMSS items, when repurposed for classroom teaching – especially with a focus on meaning-making – provided opportunities for discussion, multiple approaches, and reasoning. Teachers aimed to foster sense-making and multiple solution strategies. Such aims aligned, in part, with pupils' values, with pupils in both Year 5 and Year 9 expressing a desire to engage in collaborative work, to develop their skills in communicating reasoning, and to be permitted to approach problems in different ways or to find different solutions.

However, while there was some alignment in aims, the opportunities presented by such lessons were not always realised due to prevailing classroom or wider norms and pupil expectations. Even with an explicitly communicated focus on sense-making and problem-solving, with teachers deliberately and carefully stating they were interested in pupils' thinking, pupils frequently relied on familiar procedures and focused on obtaining correct answers. In some cases, this produced clearly incorrect answers, yet pupils persisted with a procedural answer-getting approach. For example, two Year 5 pupils over-generalised from the formula for finding the area of a rectangle to use it to find the area of a triangle (which hadn't been taught) and so arrived at a clearly nonsensical answer in the context of the given problem ('one' – see Figure 2), yet one they could not identify as incorrect as they had 'followed the procedure'.

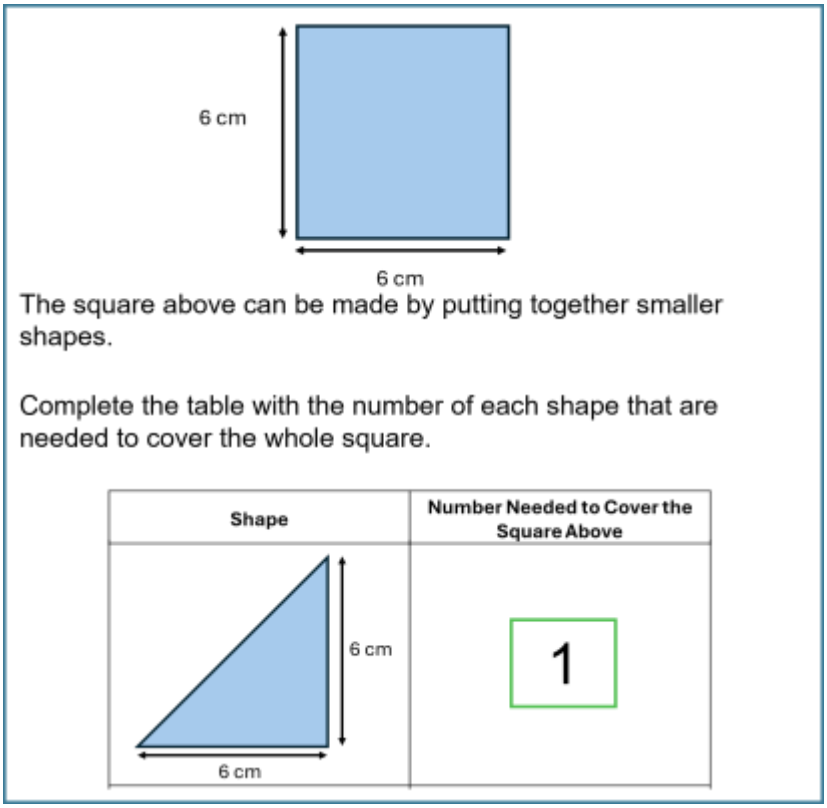

Figure 2: Part of a re-purposed Year 5 TIMSS task answered incorrectly through the application of an overgeneralised procedure.

Probing in pupil focus groups deepened our understanding of tensions between teachers' and pupils' goals. While pupils seemed to understand their teacher's goals, and indeed appeared to find them appealing, external pressures – particularly for Year 5 pupils – resulted in tasks being approached through an assessment lens, emphasising correctness, speed, and the accruing of marks. This seemed to override possibilities to act in different ways. Pupils needed to feel safe, knowing that what they were doing – and the ways they were approaching their work – were 'correct', potentially an overhang of exposure to wider assessment discourses.

Discussion: the challenge of performance-driven education

One of the most striking findings of this tangent to our main study is the pervasive answer-driven mindset among pupils, even those as young as nine or ten years old, which reflects a broader systemic issue: the dominance of superficial performance metrics in English education. In a culture where success is often equated with speed and correctness, pupils internalise the belief that mathematics is primarily about producing the right answer quickly. This would seem to reflect the work – over 20 years ago – of Boaler (2002) suggesting that even with this passage of time and a policy-level shift to a mastery approach to teaching and learning mathematics, the focus on speed and correctness persists. This orientation seems to be reinforced by assessment structures (here the 11+ and other in-school assessments pupils have been exposed to) that prioritise accuracy over reasoning, and by classroom practices shaped by accountability pressures.

Performance-driven systems can create an environment where risk-taking and exploration are undervalued. Some pupils in this study exhibited frustration when

tasks lacked definitive answers, and many rushed through problems without engaging deeply with underlying concepts. This behaviour is not accidental; it mirrors the high-stakes nature of standardised or high-stakes testing, where efficiency and precision are rewarded, while ambiguity and approximation are penalised. Consequently, learners develop habits that conflict with the very essence of problem-solving: curiosity, flexibility, and purposeful perseverance. Problem-solving requires time, reflection, and the willingness to pursue multiple pathways. Yet, in a performance-oriented culture (or at least in a culture where pupils internalise such values), these qualities are often perceived as inefficiencies. We witnessed pupils, when faced with a task, failing to pause or to mathematically model questions before jumping to find a solution and usually one which *looked* mathematical, based on superficial views as to what mathematics should look like. When the systemic priorities of a system promote an educational narrative emphasising outcomes over processes, pupils may neglect metacognitive practices that could support the development of reasoning skills and foster deeper conceptual understanding.

It is worth observing, despite the small sample size, that the assessment driven competitive tendencies appeared even more prevalent among high-attaining students, underscoring how performance pressures amplify the desire for speed. While these pupils possess strong procedural fluency, their inclination to "win" by arriving at an answer first undermines thoroughness (hence the clearly incorrect answer of 'one' in Figure 2) and creativity. This phenomenon raises critical questions about the place and role of assessment and how as educators we might reduce related undesirable impacts to focus instead on developing mathematics with meaning.

The challenge extends beyond classroom pedagogy to the structural logic of schooling. Accountability frameworks, league tables, inspection regimes and school admission policies encourage measurable outcomes (and, sometimes, the gaming of these). Teachers – and, it appears in this study, parents/carers – operating under these constraints, may feel compelled to prioritise test technique over exploratory learning. This dynamic perpetuates a narrow conception of mathematics as a discipline of certainty and dependency, rather than a field of inquiry and empowerment. Pupils' comments on the tasks further illustrated this tension: tasks were deemed "hard" when they lacked exact answers, and "easy" when they (apparently) offered clear numerical solutions. Such attitudes reflect an educational culture that conflates difficulty with ambiguity, discouraging learners from embracing the productive struggle (Kilpatrick, Swafford, & Findell, 2001) inherent in problem-solving.

While the ideas presented in this paper arose from a tangential finding to a small-scale study, they highlight and reinforce an ongoing concern in mathematics education, that of the purpose of teaching and learning mathematics and the role and responsibilities of assessment practices within this. Our findings show how engrained current assessment discourses are and suggest that we require a cultural shift in how success is defined. Teachers need support to create environments where mistakes are normalised, and where the emphasis lies on reasoning rather than rapid correctness. Our hope is that the work we have done on repurposing TIMSS items, and making this work freely available to teachers, will be one small step supporting reorientation of pupils' experiences in mathematics education toward exploration. However, any such change can only be successful if accompanied by systemic reforms, assessment models that value reasoning, professional development that foregrounds inquiry, and curricula that celebrate multiple solution paths.

Conclusion

Ultimately, our findings highlight a paradox: problem-solving is currently an aim of the National Curriculum with its priority likely to be enhanced under the Curriculum and Assessment Review (Gov.UK, 2025), yet the prevailing performance-driven ethos across all phases of mathematics education undermines its development. If education systems continue to privilege speed and certainty, efforts to nurture problem-solving will remain constrained. A genuine commitment to problem-solving demands reimagining success not as hitting a target, but as broadening meaning-making, confidence and motivation, even when the journey is uncertain. Without such change, it may be that initiatives such as that discussed in this paper can only result in tweaks "around the edges" and in classrooms where there already exists a willingness to do something differently. The challenge is achieving that at scale, including for schools, teachers and pupils most heavily embedded within, and acting within, the prevailing assessment discourses.

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