Changing Conditions to Enable Student Problem Posing: A Practice Architectures Analysis

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Posing mathematical problems is an inherent part of how we engage with mathematics in our daily lives, yet teaching students to make sense of situations and pose problems is not common practice. This paper explores the implementation of student problem posing across two iterative cycles of implementation. It draws on the Theory of Practice Architectures as an analytical framework to examine how site-specific practice architectures reconfigured across cycles to further enable student problem posing. This paper offers insights into how classroom conditions and reconfigurations make possible particular forms of participation and engagement during mathematical problem posing.

Mathematical Problem Posing (MPP) is defined as "the process of formulating and expressing a problem within the domain of mathematics" (Zhang & Cai, 2021, p.962), and includes both the generation of new problems, as well as the reformulation of existing problems (Silver, 1994). MPP is commonly categorised as free, semi-structured, or structured (Stoyanova & Ellerton, 1996). In free problem posing situations, as enacted in this study, students are invited to generate mathematical problems from a given situation, such as a visual image, without predetermined constraints (Stoyanova & Ellerton, 1996).

More than three decades after Silver's (1994) seminal paper identified problem posing as a significant instructional shift from teacher-centred to student focused practice, the challenge of implementing problem posing persists. Despite problem posing being an aim of the Australian Curriculum: Mathematics (Australian Curriculum, Assessment and Reporting Authority [ACARA, n.d.]), mathematics tasks often remain teacher-centred, prioritising the application of prescribed procedures and the production of correct answers over the exploration of underlying mathematical ideas (Schoenfeld, 2017). This didactic teaching approach has been further reinforced by recent, contested "Science of Maths" movements that foreground direct, explicit instruction over other pedagogical approaches (National Council of Supervisors of Mathematics [NCSM], 2025). Nevertheless, interest in MPP research has continued to increase, reflected in recent journal special issues, books, conferences, review papers, and meta-analyses (see Cai et al., 2024). Drawing on the Theory of Practice Architectures (TPA), this paper examines how student problem posing is shaped by the practice architectures within the site, highlighting that the enactment of problem posing cannot be understood in isolation from the conditions in which it occurs.

Background Literature

Research on MPP is often categorised into three interconnected perspectives, problem posing as a cognitive activity, as a learning goal, and as an instructional approach (Cai et al., 2024). Problem posing as a cognitive activity examines the process of how individuals construct personal interpretations of situations and formulate them into mathematical problems (Stoyanova & Ellerton, 1996), problem posing as a learning goal views the development of problem posing skills as a direct instructional objective, and problem posing as an instructional approach involves teaching mathematics through problem posing (Cai et al., 2024). While each perspective offers a distinct lens for examining problem posing, they are not mutually exclusive and frequently overlap in research and practice (Cai et al., 2024). For example, while problem posing as a learning goal is the primary focus of this article, as the classroom conditions for

(2026). In N. Berger, M. Thompson, J. Ley & C. Wilsmore (Eds.), *Beyond boundaries: Strengthening futures in mathematics education. Proceedings of the 48th annual conference of the Mathematics Education Research Group of Australasia, Sydney* (pp. 457–464). MERGA.

enabling students to problem pose are examined, in the larger doctoral study, problem posing was also used to review and teach particular mathematical concepts (instructional approach), and reveal insights into students' mathematical thinking and understanding (cognitive activity).

Research that positions problem posing as a learning goal focuses on development of students' capacity to generate problems. Early research conducted by English (1998) found that informal contexts, such as stimulus pictures and literature, were more successful in encouraging generation of diverse problem types in primary school than when asked to pose problems from provided number-sentences, or non-goal-specific statements such as "Sarah has five dolls on one shelf in her room and four toy cars on another shelf" (p.88). Lewis and Colonnese (2021) used Three-Act-Tasks to develop Year 2 students' capacity to pose problems, highlighting the use of teacher questioning, modelling, concrete materials, and generation of sequels to the Three-Act-Tasks as supportive to students developing ability. Cai and Hwang (2021) reported findings from a longitudinal study that investigated the impact of professional development on teachers' learning to integrate problem posing into the classroom, and on its impact on students' learning outcomes. Case studies from the longitudinal study provide insight into understanding how teachers learn to integrate problem posing in their classrooms (see Zhang & Cai, 2021). While research investigating how teachers implement MPP continues to grow (Cai et al., 2023), less attention has been given to how site-specific arrangements shape its enactment. Using the TPA, this paper addresses this gap by examining how cultural-discursive, material-economic, and social-political arrangements are reconfigured across two cycles of implementation to further enable student problem posing. The following research question frames this paper: *How are site-specific practice architectures reconfigured across cycles of implementation to further enable student mathematical problem posing?*

Research Design

This study adopted a Critical Participatory Action Research (CPAR) methodology (Kemmis, McTaggart et al., 2014) and drew on the TPA to examine how teacher practices were enabled and constrained during iterative cycles of problem posing and solving sequences. The TPA was employed as an analytical framework to attend to the interrelated cultural-discursive, material-economic, and social-political arrangements that shape practice (Grootenboer & Edwards-Groves, 2023). Through this lens, close analysis of how practices are enacted in particular moments and settings was possible, making visible the conditions that enable or constrain practices and the ways these conditions can be reconfigured over time in relation to the intentions, actions, and purposes of the practice (Grootenboer & Edwards-Groves, 2023).

Theoretical Framework

According to Kemmis and Grootenboer (2008), the TPA proposes that practices are comprised of three entwined, socially constructed activities: sayings, doings, and relatings. Practices both shape, and are shaped by, cultural-discursive, material-economic, and social-political arrangements, which are interconnected and held together in practice-arrangement bundles (Grootenboer & Edwards-Groves, 2023). The TPA has been used to examine practices and identify what enables and constrains practices in various fields (e.g., Gibbs et al., 2022; Rönnerman et al., 2023). It is one of many practice theories that focus on "what happens: how life unfolds - and how practices unfold, in the intersubjective space in which we encounter one another and the world" (Kemmis, 2021, p.7). The TPA provides a theoretical way of understanding education practices (e.g., teaching), with the discernment that practices are held in place by practice architectures, the cultural-discursive, material-economic, and social-political arrangements and conditions in the site (Kemmis & Grootenboer, 2008). These arrangements and conditions enable and constrain the sayings, doings, and relatings that form a practice (Edwards-Groves & Kemmis, 2016). Cultural-discursive arrangements shape the language and discourses through which practices are understood and enacted; material-economic arrangements shape the activities and use of space-time; and social-political arrangements shape relationships, power and solidarity within and across practices (Kemmis et al., 2017). Crucially, it is not these arrangements in isolation that shape practice, but their dynamic interplay within a site (Kemmis, McTaggart et al., 2014). Across sites such as lessons, classrooms, or school communities, practices and practice architectures are understood to "hang together" as part of the project of a practice, encompassing the intentions, actions and purposes that orient practice towards particular ends (Kemmis, Heikkinen et al., 2014).

Context and Participants

This study was conducted in a P-12 independent school in South-East Queensland with three Year 6 teachers: Seth (six years teaching experience), Ella (14 years), Kelly (17 years) (pseudonyms) and their classes. The teaching team was in their fifth year of working together. Kelly participated in the initial phase of the study and contributed to the first CPAR cycle before withdrawing due to personal reasons. Ella had previously participated in a research project exploring instructional strategies to support students' problem posing (Zorn, 2022). Subsequent informal discussions about the challenges of implementing these practices, particularly in supporting students to pose problems from a prompt, prompted the development of the present study.

Data Analysis

Data Analysis employed Fereday and Muir-Cochrane's (2006) hybrid approach to thematic analysis to analyse transcript data from planning meetings, classroom observations, teacher reflections, student focus group discussions, and researcher field notes. Following inductive thematic analysis, to identify the teacher practices and inquiry sequence for problem posing and solving, the TPA was applied as a deductive coding framework to analyse how the cultural-discursive, material-economic, and social-political arrangements enabled and constrained implementation across the inquiry phases. Tables of invention (Kemmis et al., 2014) were used as mapping tools to analyse data for each teaching practice and inquiry phase in relation to the practice architectures. To examine changes over time, a comparative table of invention was developed to map shifts from Cycle One to Cycle Two and the dialectical relationship between changes in practice and the practice architectures.

Results and Discussion

This section presents a comparative analysis of Cycle One and Cycle Two, focusing on how changes to classroom conditions enabled student problem posing and shaped the nature and breadth of the questions generated. While a brief description of what occurred in each cycle is provided to establish context, the analysis foregrounds connections between changing conditions, teacher practice, and student problem posing. Drawing on the TPA, the discussion examines how reconfigured cultural-discursive, material-economic, and social-political arrangements interacted with students' developing capacities to pose mathematical problems. In doing so, this section attends to the problems students posed, as well as how problem posing practices emerged through the interdependence of teaching and learning across cycles, that being how student learning shaped teacher practices, and in return shaped student learning. Findings are presented in chronological order.

Problem Posing Through the Cycles

During the initial cycle, the teachers collaboratively selected a lifeguard service sign image as the problem posing prompt, based on its perceived familiarity to the students. This rationale was articulated by all three teachers, who noted that students "would all be familiar with that, like from living around here", that "it's summer" and that the students had explored "beach safety in Year 5". Cycle One unfolded across multiple sessions spaced throughout the term, with problem posing and solving revisited over time, rather than enacted in a single block. MPP was initially introduced through whole-class modelling, with teachers presenting a real-life object such as a coffee cup and asking students, "what math questions could I possibly ask about a cup?". While this supported students' initial engagement with and orientation to MPP, subsequent small group work with the lifeguard service sign revealed limitations in the depth of questions generated. Working in groups of four or five, many students posed surface-level questions, such as, "how many words are there [on the sign]? How many people in the background? How many different colours?". Seth also reported that his students prioritised "getting it done" by posing a certain number of questions, rather than focusing on depth.

As a result, Cycle One included two sessions in each classroom focused on (1) supporting students to pose questions, and (2) increase the challenge of their questions by connecting them to mathematical concepts and distinguishing between mathematical and non-mathematical questions. Additionally, during student focus group discussions, the students expressed frustration at selecting problems to solve with peer groups. As one student explained, "we have like some people wanting different questions...it was kind of hard to choose one single question", while another noted, "it was just annoying...we all found good questions that we can choose and then we're like, we should pick this one, though, but no, actually that one, no I like this one". Although this challenge was not directly related to the generation of problems, it highlighted tensions in the problem selection phase, which was critical in the progression from problem posing to problem solving. Student-generated and selected problems from Cycle One are presented below (Table 1), grouped into four focus categories.

Table 1

Cycle one student generated problems

Category	Questions
Sign production	How much does it cost to make the sign? How big is the sign? Where did they buy the materials? How much of each material do you need? How many people took [did it take] to make it?
Lifeguard working hours	How many hours are lifeguards on duty? What is the lifeguard's schedule? How many lifeguards are on duty? How many minutes has one lifeguard been on duty in a week? Do they work longer hours on New Years Eve? How many hours/weeks/months is the beach open? How many hours is the lifeguard working for in a day? Are there any closing times?
Grains of sand	How many grains of sand are in a cubic metre? How big is the average grain of sand? How many grains of sand fit in a centimetre?
Duration of tides	How long does it take from high tide to low tide? Is it different at different times? What is the average time?

In Cycle Two, the problem posing and solving sequence was enacted within a concentrated block of time, completed across consecutive sessions (n=5). In response to student feedback following Cycle One, such as, "give us a variety of photos", "different options", and "choice of photos" students independently generated questions using a wider range of eight teacher selected visual prompts positioned around the classroom. Students circulated between the prompts, posing questions independently for ten minutes, before working collaboratively in groups of 3-4 to identify and cross out questions they considered to be non-mathematical. Students were then paired to select a prompt and problem to pursue, with opportunities to pose further questions and identify additional information required to solve their problem. As predicted by the teachers, "the more often you do it, they will straightaway jump to the mathematical question", the problem posing phase in Cycle Two was completed within a single session. Student-generated and selected problems from Cycle Two are presented below (Table 2) and have been categorised based on the prompt. While eight prompts were provided, the eighth prompt, a photograph from the recent school camp, was not selected by any student pairs, therefore is not included in table.

Table 2

Cycle Two student generated problems

Prompt	Questions
Watermelon	How many watermelons are in this [image]? What's the weight of the watermelons in this picture? How heavy is one quarter of a watermelon? How much does one whole watermelon cost?
Bottles of glue	How much glue was there combined in all the bottles? How much glue does one bottle contain? How many bottles are there? What is the viscosity of the glue? How many litres are in 24 bottles? How expensive is a single glue bottle? How much do all the bottles cost? How much slime could you make from all the glue in the picture?
Tray of chocolate	How many cubic centimetres are in a chocolate bar? How many litres of chocolate would it [the tray of chocolate] make?
Sprite bottle stack	How many bottles are there? How much did all of them cost? How many millilitres are in all the bottles? How much do all of them weigh?
Olympic swimming results	How much water is in the pool? (capacity in cubic meters)
Building heights	If the Burj Khalifa was a pyramid [similar to the Pyramid of Giza], how big would the base be? How much did the buildings cost all combined? With inflation how much would it be today? What is the height difference between the B67 (fictional tower from movie interest) and the Burj Khalifa?
Lemons	How many whole lemons are in the picture? How much juice do they make? How much did they cost? What fractions can you make from the lemons?

Changing Conditions

According to the TPA, changing the practice architectures is a fundamental way to change the practices themselves. The practice architectures are the cultural-discursive, material-economic, and social-political arrangements that enable and constrain what is said, done, and how people relate to others and the world (Kemmis et al., 2025). These arrangements prefigure, but do not predetermine, the actions undertaken in a site (Mahon et al., 2018). This section examines how the conditions supporting MPP were reconfigured from Cycle One to Cycle Two. Drawing on the TPA, the analysis focuses on how changes to the practice architectures shaped what became possible in students' problem posing practices. By comparing the two cycles, the below section illustrates how shifts in prompts, and task structure and participation altered the breadth of problems posed and the ways students engaged with problem posing.

Prompts

In Cycle One, while the single Lifeguard Service Sign prompt afforded some rich problem possibilities (e.g. schedules, tides, materials), these only became visible with teacher support to move students away from initial low-level questions focused on counting words, colours, and people. Reliance on a single context also limited opportunities for students to draw on diverse prior knowledge. The introduction of multiple prompts in Cycle Two expanded students' access to prior knowledge by providing a wider range of contexts through which they could draw on personal experiences and existing mathematical knowledge. This reconfiguration of the material-economic arrangements increased the likelihood that students would encounter a prompt that resonated with their lived experiences, disciplinary knowledge, or interests. For example, the glue bottle prompt enabled some students to draw on interests in slime making to pose related problems, while the building heights prompt supported connections to geometric and proportional reasoning. Similarly, the lemons prompt supported students to connect everyday experiences with food and fractions, generating questions about quantities and juice yield.

These examples illustrate how reconfiguring the material-economic arrangements facilitated a shift in the cultural-discursive arrangements by expanding the range of language and meanings available for problem posing. Also evident was the students' reliance on familiar discursive resources, such as established counting and measurement question structures (e.g. how many/much), reflecting established cultural-discursive arrangements within mathematics lessons in this site. In this way, multiple prompts functioned not simply as additional resources, but as conditions that enabled students to draw on varied prior knowledge and make connections between everyday experiences and mathematical concepts. The use of multiple prompts also positioned students as valuable contributors through their feedback and provided them with choice, altering the social-political dynamics within the practice. This shift supported increased student ownership, responsibility, and agency within the practice, potentially promoting further engagement (Kemmis et al., 2025).

Task structure and participation

In the initial cycle, problem posing was introduced to the students through whole-class teacher modelling and co-construction using familiar, real-life objects (e.g., mug, water bottle). However, the lesson quickly shifted to collaborative group work in groups of four or five, where many students initially struggled to pose year-level appropriate questions and tended to focus on easily accessible concepts, while others focused on quickly generating questions to complete the task. Group brainstorming relies on specific discourses that encourage participation, with shared language and conceptual resources enabling or constraining the breadth and depth of ideas generated (Mahon et al., 2018). In this context, cultural-discursive arrangements prefigured what could be said and shared, while social-political arrangements, including existing power relations within the site, may have led to particular voices being more dominant than others, contributing to limited exploration.

In the second cycle, students began by independently posing problems across multiple prompts, enabling more equitable participation and a wider range of questions being generated. Reconfiguring the timing, structure, and groupings (material-economic arrangements), simultaneously reshaped the social-political and cultural-discursive arrangements, altering how students engaged with problem posing, with one another, and with teachers. Independent work allowed students to draw on their prior knowledge and use language accessible to them, while teachers were able to engage in more targeted dialogue with individual students, for example, "Are those full lemons? If you don't know how many of those pieces make a lemon, what would the question be?”. Changes to group size supported more efficient problem selection, enabling students to transition more smoothly into the problem-solving phase.

Conclusion and Implications

This study examined the implementation of MPP across two iterative cycles of CPAR. Drawing on the TPA as an analytical lens, the study explored how cultural-discursive, material-economic, and social-political arrangements were reconfigured across cycles to support the implementation of problem posing and solving. It contributes to the growing body of problem posing research by shifting attention from tasks or student products alone to the conditions that make possible particular forms of participation and engagement with mathematical ideas during MPP.

Across the cycles, changes in student problem posing did not occur simply because students became better problem posers but because the practice architectures were progressively reconfigured. Shifting from a single prompt to multiple prompts expanded access to prior knowledge and interests, enabling students to connect personal experiences to mathematical ideas, and reducing reliance on teacher support. Reconfiguring task structures and participation to include independent problem posing before collaborative refinement supported more equitable participation, allowing for a broader range of questions to be shared. Additionally, changes in group size addressed student frustration around problem selection, supporting a smoother transition to the problem-solving phase of the sequence. These changes illustrate the interdependence of teaching and learning practices, demonstrating how adjustments to teaching practices reshaped the conditions for student learning, and vice versa.

While the form of student questions remained predominantly focused on “how many” and “how much”, this should not be interpreted as a lack of development across the two cycles. Even though cultural-discursive arrangements within mathematics classes in the site may implicitly reinforce the narrow idea that mathematics is mainly about numeration, measurement, and numerical outcomes, in this case it enabled the students to engage productively as the conditions supporting problem posing were reconfigured. These familiar question forms supported students to engage with a wider range of mathematical ideas and contexts. This reinforces the importance of interpreting student products in relation to the conditions under which they were generated, rather than solely as indicators of ability.

This study demonstrates the value of the TPA as an analytical framework for examining practice and changes over time. The use of tables of invention to systematically organise, compare, and interpret data across cycles made visible the dialectical relationship between practice and the practice architectures, offering a way to study implementation as a dynamic, site-specific process. In doing so, the study extends problem posing literature by providing a theoretically grounded account of how practices are developed and sustained through ongoing reconfigurations rather than fidelity to predetermined models.

The evidence presented in this study is limited to a single site and a small teaching team, however, it offers insights into how changing classroom conditions can support student problem posing in upper primary mathematics. Future research could explore how similar configurations operate across different year levels and contexts, and how broader practice architectures interact with classroom-level practices.

Acknowledgments

Ethics approval GU Ref No: 2024/11 was granted by Griffith University, and participants gave informed consent.

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