Planning for Mathematical Problem-Posing: Exploring Practice Through the Lens of Practice Architectures

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Mathematical problem-posing (MPP) offers an alternative to teacher-directed approaches by encouraging students to create and solve their own problems. While MPP is supported by the Australian Curriculum and empirical research has increased over the last decade, implementation in classrooms is still limited. Using The Theory of Practice Architectures (TPA), this paper reports on data from the initial phase of teacher planning for MPP, part of a larger doctoral study exploring teacher practices during MPP and solving. This paper offers insights into the practice of planning for MPP and how the TPA can be used to capture the nuances of how practice is enacted in specific settings.

Problems presented in mathematics classrooms frequently require students to apply particular algorithms or techniques, focusing on obtaining correct answers rather than exploring mathematical concepts (Schoenfeld, 2017). Mathematical problem-posing (MPP) offers an alternative to this more commonly used teacher-directed approach. Although posing problems is recognised as an aim of the Australian Curriculum: Mathematics, as well as being noted in the proficiency strands and under Mathematical Processes: Mathematical Modelling (Australian Curriculum, Assessment and Reporting Authority [ACARA, n.d.]), it is less commonly used in classrooms. While MPP has gained recognition as an essential component of mathematics education research, a Google Scholar search using various terms (mathematical problem solving – ca. 5 460 000; mathematical modelling – ca. 5 050 000; mathematical thinking – ca. 4 620 000; mathematical reasoning – ca. 3 500 000 and mathematical problem-posing – ca. 439 000) illustrates it is relatively underdeveloped when compared to other topics (Rott et al., 2024). Further exploration of this also indicates increasing interest with the number of search hits for "mathematical problem posing" continuing to increase each year (Rott et al., 2024). An increase in research activity has also been noted by Cai et al. (2024) who highlight several recent journal special issues, books and conference papers focused on a wide range of problem-posing topics. However, little research has focused on teacher practices for implementing MPP in the classroom. As part of a larger doctoral study exploring teacher practices during MPP, this paper offers insight into how the practice of planning for MPP, during one ninety-minute teacher and researcher planning session, was enabled and constrained by the practice architectures within this site. It offers suggestions for teachers looking to implement MPP in their classroom.

Background Literature

Problem-posing in mathematics education dates back several decades with researchers and mathematicians recognising that in real-life, problems are generated by the solver (Kilpatrick, 1987). MPP includes the generation of new problems, as well as the reformulation of existing problems (Silver, 1994), and can be categorised into free, semi-structured, and structured problem-posing (Stoyanova & Ellerton, 1996). Free problem-posing, implemented in this study, encourages students to create mathematical problems based on a provided situation (e.g., an image prompt) without limitations (Stoyanova & Ellerton, 1996). Problem-posing literature is generally categorised into three focus areas: as a cognitive activity, learning goal, or instructional approach. In relation to this study, problem-posing as an instructional approach focuses on the methods and strategies that teachers use to engage students in generating their own mathematical problems. Zhang and Cai (2021) analysed 22 teaching cases that focused on

(2025). In S. M. Patahuddin, L. Gaunt, D. Harris & K. Tripet (Eds.), *Unlocking minds in mathematics education. Proceedings of the 47th annual conference of the Mathematics Education Research Group of Australasia* (pp. 485–492). Canberra: MERGA.

the role of the teacher, the types of prompts used, and how teachers responded to students posed problems. They found that most real-life prompts were presented in words and that a similar lesson sequence was used: present the task, students' problem-pose, teacher guidance to solve, summary, and reflection. Jia and Yao (2021) also looked at problem-posing as an instructional approach, examining the inclusion of problem-posing in Chinese textbooks published by the same publisher over seventy years. They found that although still rare, problem-posing activities have begun to be purposefully included in these textbooks. Mathematics textbooks and teaching resources provide teachers with an important tool for preparing lessons, the rarity of inclusion highlights one of the challenges faced by teachers when planning for and implementing MPP. In a longitudinal study, Cai and Hwang (2021) investigated the impact of problem-posing professional development on teachers' conceptions of problem posing, their design of lessons to teach mathematics using problem posing, and the impact on students' learning. While Cai and Hwang recommend ways to integrate problem-posing in classrooms, they do not focus specifically on teacher practice. Whether teachers choose to use pre-designed problem-posing tasks, or design them themselves, innovating their practice in this way presents a challenge. Li et al. (2020) explain that this is likely due to a variety of factors including, limited resources or teaching materials, lack of familiarity with teaching problem-solving, difficulty shifting their practice, and lack of a supportive learning community. Through the Theory of Practice Architectures (TPA) (outlined below), the doctoral study from which this paper is drawn investigates teacher practices in one site for MPP. The following question frames this paper: *How do the practice architectures enable and constrain the practice of planning for problem-posing?*

Research Design

This study utilised a Critical Participatory Action Research (CPAR) methodology (Kemmis, McTaggart et al., 2014) to identify and examine teacher practices used when implementing MPP, and how those practices changed through iterative cycles of implementation. The TPA was chosen as an analytical framework as it considers the interplay between various elements of practice, including cultural-discursive, material-economic, and social-political arrangements (Grootenboer & Edwards-Groves, 2023). It provides a way to capture the nuances of how practice is enacted in specific moments and settings and identifies enablers and constraints influencing educational practices and how they can be transformed (Grootenboer & Edwards-Groves, 2023).

Theoretical Framework

The TPA has been used to examine practices and identify what enables and constrains practices in various fields (e.g., Rönnerman et al., 2023). First theorised by Kemmis and Grootenboer (2008), 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). 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 language (sayings), activities (doings), and relationships (relatings) that form a practice (Edwards-Groves & Kemmis, 2016). The cultural-discursive arrangements exist in the dimension of semantic space and relate to how the distinct language and discourse is situated in and about particular practices, for example, shared technical language, or discourse around inquiry learning. The material-economic arrangements exist in the dimension of physical space-time and involve the kinds of activities or work that occurs within the practice, for example, the physical set up of classrooms. The social-political

arrangements exist in the dimension of social space, how we connect and contest in relation to power and solidarity, and the patterns of relationships with living and non-living things that occur in practices, for example, the relationship between students and teachers or students and a digital mathematics program. Kemmis, McTaggart et al. (2014) explain that it is not these individual elements in isolation that constitute the arrangements and conditions that enable and constrain practices, but how they are shaped by their dynamic interplay as they combine within a site. Whether the site is a lesson, classroom, or school community, people are engaged in particular practices within those sites. In these sites or intersubjective spaces (Grootenboer & Edwards-Groves, 2023), the practices and practice architectures "hang together" with Kemmis, Heikkinen et al. (2014) describing this "hanging together" as 'the project of a practice'- the melding of practices and practice architectures, explaining that it encompasses the intention that motivates the practice, the actions (sayings, doings and relatings), and the end aims the practitioner hopes to achieve through the practice.

Context and Participants

This study was conducted in a P-12 independent school in South-East Queensland with three Year 6 teachers: Seth (6 years teaching experience), Ella (14 years), Kelly (17 years) (pseudonyms) and their classes. The teaching team was in their fifth year of working together. Ella had previously participated in a research project exploring instructional strategies that supported Year 5 students to problem-pose (Zorn, 2022). In casual conversation after this earlier project, Ella shared the difficulties she faced when attempting to implement the practices in her classroom, particularly the challenges related to posing problems based on a prompt. It was through these discussions that further interest was generated and this CPAR project was conceived.

Data Analysis

Fereday and Muir-Cochrane's (2006) hybrid approach to thematic analysis was used in the broader study to analyse transcripts from planning meeting observations and audio recordings, video observations of lessons, researcher field notes, and teacher reflections collected over seven months. Using NVivo™ data management system, preliminary themes were identified for the code manual before coding the transcript corpus. During this process, themes were continually refined and adapted based on new insights. Through this process, the practice of planning was identified as a key teacher practice for implementing problem-posing and solving. The second stage of analysis used the TPA (Grootenboer & Edwards-Groves, 2023) as a pre-determined coding system. It assisted the researcher in identifying how the practice architectures enabled and constrained the practice of implementing MPP and problem-solving. The data reported on here draws on the initial, 90-minute planning session. It offers insight into how the practice of planning for MPP was enabled and constrained by the cultural-discursive, material-economic, and social-political arrangements in this site.

Results and Discussion

The teaching practice of planning here focuses on the intentional process of preparing prompts suitable for free problem-posing, anticipating student responses, and considering how ideas are presented. In this section of the paper, transcript extracts will be presented that illustrate the teachers' sayings, doings, and relatings during the planning process. While the data reported here is not extensive, it provides a glimpse into the process of planning for MPP. An analysis and discussion follow analysing how teacher planning was enabled and constrained by the practice architectures in the site. It is important to note that, while analysing the different architectures of a practice allows for careful examination of the influences that enable or constrain the practice, in reality they are enmeshed and do not operate in isolation.

The Practices of Planning for Mathematical Problem-Posing

During the initial phase of planning, the researcher provided the teachers with a shared folder of images and website links to explore as potential prompts. After a brief look, the teachers selected a 'lifeguard service sign' based on its perceived familiarity to the students.

Figure 1

Lifeguard Service Sign

Excerpt 1

Seth : I think maybe the lifeguard thing. Just like they would all be familiar with that, like from living around here.

Ella : And it's summer.

Seth : And there are already identifiable numbers on there and things like that that they can see as a prompt. The only thing is that it is only a picture, is it going to hook them in as much as a video would? But then is it less ambiguous than a video? Like if it was that chicken one then that might be too broad for them whereas...

Ella : Yeah, I like it as a first one because...

Seth : ...just one point of focus.

Ella : ...it's just one like if we want to do just a short one, maybe going over two or three days, I think that's a good one. Kelly agrees, Kelly agrees [said louder], ha-ha [Kelly nodding]. OK. Yeah, cool. Let's do that one, then because they all love the beach. It's summer. Yeah, yeah.

Kelly: And they did beach safety in Year 5.

Once they had selected the prompt, the teachers brainstormed potential mathematical problems that could be generated from the prompt. While the teachers brainstormed together, Ella recorded the ideas. The extracts below illustrate two instances during the discussion that related to potential questions.

Excerpt 2

Kelly: They could look at the range of temperatures.

Seth : Yeah, across a week or a month.

Ella : I've got the prompt as well but keep looking at you.

Seth : There are people in the background too, so they might...

Ella : They could do like a...

Seth : Their question might be, how many people...

Ella : How many go to the beach?

Seth : ...go to the beach in summer? Or people...

Kelly: Well, they could do a survey.

Seth : Yeah, they could do, how many people in our class went to the beach?

Ella : Which one was it? Was it the Broadbeach beach sign?

Kelly: Could they look at wind speed?

Excerpt 3

Seth : Even the stuff like the unstable conditions, what, what's the metric for a lifeguard that makes it pleasant to unstable to beach closed? Like what are the considerations that have to go into that?

Ella : What would you call that? Because it's about, now, it's about, I could call it...

Seth : comparison?

Ella : No, I mean, like when, ah I can't think, when you go from, not a span. It's not mode, it's not median, it's not

Seth : Range?

Ella : Yes, range. So what range is considered hot, warm, cold or dangerous, or whatever. How would we write that?

Seth : What conditions, what range of conditions fits in unstable, what range of conditions fits in dangerous and beach closed? What would be a perfect day? That'd be a good question, what would be a perfect day? Or is there ever a perfect day?

Kelly: And does it depend on what you're looking for? It's very different to the surfer.

The teachers also discussed how to get the students to pose questions, suggesting and agreeing that co-constructing questions with the students may be a good strategy.

Excerpt 4

Kelly: I think you should say, this is an example and then do it collaboratively.

Seth : Maybe it's, this is an example because...

Ella : We could even co-construct.

Kelly: You could even analyse the word choice, this makes it a mathematical question or why does it make it a mathematical question?

Practice Architectures

Cultural-Discursive Arrangements

Cultural-discursive arrangements are realised in the semantic space, encompassing the ways in which language is used to communicate, express ideas, and construct meaning. Examining the language in Excerpt 1, the teachers' understanding of free problem-posing is highlighted. Seth comments that "there are already identifiable numbers on there and things like that, that they can see as a prompt", indicating that the presence of written numbers may make it easier for students to problem-pose in mathematics. Later he asks, "is it going to hook them in as much as a video would?", illustrating his awareness that the prompt is used as a stimulus to provoke curiosity and wonder and can include either a video or an image, accompanying the written text. While Ella's language, "if we want to do just a short one, maybe going over two or three days", suggests that the students may be somewhat limited by the lifeguard service sign, posing problems that could be solved and shared within a short timeframe. Limited experience with having students engage in problem-posing creates a duality, both enabling and constraining the practice of planning. While creating space for innovation by demonstrating a willingness to experiment with a new approach, the practice may also be constrained by the lack of teacher knowledge, preventing the teachers from optimising opportunities or envisioning how problem-posing will unfold in the classroom.

The use of technical language such as "survey, bar chart, mean, median, how many, and comparison" is also noted in Excerpts 2 and 3. This language, and corresponding knowledge of these concepts, enables the teachers to discuss ideas freely, contributing to the ongoing construction of the practice of planning for MPP. However, confusion around mathematical terminology is also evident. For example, while discussing a potential model that describes the different levels of safety and suitability, the teachers use the word 'range' (Excerpt 3) but express uncertainty about its accuracy, which constrains their practice.

Discourse associated with specific pedagogical approaches additionally enabled the practice of planning. The words and phrases used during the planning meeting such as, “workshopping”, “collaboratively”, “co-construct”, “analyse the word choice”, and “a mathematical question” (Excerpt 4) are all used without further explanation, suggesting a familiarity amongst the group in working in this way with their students. The specific pedagogical language enabled the practice of planning and influenced the way in which the individuals interacted and constructed meaning. Additionally, it is reflective of the cultural-discursive arrangements visible at the school, evident on the school’s website, which emphasises practices of “student-centred learning” and an “advisory approach” in relation to the student-teacher relationship.

Material-Economic Arrangements

Material-economic arrangements refer to the physical and economic conditions that exist, or are brought into the site, and they directly influence the types of activities that can occur, concurrently enabling and constraining the sayings and relatings. During this planning session, the seating arrangements (i.e., small group tables), facilitated the collaborative nature of the Year 6 teachers and task (i.e., planning practices). The easy availability of technology in this site, including personal devices and internet access, allowed the teachers to access the suggested websites and prompts saved on the school’s intranet. However, while suggested websites and prompt ideas were provided, teachers were also encouraged to look beyond these suggested ideas. However, despite this encouragement, the teachers chose to limit their search to the provided prompts and made their decision within the first three minutes of planning for the prompt. Although the provided resources enabled quick decision making, this likely constrained the practice of selecting a potentially more suitable prompt that may have been discovered if the teachers searched for prompts beyond those provided. During the planning session, the teachers brainstormed questions while Ella volunteered to record the responses using her laptop. While the use of the devices, and a shared file of resources facilitated the practice, it simultaneously constrained it. During the discussion Ella made two comments, “I've got the prompt as well but keep looking at you” and “Which one was it? Was it the Broadbeach beach sign?” (Excerpt 2) indicating that she found it difficult to look at the prompt while simultaneously recording and contributing to the discussion. Consequently, having the shared digital file with the prompts and planning document, and trying to view it on one personal device, constrained the practice.

Social-Political Arrangements

Social-political arrangements, highlighted by the relatings among individuals and groups, play a crucial role in influencing how practices are developed and sustained within a particular site. The familiar relationship and social dynamics between the teachers observed throughout the project, and the ease of decision making as evidenced in Excerpt 1, supported the teachers to collaborate during planning sessions. However, within this excerpt, Seth and Ella are engaged with the task of selecting a prompt, while Kelly appears to be distracted. Ella brings Kelly back into the conversation in a direct but friendly way as represented in the language used by Ella, “Kelly agrees, Kelly agrees [said louder], ha-ha [Kelly nodding]”. This re-engages Kelly into the conversation and the collaborative session continues. While in some circumstances, being distracted or having this interaction may constrain the relationships within the group and practice, here it did not appear to shift the dynamic or flow of the practice. Additionally, in the initial segment of Excerpt 2, the teachers are seen to overlap in conversation and pick up where the other left off, and in Excerpt 3 they support each other with knowledge building and recording. This is noted when Seth offers suggestions to Ella when she is trying to remember the concept of range and asks, “how would we write that?” referring to documenting the discussion, and again in Excerpt 4 when the teachers openly discuss and share ideas. As noted in researcher field notes, and evidenced in meeting transcripts, the Year 6 teachers openly

acknowledged not knowing exactly what to do at times, which perhaps indicated they felt comfortable seeking one another's opinions and advice. Here, positive group dynamics enabled collaborative practices, and these in turn helped to sustain the practice of planning. However, positive group dynamics can sometimes constrain practice, leading to 'groupthink' or creating pressure for group members to conform to maintain cohesion.

Conclusion and Implications

Examining the practice of planning through the lens of TPA reveals that the practice, which is site based, does not happen in isolation; instead, it is embedded within broader cultural, material, and social contexts. For example, the practice of planning in this instance required the teachers to work together, which is both influenced by, and held in place by, the practice architectures. While the teachers' limited knowledge of MPP potentially constrained them from optimising opportunities or envisioning how things could unfold in the classroom, the shared pedagogical knowledge (cultural-discursive) and positive group dynamics (social-political) supported the practice of planning, providing space for innovation. The unfamiliarity with MPP and their familiarity with each other, may have also contributed to the decision to quickly choose one of the provided prompts. The material-economic arrangements (provided shared file of resources) were seen to be held in place; supported and constrained simultaneously by the cultural-discursive and social-political arrangements.

By examining practices through the TPA, the researchers and practitioners gained a holistic understanding of the interconnectedness of practices and, consequently, a better understanding of the dynamics involved. As the complexities and nuances of the practice are revealed, informed interventions and changes can be made to improve practices over time. Focusing solely on the practice, without focusing on the factors or arrangements that enable or constrain it, is likely to lead to that practice being unsustainable. While only a small subset of data is explored here, this limitation does not diminish the validity and contribution to meaningful insights into using the TPA in mathematics education to examine how practices unfold within a specific site. Additionally, it provides insight for teachers looking to implement MPP in their classrooms. Shifting pedagogical practice is challenging (Fry et al., 2025), and while it may feel daunting to find the time and energy to do so, it has been illustrated here that prior experience, pedagogical and content knowledge, and healthy interpersonal relationships support the process of planning when innovating practice. More generally, it is important to take stock of available resources, both physical and human, seek the opinions of others, and be open to change. In relation to free MPP, the teachers highlight the initial steps of finding a prompt which their students will connect with, brainstorming mathematical connections, questions, and concepts, and most importantly, the importance of getting started with MPP, even when unsure of all the next steps.

Acknowledgements

Ethics approval GU RefNo: 2024/11 was granted by Griffith University, and participants gave informed consent.

References

Australian Curriculum Assessment Reporting Authority. (n.d.). *Foundation to Year 10 Curriculum.* Retrieved May 26, 2025, from https://v9.australiancurriculum.edu.au/f-10-curriculum/learning-areas/mathematics/year-10

Cai, J., & Hwang, S. (2021). Teachers as redesigners of curriculum to teach mathematics through problem posing: Conceptualization and initial findings of a problem-posing project. *ZDM – Mathematics Education, 53*, 1403-1416. https://doi.org/10.1007/s11858-021-01252-3

Cai, J., Koichu, B., Rott, B., & Jiang, C. (2024). Advances in research on mathematical problem posing: Focus on task variables. *The Journal of Mathematical Behavior, 76,* 1-17. https://doi.org/10.1016/j.jmathb.2024.101186

Edwards-Groves, C., & Kemmis, S. (2016). Pedagogy, education and praxis: Understanding new forms of intersubjectivity through action research and practice theory. *Educational Action Research, 24*(1), 77-96, https://doi.org/10.1080/09650792.2015.1076730

Fereday, J. & Muir-Cochrane, E. (2006) Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods, 5*(1), 1-11. https://doi.org/10.1177/160940690600500107

Fry, K., Nakar, S., & Zorn, K. (2025). Professional learning interventions for inquiry-based pedagogies in primary classrooms: A scoping review (2012-2022). *Mathematics Education Research Journal, 3*(25), 1-35. https://doi.org/10.1007/s13394-024-00516-x

Grootenboer, P. & Edwards-Groves, C. (2023). The theory of practice architectures: Researching practices. Springer.

Jia, S., & Yao, Y. (2021). 70 years of problem-posing in Chinese primary mathematics textbooks. *ZDM – Mathematics Education, 53*, 951-960. https://doi.org/10.1007/s11858-021-01284-9.

Kemmis, S. (2021). A practice theory perspective on learning: beyond a 'standard' view. *Studies in Continuing Education, 43*(3), 280-295. https://doi.org/10.1080/0158037X.2021.1920384

Kemmis, S. & Grootenboer, P. (2008). Situating praxis in practice: Practice architectures and the cultural, social and material conditions for Practice. In S. Kemmis & T.J. Smith (Eds.), *Enabling Praxis: Challenges for education,* (37–64). Sense Publishers.

Kemmis, S., Heikkinen, H., Fransson, G., Aspfors, J. & Edwards-Groves, C. (2014). Mentoring of new teachers as a contested practice: Supervision, support and collaborative self-development. *Teaching and Teacher Education, 43,* 154-164. https://doi.org/10.1016/j.tate.2014.07.001

Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The action research planner: Doing critical participatory action research.* Springer. https://doi.org/10.1007/978-981-4560-67-2

Kilpatrick, J. (1987). Problem formulating: Where do good problems come from? In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 123–147). Lawrence Erlbaum Associates.

Li, X., Song, N., Hwang, S., & Cai, J. (2020). Learning to teach mathematics through problem posing: Teachers' beliefs and performance on problem posing. *Educational Studies in Mathematics, 105,* 325-347. https://www.jstor.org/stable/45380372

Rönnerman, K., Grootenboer, P., & Edwards-Groves, C. (2023). The practice architectures of middle leading in early childhood education. *International Journal of Child Care and Education Policy, 11*(1), 1-20. https://doi.org/10.1186/s40723-017-0032-z

Rott, B., Cai, J., Leikin, Roza, Kontorovich, I., Jiang, C., & Marcatto, F.S.F. (2024, July 7-14). *Mathematical problem-posing processes* [Conference presentation]. ICME-15 2024 Congress on Mathematical Education, Sydney, Australia. https://icme15-c10000.eorganiser.com.au/data/clients/1/773/submissions/183437/abstract.pdf

Schoenfeld, A. H. (2017). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics (Reprint). *Journal of Education, 196*(2), 1-38. https://doi.org/10.1177/002205741619600202

Silver, E. A. (1994). On mathematical problem posing. *For the Learning of Mathematics, 14*(1), 19–28. https://www.jstor.org/stable/40248099

Stoyanova, E., & Ellerton, N. F. (1996). A framework for research into students' problem posing. In P. Clarkson (Ed.), *Technology in mathematics education* (pp. 518-525). Mathematics Education Research Group of Australasia.

Zhang, L., & Cai, J. (2021). Teaching mathematics through problem posing: Insights from an analysis of teaching cases. *ZDM-Mathematics Education, 53*, 961-973. https://doi.org/10.1007/s11858-021-01260-3

Zorn, K. (2022). *Student perceptions of engagement and problem-posing during an inquiry-based learning mathematical investigation.* [Master's thesis, Griffith University]. Griffith University.