



Developing Problem-Posing Efficacy in Preservice Mathematics Teachers: A Competency Intervention Study

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ARTICLE INFO	ABSTRACT
Published Online: 07 April 2026	This study explored the effects of a structured problem-posing intervention on preservice mathematics teachers' (PSTs) problem-posing efficacy. Using a mixed-methods approach, 25 PSTs participated in multiple intervention sessions, with data collected through pre- and post-surveys and semi-structured interviews. Results showed a significant improvement in efficacy, with mean scores rising from 2.27 to 4.07 and an effect size of Hedges' $g = 1.85$. Qualitative analysis highlighted themes such as increased confidence and independence, collaborative strategies for overcoming challenges, and criteria for effective problem design. The findings suggest that such interventions can enhance PSTs' pedagogical skills, urging their inclusion in teacher preparation programmes.
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I. INTRODUCTION

A. Background and Context

Problem-posing, defined as the generation of new problems and the reformulation of given ones, is increasingly recognised as a critical component of mathematical proficiency and a vital pedagogical skill [1][2]. It shifts the focus of cognitive agency from teacher to learner, fostering deeper conceptual understanding, creativity, and critical thinking. In recent years, mathematics education research has shifted from focusing primarily on problem-solving to explicitly investigating problem-posing as both a learning activity for students and a teaching competency for mathematics educators [3].

The efficacy of preservice teachers (PSTs) in posing mathematical problems is of paramount importance. Teacher efficacy – the belief in one's ability to organise and execute courses of action required for the successful accomplishment of a specific teaching task – is a powerful predictor of instructional behaviour, resilience, and student outcomes [4][5]. One aspect of pedagogical content knowledge is problem-posing efficacy of preservice mathematics teachers, defined as the confidence and perceived ability to create, modify, and use mathematical problems meaningfully [6]. The development of this efficacy is essential for PSTs to shift from passive consumers of the curriculum to active curriculum designers, creating mathematical experiences that

facilitate inquiry and conceptual understanding among learners [7].

This competency is directly aligned to current standards-based curricula such as the National Council for Curriculum and Assessment (NaCCA)'s [8] common core mathematics curriculum, the Common Core State Standards for Mathematics (National Governors Association Centre for Best Practices & Council of Chief State School Officers, [9] and PISA 2022 Mathematics Framework [10] that focus on specific mathematical practices such as modelling with mathematics, reasoning, and argumentation. Problem-posing, in all its forms, is a means of exercising these related practices, as it requires teachers to devise mathematically viable, relevant, and engaging problems that are appropriately challenging for a range of learners [11]. Therefore, the efficacy of problem-posing is a crucial focus of teacher development, integrating subject matter knowledge (SMK), pedagogical content knowledge (PCK), and the adaptive expertise of responsive teaching in diverse classrooms [12].

B. Problem Statement

While previous studies have noted the importance of problem-posing (e.g., [1]) and documented broad challenges faced by teachers [13][14], the mechanisms of developmental change in PSTs remain a critical gap. Most studies focus on

outcomes (e.g., the quality of the problem) or on broad attitudes and utilise qualitative or quantitative approaches. Few utilise a deliberate mixed-methods design to connect the quantitative development of self-efficacy with the qualitative lived experience of the cognitive and affective struggles that characterise the journey from novice to competent designer [15][16]. The specific relationship between the processes of (a) overcoming specific challenges of the content (e.g., diagram interpretations) and the strategic heuristics PSTs develop in response, and (b) the subsequent development of more refined implicit evaluative standards of effective problem-posing remains largely unexplored [17][18]. The current study undertakes this task using a convergent parallel mixed-methods approach to describe not only whether gaps in efficacy are closed, but also how and through what experiential and social processes this change occurs, thereby presenting a more elaborate framework for intervention design. Providing a generation of teachers with a high level of problem-posing efficacy could significantly impact mathematics classrooms by creating more inquiry-based, student-centred classrooms, thereby achieving the goals of standards-based reform and addressing the persistent problem of student disengagement [19].

C. Research Questions

This study was guided by the following primary research question: What is the effect of a structured problem-posing intervention on preservice mathematics teachers' problem-posing efficacy? The specific objectives included:

1. To assess changes in PSTs' self-reported confidence and competence in problem-posing after an intervention.
2. To explore PSTs' experiences, their challenges and adaptive strategies during the problem-posing intervention.
3. To examine the criteria PSTs formulate to assess the success of their mathematical problems.

D. Significance of the Study

The study offers insights into mathematics teacher education and pedagogical design by documenting the developmental growth empirically of the phenomenon described as problem-posing efficacy. The study provides a detailed practice-oriented framework for the development of effective teacher preparation modules by addressing the challenges PSTs encounter, such as cognitive load, content-related barriers, and time management, along with the micro-strategies to circumvent such barriers, including peer collaboration, self-solving heuristic, and reflective practice. The findings are intended to directly inform curriculum developers and mathematics teacher educators in implementing standards-based teaching framed by problem-posing pedagogy, as well as in developing the reflective and adaptive practices described as critical for ongoing professional growth [20].

II. LITERATURE REVIEW

A. Problem-Posing in Mathematics Education

The problem-posing approach draws on constructivism and sociocultural learning theories, particularly the notion of learning as an interactive process with meaningful tasks and social discourse [21]. This emanated from the seminal work of Brown and Walter [22] on the "What-If-Not?" strategy and Silver's [23] categorisation of problem-posing as both pre-solution (posing from a stimulus) and within-solution (reformulating during solving) activity, it is recognised as a higher-order cognitive process integral to mathematical inquiry [24]. Research shows several advantages for students, such as greater flexibility in problem-solving, deeper understanding of concepts, more positive feelings about mathematics, the development of mathematical creativity and identity, and growth in mathematical understanding [1][2][25]. For teachers, problem-posing entails a deep level of SMK, high-order PCK, and insight into students' thought processes [26]. However, prior studies of interventions with in-service teachers revealed common patterns of challenges in addressing problems that go beyond procedural, single-answer tasks to more open-ended, concept-rich problems that invite exploration. Often, teachers cite a lack of or insufficient training and modelling as an explanation for the low self-efficacy they feel about their ability to pose problems [13][14][27].

B. Problem-Posing Efficacy in Mathematics Preservice Teachers

Efficacy beliefs, central to Bandura's [4] social cognitive theory, are formed through four primary sources: mastery experiences (the most potent), vicarious experiences, social persuasion, and physiological/affective states. In the context of problem-posing, a PST's efficacy is likely shaped by direct experience in posing and testing problems, observing expert and peer models, receiving constructive feedback from instructors and colleagues, and managing the anxiety or frustration associated with initial attempts [28]. Teacher preparation programmes that provide structured, scaffolded opportunities for problem-posing can create powerful mastery experiences that counter initial apprehension [15][29]. On the other hand, Liljedahl [30] indicates that without intentional support for these practices, PSTs might begin their professional lives with a low sense of efficacy in problem posing, leading them to rely on textbook exercises and to miss critical opportunities for formative assessment, differentiation, and cognitive engagement.

C. Standards-Based Curriculum and Problem-Posing Efficacy

Current standards-based curricula from Ghana [8] and around the world emphasise the need for mathematics to be taught as a sense-making and applied discipline. Problem-posing is inherently aligned with standards that value reasoning, communication, modelling, and real-world application [9][10]. It serves as a pedagogical mechanism to

achieve these standards by placing students in the active role of questioners. There is, however, an important tension: while standards call for such investigative work, a packed curriculum, a prescribed pacing guide, high-stakes accountability tests, and all the attendant pressures create a pressure that pushes teachers to work efficiently and perform predictable closed-form tasks [19][31]. Building PSTs' capacity for problem-posing must encompass two intertwined aspects: developing the ability to create problems and the pedagogical capacity to strategically position and integrate them within the constraints of the curriculum's learning objectives, assessment, and time [11]. This calls for incorporating curriculum analysis and alignment into the intervention design.

D. Deepening Conceptual Understanding through Problem-Posing

Problem-posing as a constructive pedagogical practice is in itself an exercise for the problem poser. Engaging in problem-posing requires PSTs to break down a problem, analyse the mathematical relationships among its components, and strategise and explain different pathways to a solution [26]. In so doing, they often discover that they have a limited understanding of mathematics, which is an important feedback loop for their own learning [32]. In the best of circumstances, this is what effective interventions can do when they invite PSTs to consider the mathematics, structure, and gaps in the problem they construct, thereby deepening their pedagogical content knowledge [33].

E. Identifying and Bridging Knowledge Gaps through Problem-Posing

Problem-posing can provide insight into the level of subject-matter knowledge that PSTs possess. According to Cai [17], the inability to pose a coherent, solvable problem indicates a lack of understanding of certain mathematical concepts or of how they are interrelated. For example, gaps in constructing problems from diagrams may reflect insufficient spatial reasoning or representational fluency. Leung [23] states that PSTs can build knowledge networks that are more interconnected and robust through supported interactions following collaborative problem-posing and analysis activities.

F. Overcoming Conceptual Challenges in Problem-Posing

PSTs face distinct conceptual challenges when beginning to pose problems. These include cognitive fixation. That is, being anchored to standard problem types encountered in their own education [30]; more so, having limited example spaces, thereby having to draw from a narrow range of contextual or mathematical situations [25]; and finally, having difficulty with appropriateness, that is, judging the cognitive demand and solvability of a self-generated problem [13]. Overcoming these challenges requires more than practice; it necessitates explicit strategy instruction (e.g., "What-If-Not?", changing parameters, varying

contexts), exposure to diverse exemplars, and frameworks for evaluating problem quality [27].

G. Theoretical Framework

This study is guided by an integrated framework combining Bandura's [6] Self-Efficacy Theory (SET) and Kolb's [34] Experiential Learning Theory (ELT), viewed through a social constructivist lens [21]. Self-efficacy theory provides the explanatory mechanism for the outcome – the development and consequences of PSTs' beliefs about their problem-posing capabilities. It predicts that successful mastery experiences within the intervention will be the primary driver of efficacy growth. ELT provided valuable insights into the learning process during the intervention through the iterative cycles of concrete experience, reflective observation, abstract conceptualisation, and active experimentation. The problem-posing tasks acted as concrete experiences, and the guided instructor feedback sessions served as reflective observation. Thematic discussions on the criteria of the problems led to abstract conceptualisation, and then, more complex problem-posing tasks represented active experimentation. The social constructivist overlay emphasises that this cycle is socially mediated – knowledge and efficacy are co-constructed through dialogue, collaboration, and guided participation within a community of practice [35]. This tripartite framework justifies the study's mixed-methods focus on both quantitative change in efficacy beliefs and the qualitative, socially situated journey of learning and identity formation.

III. METHODOLOGY

A. Research Design

This study employed a convergent parallel mixed-methods design within an interpretivist paradigm [36]. The interpretivist approach was chosen to gain a deeper understanding of the PSTs' subjective experiences, meanings, and transformations. Quantitative and qualitative data were collected concurrently, analysed separately, and then integrated to provide a comprehensive understanding of the intervention's impact.

B. Participants and Sampling

Participants were 25 third-year mathematics preservice teachers (12 females, 13 males) enrolled in a basic school teacher preparation programme at a college. Their ages ranged from 15 to 24 years. A purposive sampling method was used to select participants who had completed core mathematics and pedagogy courses but had no formal exposure to problem-posing as a pedagogical strategy, ensuring relevance to the research questions.

C. Data Collection

A six-item Problem-Posing Efficacy Survey (PPES) was crafted for this study, informed by the constructs of Tschannen-Moran and Hoy [5] and the problem-posing

literature. Items used a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) to measure confidence level. The first draft of the items was reviewed for content validity by two mathematics education experts, and the items were then modified based on their suggestions to enhance clarity and relevance. This version was administered to a group of 30 PSTs with similar characteristics at another college, resulting in a few minor wording changes. The final version of the survey showed a high level of internal consistency, with a reliability measurement of ($\alpha = 0.89, 0.92$) in the pre and post-tests, respectively.

Semi-structured interviews were conducted post-intervention; all 25 PSTs participated in individual, audio-recorded interviews (35-45 minutes each). The interview protocol focused on three major objectives: changes in confidence, challenges faced, and criteria for effective problem-posing. In addition, PSTs produced problem-posing tasks throughout the intervention, providing tangible evidence of growth in complexity, clarity, and alignment.

D. Intervention Procedures

The intervention consisted of twice one-and-a-half-hour sessions over six weeks in a semester to activate Bandura's [4] sources of efficacy. The sequence was introduction to problem-posing (pre-intervention survey, theory, examples, and benefits) as sessions 1 – 2; structured practice with different prompts (numerical expressions, real-world scenarios, diagrams) for sessions 3 – 5, that provided guided mastery experiences; peer feedback workshops and lesson plan integration as sessions 6-7, that was designed for vicarious learning and social persuasion; and reflection, final problem creation, and post-intervention survey as session 8. Instructional support focused on modelling, providing heuristic strategies (e.g., "What-If-Not?", "Solve-Pose-Solve"). This deliberate alignment ensured the intervention was theoretically coherent and replicable. These were followed by the interview sessions.

E. Data Analysis

1. *Quantitative:* Pre- and post-survey means and standard deviations were calculated for each item and overall. Paired-sample t-tests assessed statistical significance of changes ($p < .001$). The effect size was assessed using Hedges' g for small samples [37]. The effect size was described using Cohen's [38] benchmark, which categorises effect sizes as small (0.2), medium (0.5), and large (0.8).

2. *Qualitative:* Interview transcripts were analysed using thematic analysis [39] by aligning the research objectives with the overarching themes, aided by the dynamic software AILYZE [40] to enhance the analysis beyond manual methods [41]. An inductive approach was initially used: transcripts were categorised into three major themes based on the interview questions reported. Subthemes were then generated using the dynamic software. Artefact (test items) analysis provided triangulating evidence for qualitative

claims. Thick descriptions of the context and participant quotes were provided to support transferability judgments. The results were merged through narrative integration during the interpretation and analysis phases. This involved directly linking each major quantitative finding to the qualitative themes and participant accounts that explained its context, mechanism, and meaning, thereby drawing coherent meta-inferences about the intervention's impact.

IV. RESULTS

To address the research objectives, three major interview questions were asked, each followed by follow-ups. Hence, three major themes were identified, each with its revealed sub-themes. The first question was 'Reflecting on your experiences with problem-posing activities, how has your confidence in this area changed for you to perceive your ability to create engaging and meaningful mathematical problems for your students?', with the categorised theme as 'Evolving problem-posing confidence and engagement of PSTs in teaching mathematics'. This initial categorisation was followed by the emergence of subthemes.

A. Evolving Problem-posing Confidence and Engagement of PSTs in Teaching Mathematics

1. *Confidence growth through structured intervention and practice:* Evolving problem-posing confidence and engagement among preservice teachers in teaching mathematics were observed to develop in response to a lack of prior exposure and knowledge about problem-posing, leading to initial hesitation and doubt about their ability to pose mathematical problems as reflective, adaptive problem posers. Participant PST24 explicitly stated unfamiliarity with problem-posing that, "*Before this intervention, I didn't know there was anything like problem-posing...*" and PST3 admitting that, "*I had no idea about the problem-posing because I haven't encountered or I've not been seeing a teacher using the problem-posing in lessons*" and "*.....I found it difficult because I've never seen anything like that before....*" (PST17). This was amplified by participants' cognitive constraints, which seemed to be the primary source of their initial reluctance and doubt regarding problem-posing. These difficulties included interpreting scenarios, deriving questions, and accurately judging problem difficulty. For example, PST17 stated, "*I found it difficult to derive a question or find a question from the scenario given to us,*" while "*Struggling to formulate questions from given scenarios lowers your confidence and may lead to giving up*" (PST3). This unfamiliarity led to initial frustration and low confidence, which were significant barriers to early engagement, although they began to overcome these difficulties during instruction and practice.

2. *Resilience and persistence in overcoming problem-posing challenges:* Participants' confidence and willingness to pose problems were influenced by a self-assessment of

their own mathematical ability. Many participants experienced self-doubt, as evidenced by the following comments:

PST3 stated that “...if you have a scenario and you are struggling to pose questions out of it, and you don’t get it, it lowers your confidence..., you would see that this is very challenging, and you would like to stop.” Some expressed nervousness and doubt.

PST20 stated that, “I was so nervous, I was so doubtful to pose my own question. But through the intervention, I have been able to pose my own questions through the understanding I have.”

PST18: *At first, I struggled with my confidence when it came to posing questions to the learners. But now, I feel much more confident and capable of engaging them with those questions.*

PST19: *It has affected it positively because now when the scenario is given to me, I’m able to stand on my own and then work on how to pose the problem as compared to earlier.*

In this case, self-perception, combined with cognitive challenges, led to hesitation and doubt, with self-perceived ability as the primary factor in the initial friction in PSTs that hindered the development of confidence in problem-posing. The emotional stresses of frustration, nervousness, and anxiety created in participants illustrated the emotional barriers faced and their role in the initial hesitation and doubt about their problem-posing abilities. These experiences from the first week’s interactions indicated that a lack of prior exposure and unfamiliarity with problem-posing led some to doubt their ability to pose problems. These challenges at the affective level posed the greatest issues, manifesting as hesitation, self-doubt, and, ultimately, disengagement.

3. The role of peer feedback and support in building confidence: As a result of the intervention, participants reported that the initial challenges were gradually overcome through peer support and self-reflection, enabling them to develop problem-posing skills with confidence and competence. The instruction and peer support played a significant role in helping participants overcome initial doubts about their problem-posing abilities. PST21 described how “seeking assistance from a friend helped improve problem framing,” which speaks to the value of peer feedback and mentorship.

Instructional support addressed misconceptions, cognitive challenges, and emotional barriers, enabling participants to develop competence and confidence. Over time, this confidence-building through practice and reflection transformed initial hesitation into growing competence.

PST2: *“I’m confident that I can create problems in specific topics or areas to enhance the effective learning of students. I can do that. I’m confident in that”,* reflecting this growth.

PST9 noted that, “*At the beginning, since I wasn’t familiar with it, it was quite difficult to cope with it. But as the intervention continued, I became familiar with it and I understand it*”.

PST22: *Depending on the feedback I get from the student, I’ll know whether it’s effective. If most of them can provide the feedback I need, I would think it is effective.*

These progressions were supported by experiential learning theory and reflection in fostering self-efficacy in problem posing.

4. Transformational shift in confidence: Participants reported a transformational shift in their confidence and their ability to independently pose mathematical problems. Participants described the change from initial unfamiliarity and self-doubt to greater autonomy and confidence. “*Now, I have the confidence and boldness to pose a problem or pose a problem through teaching*” (PST17). This affirmation suggests a considerable development in teaching practice and pedagogical identity as it included problem formulation, evaluation of problem difficulty, and integration within the curriculum. Participants described a transformative change when they included real, culturally relevant contexts and integrated these frameworks into problem posing. PST6 described the importance of cultural relevance when saying, “*All the problems you are going to pose must be culturally relevant to the learners,*” and PST19 explained this shift by saying, “*I can create, I’m able to communicate mathematical problems and concepts to real-world situations.*” This pedagogical transformation could connect mathematics to students’ lives, enhancing engagement, comprehension, and critical thinking by making problems meaningful and accessible. This transformation shift was depicted in Table 1. Their problem-posing efficacy shifts were rated on a 5-point Likert scale, measured as ‘Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), Strongly Agree (5)’, and so a mean of 4.20 indicated a great improvement.

As depicted in Table 1, all six survey items showed substantial increases in mean scores from pre- to post-intervention, indicating a significant transformational shift in the problem-posing efficacy of the preservice teachers as a result of the intervention. The indications point to a critical shift in efficacy, with the overall mean score rising from 2.27 (SD = 1.12) to 4.07 (SD = 0.68), indicating a strong, positive shift in problem-posing efficacy and a large effect size (Hedges’ $g = 1.85$). The largest gains were in willingness to experiment with new strategies (2.20 to 4.20) and confidence in posing creative problems (2.24 to 4.12). The least, though still marked, increase was in confidence in designing inquiry-based learning activities (2.04 to 3.88); it was unclear whether participants would maintain their confidence in designing problem-posing activities that stimulate inquiry-based learning, suggesting this aspect may require more sustained practice.

Table 1: Survey results on problem-posing efficacy

Statement	Pre-Intervention		Post-Intervention		N
	Mean	Std. Dev.	Mean	Std. Dev.	
I am confident in my ability to pose creative mathematical problems that engage students	2.240	1.1650	4.120	0.6000	25
I feel well-prepared to design problem-posing activities that stimulate inquiry and critical thinking	2.160	1.0279	3.920	0.7594	25
I am confident in designing problem-posing activities that stimulate inquiry-based learning	2.040	1.0985	3.880	0.7257	25
I am willing to experiment with new problem-posing strategies in my teaching practice	2.200	1.1547	4.200	0.7638	25
I feel that my current training has equipped me adequately to pose innovative and meaningful mathematical problems	2.680	1.3454	4.200	0.5774	25
I will actively pursue professional development opportunities related to problem-posing in mathematics	2.320	1.2490	4.120	0.9274	25

In all this, PSTs demonstrated a journey from initial apprehension to growing confidence. A pervasive initial barrier was sheer unfamiliarity: “Before this intervention, I didn’t know there was anything like problem-posing” (PST24). This lack of prior exposure led to cognitive constraints in interpreting scenarios, for example, “Posing problems based on diagrams was a particular challenge” (PST4), indicating a specialised cognitive barrier distinct from general problem-posing doubts; and deriving questions, resulting in frustration and self-doubt, “Struggling to formulate questions... lowers your confidence and may lead to giving up” (PST3). Emotional stresses like nervousness were common.

This initial friction was overcome through structured intervention, practice, and peer support. PSTs mentioned that peer feedback helped them to refine their framing (PST21) and that instructional support helped to address their misconceptions. This led to a transformational shift. PSTs began to see themselves as capable problem-posers: “I’m confident that I can create problems... to enhance the effective learning of students” (PST2). Crucially, confidence evolved to include a focus on cultural and real-world relevance: “All the problems you are going to pose must be culturally relevant to the learners” (PST6). The change represented a transformation in their pedagogical identity, enabling them to teach in a more responsive and active manner. With longer, sustained interventions, they are

believed to be able to overcome these barriers more effectively.

The second question was, “What challenges did you face during the problem-posing intervention, and how did you overcome them?” How has overcoming these challenges affected your confidence in your ability to pose relevant and effective mathematical problems? with its developed theme as ‘Navigating challenges of the PSTs’ growth in mathematical problem-posing’. This initial categorisation was followed by emerging subthemes as follows:

B. Navigating challenges of the PSTs’ growth in mathematical problem-posing

1. *Initial unfamiliarity and cognitive challenge in problem-posing:* One challenge identified in the preservice teachers’ problem-posing intervention activities was difficulty understanding and interpreting problem scenarios, particularly visual and contextual elements. This emerged very strongly in the interviews. Participants reported confusion and difficulty understanding the scenarios’ meaning and context, which limited their ability to construct meaningful, solvable problems.

PST4: *The challenge that I encountered during the intervention was posing problems with diagrams. When a diagram is presented to you, how do you pose problems from it? That was my challenge.*

PST21: *With the challenges, I would say planning the lesson, using problem posing, was very challenging.*

PST3: *“Some of the challenges I had were when the scenario you are given to pose is not quite clear, you will find it very difficult to bring a solvable question out of it. So, if the directions are not clear, you’ll not be able to pose a problem....”*

PST19: *The problem-posing involves critical thinking, and it’s not that I wasn’t thinking critically, but then it’s because I didn’t have an idea about it. I was like, then let me just put in some figures and pose the question of whether the thing could be solved.*

The cognitive challenges were compounded by limited subject matter and unfamiliarity with the skills required to pose problems. Navigating these challenges required PSTs to adopt reflective practices, engage in strategic learning, and undergo repeated exposure, so that, over time, they may develop critical thinking, improved abilities, and the confidence to pose problems.

2. *Content-specific and contextual challenges in problem creation:* Preservice teachers’ problem-posing efficacy was shown to be affected by their struggles to understand mathematical content and to modify problems in content-specific and contextual problem creation. While contextual difficulties included understanding problems and integrating problem-posing into lesson design.

PST5: *I think the concept, sometimes, is not really getting the topic... And sometimes too, the modification of*

the problem... It was really hard doing the modification.

PST10: First, I found it difficult to understand the meaning of the given scenario. And second, the exact contents, where the scenario is coming from, because, before you can pose a question about a scenario, you have to know what the scenario is talking about.

PST15: My first challenge was writing a lesson plan using problem-posing. Although we were given an exercise in class to write a lesson plan. So, I was worried about how to write a lesson plan that would include more problem-posing activities.

The cognitive load associated with problem-posing hinders PSTs' ability to pose appropriate, content-specific problems. When one lacks subject-matter knowledge, making connections between concepts to pose problems can be very challenging; hence, adapting this to lesson planning is practically unachievable.

Overcoming these challenges requires critical thinking, reflective practice, instructional support, and consistency. If they were able to navigate these difficulties, it could lead to increased confidence, improved problem-posing skills, and a deeper understanding of how to create meaningful, solvable, and contextually appropriate mathematics problems.

3. Reflective, strategic, and collaborative methods to overcome challenges: To overcome some of the challenges, reflection and strategic collaboration enabled them to critically evaluate their problem-posing processes by assessing problem solvability and difficulty levels, and by reviewing their own understanding.

PST19: First, thinking critically of the questions to pose, and making sure the problem I'm posing is solvable or not.

PST3: I took my time to analyse the question very well... I would take my time to pose just a simple and easy one, which is solvable.'

PST21: I sought assistance from a friend... she was like, I've been able to pose the question, but it should have been more effective if I framed it this way.

PST3 emphasised the importance of self-solving problem strategy, stating, “you have to solve it yourself to see whether if you give it out to your learners, it would be solvable or not.” PST11 addressed this challenge by using self-solving, saying, “I solve it myself first.” Through this self-solved approach, the preservice teachers demonstrated growth in becoming more efficient at navigating the challenge. Employing these strategic approaches, such as heuristics, decomposing scenarios, and simplifying problems to manageable levels, together with peer feedback and collaboration, was intended to ensure cultural and curricular relevance. Because, “I realised that all the problems you are going to pose must be culturally relevant to the learners. They have to be familiar with whatever comes in posing of the problem” (PST6).

4. Problem-posing and time management: Participants experienced a notable shift in perception from viewing problem-posing as a time-wasting activity to recognising it as a valuable constructivist learning process. Participants initially expressed doubts about the usefulness of the problem-posing technique, such as PST7 saying, “I was having the misconception that there would be certain questions which would be irrelevant, and they would be wasting time.” However, with time, this view has evolved, and through reflection, with a more constructivist view, saying, “But now, it has given me some sort of confidence after I was able to overcome this, and rather than transforming from wasting time to something that is constructivist, that is, learners are constructing their own ideas. By so doing, they can better understand their mistakes.”

This suggested a greater appreciation of the potential problem-posing holds about learner engagement as active participants in knowledge creation, and of the significance of addressing time management during problem-posing. Participants highlighted the need to take time to analyse the questions before reframing them into simpler, manageable versions. As explained by PST3, “I took my time to analyse the question very well... posed just a simple and easy one, which is solvable.” PST23 identified the importance of pre-solving and constructing questions with respect to learner abilities when he stated, “I'll first solve the problem which I have posed before I'll pose the problem too, I have to know my learners and their capability, to structure the question”. PST11 described using their own problem-solving time as a benchmark, stating, “I took 10 minutes to solve this question, and so for the learners, they will take about 20 minutes or more”. Participants also reported becoming more efficient. For example, PST12 reported that he reduced the time to pose a challenging question from 10 to 7 minutes. These strategies illustrated the critical role of thoughtful time management in enhancing problem-posing effectiveness and confidence.

PSTs described the initial cognitive challenges as a specific barrier and the strategies they used to overcome them. That is, difficulty in interpreting scenarios, especially visual ones (diagrams), was prominent. PST4 noted, “Posing problems based on diagrams was a particular challenge.” PSTs faced content- and context-specific challenges as they struggled with the deep mathematical understanding needed to modify problems and integrate problem-posing into lesson planning (e.g., PST5, PST15). Thus, PSTs adopted overcoming strategies, such as reflective and strategic methods like self-solving, which emerged as a key heuristic: “You have to solve it yourself to see... if it would be solvable” (PST3). Peer collaboration provided critical external feedback (PST21). They also reframed their views of time management, moving from seeing problem-posing as time-wasting to valuing it as a constructivist process (PST7). Strategic simplification and

pre-solving based on estimated learner time (PST11) to enhance their efficiency and confidence.

The third question was, ‘How would you determine whether a problem you have posed is effective in helping students understand mathematical concepts?’ with its developed theme as ‘Designing effective criteria for mathematical problem-posing to enhance understanding’. This initial categorisation was followed by emerging subthemes as follows:

C. Designing effective criteria for mathematical problem-posing to enhance understanding

1. Ensuring problem solvability and teacher validation:

The data revealed that effective mathematical problem-posing hinged on multiple interrelated criteria centred on designing for understanding. And so, teacher self-solving was identified as a critical solvability check among the preservice teachers engaging in the problem-posing intervention. PST3 and PST19 stressed that a teacher must personally solve the problems they pose to verify their accuracy, appropriateness, and solvability before presenting them to students. “So, ... after posing the question, you have to solve it yourself to see whether if you give it out to your learners it can be solvable or not” (PST3). This was reinforced by PST19, who said, “You are the person posing the problem; you should be able to solve it before bringing this out to the learners.” This practice ensures that the problems align with the curriculum standards, are of appropriate difficulty, and are linked to everyday life,

thereby equipping the teacher to assist learners without causing unintended negative outcomes. Hence, teacher self-solving of problems is key to constructive problem-posing and student engagement.

2. Incorporating real-world and cultural contexts for relevance: Basing mathematical problems in these contexts was essential for meaningful engagement and effective problem-posing. The importance of cultural relevance and scenario-based problem posing was highlighted by PST11: “The problem ... must be linked to real-life situations; and also, that problem can also be linked to other related topics that can be taught within that lesson”, placing importance on real-life situations. PST6 underscored cultural relevance by asserting that, “All the problems you are going to pose must be culturally relevant to the learners”. Integrating problems grounded in students' lived experiences draws connections between the abstract and the real, promoting understanding, interest, and participation. The problem-

aligned situation fosters solvability by ensuring the problem is within reach and relevant, thus engaging the learners.

3. Aligning problems with learners' abilities and curriculum objectives: Posing problems that match students' capabilities is a common criterion for effective mathematical problem-posing, identified by most participants. As PST3 put it, “I would take my time to pose just a simple and easy one, which is solvable.” PST8 advises, “Before posing a problem, you're supposed to make sure the problem you pose won't exceed the level of the child's ability.” This adjustment ensured that the problem was accessible, solvable, and engaging, which promotes self-directed problem-solving and significant learning. This also promotes differentiated inclusive learning by addressing learner variances and building confidence at all levels of capability.

It was critical to ensure that posed problems align with the curriculum standards and instructional goals, which is fundamental to effective problem-posing as PST15 made a case that “I would have to check if it aligns with the content standards and then the indicator that I've chosen from the curriculum,” while PST19 highlights the need to “critically evaluate the problem to ensure it is solvable and appropriate for both teacher and student levels.” According to them, this alignment would guarantee pedagogical soundness, relevance, and accessibility, thereby supporting solvability and meaningful learning outcomes.

From the responses, it became clear that PSTs developed sophisticated, student-centred criteria for effective problems, such as ensuring solvability and teacher validation. Thus, a unanimous criterion was identified as necessary for the teacher to solve the problem first, to verify its accuracy and appropriateness (PST3, PST19), while incorporating real-world and cultural contexts. Relevance was deemed essential for engagement and understanding, so problems needed to be “linked to real-life situations” (PST11) and culturally familiar to learners (PST6). Finally, aligning problems with learner ability and curriculum objectives so that problems must match students' cognitive levels, “pose just a simple and easy one, which is solvable” (PST3). Simultaneously, they must align with curriculum standards and lesson objectives (e.g., PST15, PST19) to ensure pedagogical soundness. Table 2 captures the themes, key insights, and representative PST growth.

Table 2: Summary of responses to problem-posing efficacy

Theme	Key Insights	Samples of PSTs	
		Demonstrating Growth	Supporting Quotes
Evolving Confidence	Shift from avoidance to proactive problem-posing; cultural adaptation as a key driver.	PST1, PST7, PST25	PST5, PST20, PST20: From nervous to fluent – problem-posing is now my teaching tool.
Navigating Challenges	Scaffolding through tiered questions, peer support, and time management.	PST3, PST12, PST19	PST11, PST18, PST12: 7-minute problems > 10-minute struggles.
Designing for Understanding	Success indicators: solvability checks, real-world relevance, and iterative feedback.	PST2, PST17, PST24	PST10, PST21, PST17: Good problems are like bridges – every student should cross.

Integrating the quantitative and qualitative results to provide a nuanced explanation of the observed efficacy gains showed that the most substantial quantitative increase was in PSTs' *willingness to experiment with new problem-posing strategies* (Item 4, $M\Delta = +2.00$). This leap was not an isolated statistical trend but is vividly explained by the qualitative theme of “Navigating challenges through strategic collaboration”. Participants described how cognitive fixation was initially overcome with peer feedback and heuristics, with PST21 stating that *‘seeking assistance from a friend helped improve problem framing.’* Likewise, the significant increase in confidence in posing creative problems (Item 1, $M\Delta = +1.88$) was explained by the theme of “Evolving confidence and engagement,” with PST17 stating, *“Now, I have the confidence and boldness to pose a problem...,”* which demonstrated a shift from self-doubt to self-sufficiency. This narrative integration illustrated that the numerical gains were a measurable manifestation of the qualitatively lived experiences of the developmental process.

V. DISCUSSION

The study's findings, situated within NaCCA's [8] curriculum and the Ghanaian context, extended the discourse on problem-posing beyond the often Western-centric research base, demonstrating that a structured, experiential intervention can significantly enhance PSTs' problem-posing efficacy and support prior research [1][7]. The quantitative leap in efficacy scores, with an overall mean shift from 2.27 to 4.07, and the effect size of $g = 1.85$ strongly supported Bandura's [4] contention that enactive mastery experiences were the most potent source of efficacy beliefs. Bandura's sources of efficacy were operationalised within the intervention structure: mastery through scaffolded problem-posing tasks; vicarious learning through instructor and peer modelling; social persuasion through structured feedback; and affective management through reflective discussion. The qualitative growth – from unfamiliarity and affective doubt, through strategic struggle, to competent, criteria-driven design – clearly illustrated Kolb's [34]

experiential learning cycle operationalised within a social constructivist environment [35].

The findings provided insightful answers to the three research objectives. First, with respect to the evolution of confidence, the initial “friction” the PSTs encountered corresponded to the “cognitive conflict” described as necessary for a teacher to achieve a conceptual shift [29]. The shift from perceiving problem-posing as an “obscure” skill to seeing it as a “teaching tool” indicated a change in pedagogical identity, in which the ability to pose problems becomes part of one's self-as-teacher [42]. The focus on cultural relevance (PST6) and the importance of real-world connection represented a significant shift from the simplistic generation of problems to a contextualised, culturally responsive pedagogy, which should be the renewed focus for the current teacher education [43]. This also suggested that in an educational landscape where teacher-centred instruction has been predominant, the initial “friction” and affective barriers for PSTs may be more pronounced, making structured collaborative support even more critical.

Navigating challenges also yielded important insights. The specific challenges associated with diagrammatic prompts (PST4) demonstrated a need to advocate for problem-posing as a multi-representational practice rather than a generic one. This aligned with literature in describing the specific cognitive demands of visual-spatial reasoning in relation to mathematics [44]. The use of self-solving as a principal heuristic (PST3, PST11) represented a positive strategic change. This, in part, represented the internalisation of the “anticipatory” dimension of pedagogical content knowledge (PCK) by most respondents. This concerned predicting students' responses and the challenges they were likely to encounter [28], and subsequently addressing them. This practice positioned the mathematics preservice teacher as someone who moves from merely assigning problems to actively investigating them, thereby enhancing their own SMK [32]. The reframing of time management from a concern about “wasting time” to a concern about “constructivist time” (PST7) constituted a belief change in

belief about learning, particularly as it relates to a shift from a transmission to a constructivist perspective on teaching [35].

Again, PSTs' criteria for effective problem posing indicated the development of their PCK. Their triad of solvability (teacher validation), relevance (cultural/real-world), and alignment (learner's capacity and curriculum) was similar to some of the established criteria for evaluating mathematical tasks [45]. That PSTs organically derived these criteria through experience and reflection was powerful evidence of the intervention's success in fostering principled practice rather than just procedural skill.

The consistent, although improved, lower level of confidence in designing problems for inquiry-based learning (Item 3, from 2.04 to 3.88) was telling. It indicated that PSTs viewed this as a higher-order integration skill, requiring them to sequence and scaffold multiple problems to sustain inquiry rather than simply pose a single engaging problem. This was consistent with the literature, which distinguished between task design and lesson design [46].

Having their confidence evolved from unfamiliarity and an inability to pose problems, with cognitive challenges, to seeing problem-posing as a “teaching tool” suggested a transformative shift in the pedagogy of mathematics teaching with cultural relevance and responsiveness. A fit that assisted preservice teachers in navigating their difficulties, developing self-solving strategies to validate posed problems, anticipating learners' difficulties, and seeing problem-posing as a means of engaging learners rather than wasting time. This attitude was beneficial to promoting problem-posing as envisioned in a standards-based curriculum.

VI. CONCLUSION

This study confirmed that problem-posing efficacy is a malleable and teachable component of preservice mathematics teacher preparation. PSTs demonstrated significant quantitative growth in confidence and qualitatively evolved in their pedagogical reasoning. They managed to navigate the cognitive and affective barriers and become more reflective designers of mathematical problems and advanced criteria that were student-centred in effectiveness. The findings support the notion that structured activities, underpinned by experiential and social learning theories, can address the challenge of recognising the value of problem-posing and developing the practical competence and confidence to do so.

The importance of cultivating problem-posing efficacy extends beyond simply adding a skill to a PST's repertoire. It is also an investment in the adaptive expertise required for responsive and equitable mathematics teaching. It enables teachers to work alongside their students as co-inquirers, design effective learning experiences, and critically analyse and interpret the curriculum. Given the standards-based curriculum [8], which promotes more meaningful and

engaging mathematics teaching and learning, problem-posing is a critical pedagogy, especially when it encourages standards-based instruction. The core findings, the efficacy of experiential mastery, the role of peer collaboration, and the evolved learner-centred design criteria, demonstrated significant transferability. They showed that the intervention's theoretical foundations (SET, ELT) were robust across contexts. However, implementation must be sensitive to local curricular priorities and PSTs' prior pedagogical basis. The study, therefore, contributed a case for how standards-based reforms like NaCCA's can be operationalised through problem-posing in teacher education, providing a model for similar Global South settings. This study serves as a call to action for teacher educators to intentionally embed problem-posing at the heart of preparation programmes, for researchers to continue exploring its profound potential to transform both teacher development and student learning, and for mathematics curriculum experts to consider integrating it into basic schools' curricula.

A. Implications for Teacher Education

The findings showed that problem-posing needs to be made explicit and extended in the mathematics teacher preparation curriculum. Problem-posing must be a named, scaffolded strand throughout teacher preparation, not a one-off workshop. It should connect methods courses, content courses, and field experiences.

It must be designed to accommodate affective components of both PSTs and learners. Interventions and implementations must anticipate and normalise teachers' initial frustration and self-doubt. Creating a safe, collaborative environment for sharing imperfect problems is as important as providing strategic instruction.

In engaging with problem-posing, prompts and heuristics must be varied. Training should include practice with varied stimuli (stories, data, diagrams, equations) and explicit teaching of heuristics like “What-If-Not?”, “pose-solve-repose” or “solve-pose-solve”, changing constraints, and reversing standard problems [22][25].

It should be embedded in the teacher preparation and the standards-based curricula. This is because PSTs need direct practice aligning their posed problems with specific curriculum standards and learning progressions. It enables problem-posing to be viewed as a means of achieving the stated objectives rather than as a deviation from them.

Through professional development sessions, problem-posing should foster communities of critique, with structured peer feedback sessions as a core component during training, teaching PSTs how to give and receive constructive feedback on problem quality, solvability, and potential for student thinking.

One implication is that preservice mathematics teacher educators must model the “teacher-as-the-poser”. Teacher educators must consistently model the practice of posing

and analysing their own posed problems, making this metacognitive process visible to PSTs.

B. Limitations of the Study

The study has limitations that contextualise its findings. The single-group pretest-post-test design provided no basis for strong causal inference, even with mixed-methods triangulation. The qualitative sample, while sufficient for a detailed analysis, was drawn from a single institution, limiting the transferability of the results. The reliance on self-reported efficacy was necessary, even though actual behavioural change in classroom practice could not be measured. The 'efficacy' demonstrated was therefore a confidence and perceived competency gained in a supportive, training environment. Future research should include observational data on PSTs engaged in problem-posing in the classroom. The intervention's duration (one semester) leaves the sustainability of the gains in efficacy and their translation into actual teaching practices during student teaching and induction unknown. Finally, while the study identified some challenges, the intervention design itself may not have fully addressed the specific gap in posing problems from diagrams, suggesting the need for further refinement of the instructional design.

C. Directions for future research

Future research ought to focus on:

- 1) Longitudinal quasi-experimental designs with control groups and follow-ups extending to the practicum year to assess the sustainability and classroom effects of the gains in efficacy.
- 2) Assessing the distinct impacts of particular components of the intervention (e.g., peer feedback as opposed to heuristic instruction) on various facets of problem-posing efficacy.
- 3) Exploring the relationship between problem-posing efficacy and the quality of PSTs' lesson planning and instructional decision-making in their practicum.
- 4) Examining how problem-posing interventions can be tailored to address specific content domains (e.g., algebra or geometry) where posing challenges may differ.
- 5) Developing and psychometrically validating a more comprehensive, multi-dimensional scale for measuring problem-posing efficacy.

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Before the study, all PSTs were provided an information sheet outlining the objective, procedure, risks and benefits, and the right to withdraw. Consent was acquired in writing. To protect confidentiality, all data were de-identified using codes (PST1, PST2, etc.) immediately upon collection; the master list linking codes to names is stored separately on a password-protected folder. Audio files and transcripts were accessible only to the research team.

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