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# Variation of problem-posing approaches to improve learning outcomes and problem-posing abilities of prospective mathematics teachers

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## Abstract

This study explores the effectiveness of different problem-posing approaches in improving learning outcomes and problem-posing abilities among prospective mathematics teachers. This study employed a pre- and post-tests control group experimental design. The experimental group engaged in online and direct problem-posing, the comparison group used peer-assisted and direct problem-posing while the control group relied solely on direct problem-posing. Three classes were selected through purposive sampling as the sample with 32 students assigned to the experimental group, 30 students to the comparison group, and 31 students to the control group. A one-way multiple analysis of variance (MANOVA) was conducted to determine the effect of problem-posing variations on material mastery and problem-posing ability both separately and simultaneously. Findings indicate significant differences among the three groups. Online problem-posing serves as an effective preparatory stage before direct problem-posing allowing students to build confidence and reduce anxiety. Problem-posing ability was assessed across two dimensions, the ability to formulate and present problems. The study highlights that structured problem-posing approaches enhance learning outcomes and problem-posing abilities. These findings emphasize the importance of incorporating online and peer-assisted problem-posing strategies in mathematics education to support student engagement, critical thinking, and skill development.

**Keywords:** Direct problem-posing, Learning outcomes, Mathematics, Online, Peer assistance, Problem- posing abilities, Problem-posing approaches.

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## Contents

**Contribution of this paper to the literature**
This paper's contribution is the variation of problem-posing to obtain more optimal learning outcomes. Direct problem-posing should be preceded by online problem-posing as some students struggle with it due to cognitive style, personality or other factors. A mediator helps them practice before engaging in direct problem-posing.

## 1. Introduction

Problem-posing fosters a democratic approach to education, enabling students to think critically and develop self-awareness in contrast to the traditional education system which perceives students as inactive receivers of knowledge (Freire, 2000). Over time, problem-posing has evolved into a key pedagogical tool (Choe & Mann, 2012). As an innovative approach in mathematics education, problem- posing has been widely studied (English, 1997; Freudenthal, 1973; Polya, 1954; Silver & Cai, 1996; Stoyanova, 1997). It is recognized as a crucial element in mathematics learning (Brown & Walter, 1993; Hsu, Wu, Wong, Yang, & Hsu, 2005; Kojima, Miwa, & Matsui, 2009; NCTM, 2000) and has also been employed as an assessment tool in mathematics education (Kwek, 2015; Lin, 2004; Mishra & Iyer, 2015; Munroe, 2016). Beyond its role in assessment, problem- posing contributes significantly to enhancing creativity (Yildiz, 2022), critical thinking and mathematical skills (Kwon & Capraro, 2018) and students' problem-solving abilities (Cankoy & Özder, 2017; Leung, 2013; Silver, 1994; Stoyanova, 2003). Additionally, research has shown that problem -posing positively influences student achievement and attitudes toward learning (Demir, 2005).

Mathematics teachers play a crucial role in facilitating mathematics learning. Problem- posing is a fundamental activity in mathematics education utilized by teachers to assess students' prior knowledge, monitor learning progress, and provide feedback. Mastering problem-posing skills is essential for mathematics teachers, as it broadens their instructional perspectives (Elwan, 2016) enhances students' problem-solving and metacognitive abilities (Ghasempour, Bakar, & Jahanshahloo, 2013) and helps teachers understand students' thinking and learning patterns (Unal & Arikan, 2014).

A teacher's experience plays a crucial role in their ability to effectively incorporate problem- posing into mathematics instruction (Erdik, 2019; Patáková, 2013). However, many prospective mathematics teachers have limited exposure to problem- posing practices (Şengül & Katranci, 2015). Research indicates that teachers often generate general rather than structured problems (Lavy & Shriki, 2007), and among elementary school mathematics teachers, fewer than a quarter demonstrate proficiency in problem- posing (Dogan-Coskun, 2019). Therefore, prospective teachers are advised to get the opportunity to explore problem- posing (Singer, Ellerton, & Cai, 2013). After becoming teachers, they should be equipped to foster a classroom environment that encourages effective problem- posing (Ghasempour et al., 2013).

Effective mathematics instruction necessitates thorough training in problem- posing. It is essential to expose prospective teachers to problem-posing experiences early in their education. Various methods have been employed to strengthen the problem-posing abilities of future mathematics teachers, including case diversification (Kojima et al., 2009), the what-if-not strategy (Lavy & Shriki, 2007) educational games (Pintér, 2012) and integrated assessment training (Lin, 2004). This study investigates different problem-posing approaches aimed at enhancing both students' problem-posing abilities and academic achievement in mathematics education. A range of complementary strategies was analyzed to assess their effectiveness in skill development.

Traditionally, problem- posing in the classroom has been conducted using a direct approach where students present problems orally in small groups or during class discussions. However, individual personality traits significantly impact oral communication skills (Prabavathi & Nagasubramani, 2018). Factors such as academic competence, self-confidence, cognitive preferences, and individual traits affect students' preparedness to engage in direct oral problem posing. Learners with limited self-confidence are more likely to procrastinate or refrain from completing assignments (Bandura, 1995) making them less inclined to participate in direct oral problem-posing activities.

Students' cognitive styles also play a crucial role in their readiness for direct oral problem- posing. An impulsive cognitive style tends to respond quickly, often posing problems without thorough evaluation, whereas reflective learners require more time to respond as they engage in deeper analysis and evaluation (Chen, 2021). Consequently, impulsive students tend to dominate problem-posing activities even though their responses may not always be accurate. In contrast, reflective students struggle with problem- posing due to their preference for careful and detailed analysis before expressing their thoughts. Even when they successfully formulate problems, they are often hesitant to share them unless explicitly required to do so.

Similarly, personality traits influence students' engagement in problem -posing. Extroverted students prefer interaction through conversation and frequently engage in trial-and-error approaches making them more active in problem- posing. On the other hand, introverted students tend to be more cautious and avoid making mistakes (Boroujeni, Roohani, & Hasanimanesh, 2015). As a result, extroverted students tend to participate more actively in problem-posing activities whereas introverted students may struggle to express their thoughts unless prompted.

Students with low academic ability often tend to avoid engaging in problem- posing due to a fear of embarrassment. They may worry that their questions will be perceived as too simple, off-topic or lacking depth, particularly in environments where peer criticism or mockery is common. As a result, these students remain passive choosing to observe rather than actively participate in problem-posing activities. Such a situation is concerning as it not only hinders their problem-posing development but also negatively impacts their overall academic achievement by limiting their engagement in critical thinking and classroom discussions.

An approach is required that simultaneously trains problem-posing skills while addressing oral communication barriers to enhance students' ability to engage in direct oral problem posing. This study explored two potential strategies. The first approach involved online problem- posing through the WhatsApp application. This method was selected based on evidence that computer-mediated communication (CMC) fosters stronger social interactions compared to face-to-face communication (Yu & Yuizono, 2021). Additionally, online discussions have been shown to enhance conceptual understanding and promote independent learning (Lim & Chai, 2004; Marra, Moore, &

Klimczak, 2004). Furthermore, CMC allows individuals to maintain a degree of anonymity which encourages more open and uninhibited participation (Kumar, Natarajan, & Acharaya, 2017).

Secondly, used as a comparison, it involved peer assistance. In this method, lecturers instructed students to make note of the problems they planned to pose in writing. This strategy was designed to help students organize and articulate their thoughts in writing before presenting them verbally. The written problems were then circulated among peers allowing students to review and discuss them before a selected student, chosen by the lecturer presented one of the problems. Over time, the lecturer encouraged the original author of the problem to read it aloud, progressively preparing students for direct oral problem -posing. However, oral problem -posing is often influenced by the personal characteristics of students, including apprehension (Huxham, Campbell, & Westwood, 2012) anxiety, a lack of drive, and diminished self-esteem (Aslan & Şahin, 2020) which can create challenges in direct verbal participation.

In application, problem- posing is strongly linked to problem- solving (Ghasempour et al., 2013; Kwek, 2015; Lavy & Shriki, 2007; Silver, 1994). In recent years, problem -posing has gained recognition as a fundamental aspect of problem- solving (Singer et al., 2013). It may take place at any stage, before, during, or after the problem-solving (Silver, 1994). Prior to solving a problem, students may pose questions to clarify their understanding. Similarly, during problem-solving activities, they may formulate additional related problems as needed. Even after arriving at a solution, students can propose alternative or extended problems, fostering a continuous learning cycle where each problem generates new inquiries, ultimately stimulating curiosity and deeper engagement (Xia, Lü, & Wang, 2008).

Problems generated through problem- posing can either be entirely new problems or modifications of existing problems (Silver, 1994). Additionally, problems may emerge from previously solved problems, enabling students to expand their understanding. The process of mathematical problem- posing should be grounded in real-life situations (Stoyanova, 1997). Students can utilize contextual information to reformulate or refine given problems by applying their cognitive skills. One effective way to enhance problem-posing abilities is by presenting students with ill-structured or partially formulated problems and guiding them through the process of refinement and problem construction (Silver, 1994).

According to English (1997) the fundamental aspect of problem- posing is the creation of new questions derived from a specific mathematical task or problem. To achieve this, students should be modifying existing problems to create new ones. Problem -posing allows students to construct and express problems in their own words while drawing from real-life contexts (Demir, 2005). This process offers an iterative learning experience where students continuously solve problems, generate new ones and refine their problem-solving skills, ultimately enhancing their overall competence.

The appropriate conditions must be established to ensure the effectiveness of problem posing in mathematics learning (Ghasempour et al., 2013; Kojima et al., 2009; Lin, 2004). Stoyanova (1997) categorizes the following three distinct problem-posing types: free, semi-structured, and structured situations. Free situations involve entirely new problems derived from real-life contexts. Students are given a general topic and asked to formulate a problem without any predefined description, data, or constraints. Semi-structured situations require students to develop problems based on provided illustrations or existing problem contexts. Furthermore, structured situation involves reformulating problems based on previously solved examples, encouraging students to extend their understanding through modification and adaptation.

If the discussion topic involves the relationship between two sets, students in free situations may be encouraged to formulate and pose problems related to this concept. The complexity of the problems they generate will vary based on their individual knowledge and experiences. In semi-structured situations, students are instructed to pose problems specifically related to the relation of two sets with asymmetric properties. Meanwhile, in structured situations, students are provided with examples of relational problems between two sets exhibiting equivalent properties after which they are asked to formulate similar problems involving equivalence.

Several criteria have been established for assessing problem-posing ability. Grundmeier (2003) evaluates problem- posing based on its feasibility, the sufficiency of provided information and the number of steps required to reach a solution. Silver and Cai (1996) propose three key criteria: quantity, originality, and complexity. Additionally, Sengül and Katranci (2012) introduce five assessment criteria: problem comprehensibility in terms of language clarity, consistency with mathematical concepts, problem structure, number of questions posed, and problem solvability. Papadopoulos and Patsiala (2019) adopt the three Silver and Cai's (1996) criteria to measure problem-posing abilities in their research.

This study adopts the assessment criteria proposed by Silver and Cai (1996) to evaluate problem-posing abilities, focusing on quantity, originality and complexity. The quantity criterion measures the number of mathematical problems generated by students, excluding non-mathematical problems from the evaluation of learning progress. Originality pertains to the development of unique problems that are not typically found in standard learning materials. Complexity is examined through two sub-indicators: linguistic complexity, which assesses the clarity and difficulty of the problem statements, and mathematical complexity, which evaluates the depth of logical reasoning and the complexity of calculations required for problem-solving.

## 2. Methodology

### *2.1. Research Design*

This study employed a pre- and post-tests control group experimental design (Campbell & Stanley, 1963; Gravetter & Forzano, 2009) to examine the effectiveness of different problem-posing approaches in mathematics education. The research was conducted over a semester-long period, involving three groups: an experimental group, a comparison group, and a control group.

The experimental group engaged in online and direct problem -posing, where students initially posed problems using the WhatsApp application and later transitioned to oral problem posing. The comparison group used peer-assisted and direct problem- posing, wherein students wrote problems on paper, received peer assistance, and then presented them orally. The control group relied solely on direct problem posing, where students formulated and presented problems orally throughout the study. The experimental design is summarized as follows:

**Table 1.** Experimental design.

| Experimental group | O1 | T1 | O2 |
|---|---|---|---|
| Comparison group | O1 | T2 | O2 |
| Control group | O1 | T3 | O2 |

**Note:** O1 = Pre-test.
T1 = Online + direct problem- posing.
T2 = Peer assistance + direct problem- posing.
T3 = Direct problem- posing only.
O2 = Post-test.

Table 1 presents the experimental design used in this study which consists of three groups: the experimental group, the comparison group, and the control group. Each group undergoes a pre-test (O1) before receiving different instructional treatments. The experimental group engages in a combination of online and direct problem posing (T1), the comparison group utilizes peer assistance along with direct problem posing (T2), and the control group follows the direct problem posing approach only (T3). After the intervention, all groups complete a post-test (O2) to measure learning outcomes and problem-posing abilities.

## *2.2. Sample and Data Collection*

Participants were 93 undergraduate students enrolled in the Mathematics Education program at Universitas Pendidikan Ganesha, Indonesia. The sample consisted of 32 students in the experimental group, 30 in the comparison group, and 31 in the control group. Participants were selected through purposive sampling, ensuring homogeneity in academic background and prior exposure to problem- posing. The study was conducted during lectures on set theory, relations and functions, and logic. Students practiced problem- posing according to Stoyanova's (1997) framework, which categorizes problems into free situations, semi-structured situations, and structured situations. In free situations, students pose problems freely within the scope of the lecture material. In semi-structured situations, students create problems based on mathematical concepts or principles from the material. In structured situations, students develop problems derived from previously solved problems.

Material mastery and problem-posing ability were evaluated separately to assess learning outcomes. Mastery of material was measured through a performance test based on course syllabi, where students completed 10 test items, and scored using a customized rubric. Problem-posing ability was assessed by requiring students to submit 10 problems, categorized as four free-situation problems, three semi-structured problems, and three structured problems. Evaluations followed Silver and Cai's (1996) criteria, namely quantity, originality, and complexity.

The quantity criterion is determined by the total number of problems submitted by students, categorized as either solvable or unsolvable. Scores are assigned based on the number of solvable problems while unsolvable problems are excluded from evaluation. The originality criterion assesses the novelty of the problems, classifying them as good, moderate, or poor. Complexity is evaluated through two dimensions: linguistic complexity and mathematical complexity. Linguistic complexity examines the clarity and sophistication of problem statements, categorizing them as simple, moderate, or complex while mathematical complexity assesses the depth of mathematical concepts involved in solving the problem. These criteria are outlined in the following rubric:

**Table 2.** Problem -posing ability assessment rubric.

| Criteria | Quality ( score) | | |
|---|---|---|---|
| Quantity | A little (0-40) | Enough (41-80) | Lots (81-100) |
| Originality | Poor (0-40) | Moderate (41-80) | Good (81-100) |
| Complexity | Simple (0-40) | Moderate (41-80) | Complex (81-100) |

Table 2 presents the problem-posing ability assessment rubric used to evaluate students' proficiency in problem- posing based on three key criteria: quantity, originality, and complexity. The quantity criterion measures the number of problems students generate, categorized into three levels: a little (0–40), enough (41–80), and lots (81–100). Originality assesses the uniqueness of the problems posed, classified as poor (0–40), moderate (41–80), or good (81–100). Complexity is evaluated based on linguistic and mathematical difficulty categorized as simple (0–40), moderate (41–80) or complex (81–100).

Pre-tests were conducted to assess students' initial proficiency in material mastery and problem posing, while post-tests measured learning progress after treatments. To minimize the influence of individual student characteristics, the normalized gain score (Gery, 1972) was applied: S = (pos-pre)/(max-pre) where S represents the final score, pos is the posttest score, pre is the pretest score, and max is the ideal maximum score (100). This formula ensures that pre-existing disparities among students do not affect the study's validity.

## *2.3. Analyzing of Data*

Data were initially analyzed using descriptive statistics classifying scores into categories: poor (0-40), moderate (41-80), and good (81-100). Further analysis employed one-way multiple analysis of variance (MANOVA) to determine the effect of problem-posing variations on material mastery and problem-posing ability, both separately and simultaneously.

To reinforce the quantitative findings, qualitative data were collected through continuous observations and semi-structured interviews with selected students using the snowball sampling technique (Creswell, 2008). Observations monitored students' engagement during the experiment while interviews explored their perceptions and challenges in problem- posing. This mixed-methods approach provides a comprehensive understanding of the instructional effectiveness of various problem-posing strategies.

## 3. Results

The distribution of problem-posing abilities across the experimental, comparison, and control groups categorized as poor, adequate and good is presented in Table 3.

**Table 3.** Data description of problem- posing ability by treatment group.

| Criteria | Experiment class | | | Comparison class | | | Control class | | |
|---|---|---|---|---|---|---|---|---|---|
| | Poor | Enough | Good | Poor | Enough | Good | Poor | Enough | Good |
| Quantity | 15.63 | 59.38 | 25.00 | 17.24 | 62.07 | 20.69 | 26.67 | 63.33 | 10.00 |
| Originality | 18.75 | 53.13 | 28.13 | 24.14 | 58.62 | 13.79 | 23.33 | 60.00 | 16.67 |
| Complexity | 12.50 | 59.38 | 25.00 | 20.69 | 62.07 | 17.24 | 26.67 | 56.67 | 16.67 |

In Table 3, the three groups demonstrated problem-posing abilities that generally fell within the adequate category for quantity, originality and complexity. A closer examination reveals that the experimental group had the lowest percentage of poor-quality responses across all criteria followed by the comparison group with the control group exhibiting the highest proportion of poor-quality responses. Conversely, the experimental group attained the highest percentage of good-quality responses in all criteria followed by the comparison group, and lastly, the control group. These findings suggest that the treatment applied in the experimental group led to the most substantial improvement in problem-posing abilities compared to the other two groups.

Table 4 presents a percentage-based data description of students categorized by high, moderate, and low levels of material mastery detailing their problem-posing abilities across three criteria of poor, adequate, and good.

**Table 4.** Data description of problem-posing ability based on material mastery.

| Criteria | High | | | Moderate | | | Low | | |
|---|---|---|---|---|---|---|---|---|---|
| | Poor | Enough | Good | Poor | Enough | Good | Poor | Enough | Good |
| Quantity | 6.67 | 63.33 | 30.00 | 25.00 | 52.50 | 22.50 | 23.33 | 63.33 | 13.33 |
| Originality | 16.67 | 56.67 | 26.67 | 30.00 | 50.00 | 20.00 | 26.67 | 56.67 | 16.67 |
| Complexity | 13.33 | 63.33 | 23.33 | 22.50 | 60.00 | 17.50 | 20.00 | 60.00 | 20.00 |

Table 4 indicates that the problem-posing ability in terms of quantity, originality, and complexity generally falls within the adequate category across all groups. However, notable differences emerge between students with low and high material mastery. The high material mastery group exhibited the smallest percentage of poor-quality responses across all criteria, followed by the moderate material mastery group while the low material mastery group had the highest percentage of poor-quality responses. In contrast, the high material mastery group achieved the largest proportion of good-quality responses followed by the moderate material mastery group, with the low material mastery group scoring the lowest. These findings suggest that students with stronger material mastery demonstrate superior problem-posing abilities compared to those with moderate or low material mastery levels.

The results of the MANOVA analysis revealed significant differences in material mastery and problem-posing abilities among the experimental, comparison, and control groups as presented in Table 3. The multivariate tests—Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root produced f-values of 12.745, 14.939, 17.175, and 34.932, respectively, all with a significance level of $p = .000$. These findings indicate that the mode of problem- posing significantly influenced students' mastery of the material and problem-posing skills. Specifically, students exposed to the online and direct approach, peer-assisted and direct approach, and direct-only approach exhibited statistically significant differences in their learning outcomes and problem-posing proficiency as shown in Table 5.

**Table 5.** Multivariate tests.

| Effect | | Value | F | Hypothesis df | Error df | Sig. |
|---|---|---|---|---|---|---|
| Group | Pillai's trace | 0.441 | 12.745 | 4.000 | 180.000 | 0.000 |
| | Wilks' Lambda | 0.560 | 14.939 | 4.000 | 178.000 | 0.000 |
| | Hotelling's trace | 0.781 | 17.175 | 4.000 | 176.000 | 0.000 |
| | Roy's largest root | 0.776 | 34.932 | 2.000 | 90.000 | 0.000 |

A separate analysis of each variable revealed significant differences among the experimental, comparison, and control groups in both material mastery and problem-posing abilities as shown in Table 4. The analysis for material mastery resulted in $F = 19.234$ and $p = .000$, indicating a statistically significant difference between students exposed to the online and direct approach, the pair aid and direct approach, and the direct-only approach. Similarly, the analysis for problem-posing ability yielded $F = 24.989$ and $p = .000$ confirming notable differences among the three groups as presented in Table 6.

**Table 6.** Tests of between-subjects effects.

| Source | Dependent variables | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|---|
| Group | Material mastery | 0.432 | 2 | 0.216 | 19.234 | 0.000 |
| | Problem posing ability | 0.500 | 2 | 0.250 | 24.989 | 0.000 |

Students who engaged in problem -posing using the online and direct approach demonstrated the highest levels of both material mastery and problem-posing ability followed by those in the pair aid and direct approach, while the lowest scores were recorded in the direct-only approach group. These findings are detailed in Table 7.

**Table 7.** Descriptive statistics.

| | Experimental, comparison, and control | Mean | Std. deviation | N |
|---|---|---|---|---|
| Material mastery | 1 | 0.635 | 0.107 | 32 |
| | 2 | 0.554 | 0.112 | 30 |
| | 3 | 0.469 | 0.097 | 31 |
| | Total | 0.553 | 0.125 | 93 |
| Problem- posing ability | 1 | 0.653 | 0.097 | 32 |
| | 2 | 0.549 | 0.088 | 30 |
| | 3 | 0.476 | 0.112 | 31 |
| | Total | 0.561 | 0.123 | 93 |

Observations made throughout the study reinforced these quantitative findings. It was evident that students who participated in online problem- posing before transitioning to direct problem-posing displayed greater engagement and higher levels of activity compared to those who followed the direct-only approach. Furthermore, interviews conducted with student representatives provided additional support for these findings. Most of the students interviewed expressed that engaging in online problem- posing was an invaluable preparatory experience, helping them gradually build the confidence required for in-person problem-posing. They also noted that the online phase enabled them to develop a structured understanding of problem-posing, which ultimately enhanced their performance during direct interactions.

## 4. Discussion

The findings indicate that it is expected for students who engaged in the online and direct problem-posing approach to exhibit greater mastery of material and stronger problem-posing abilities compared to those who solely relied on direct problem- posing. One key factor is the anonymity and reduced social pressure inherent in online problem -posing, which facilitates more open and direct communication (Kumar et al., 2017). This approach enables students to express their thoughts freely without fear of embarrassment or criticism.

Problem- posing as a learning model, particularly when framed within a dialogue-driven and freedom-based learning process (Durakoğlu, 2013) is well supported by online communication. Furthermore, engaging in problem -posing through digital platforms ensures student privacy, thereby reducing potential distractions from peers. Since online interactions are often detached from traditional social norms, students tend to be less concerned about external judgments or scrutiny (Sproull & Kiesler, 1991). Additionally, online communication fosters a sense of group cohesion, promoting collaborative learning and shared understanding among students (Becker & Mark, 2002).

Although not as effective as the online and direct problem-posing approach, the peer-assisted and direct problem-posing approach still resulted in better material mastery and problem-posing skills compared to the direct approach alone. Observations revealed that students generally did not struggle significantly with constructing problems. However, difficulties arose when they were required to present their problems. Having a peer appointed by the lecturer to initiate problem- posing proved to be highly beneficial. Students can communicate more freely and comfortably with their peers compared to their interactions with lecturers. The gradual reduction of peer support encouraged students to become more independent in raising their concerns. In this sense, peer-assisted learning serves as a form of scaffolding (Ghasempour et al., 2013) gradually transitioning students toward greater autonomy in problem- posing. Moreover, engaging in peer-assisted problem- posing helps cultivate a sense of optimism, which has been shown to positively influence problem-posing abilities (Zulfikar, Anwar, & Yusrizal, 2020).

Variations in problem-posing approaches have been shown to enhance both material mastery and problem-posing abilities among prospective mathematics teachers. Specifically, the online and direct approach and the peer-assisted and direct approach resulted in greater improvements compared to the traditional direct oral problem-posing approach that has been commonly used. These results corroborate previous studies demonstrating that structured learning approaches, particularly those incorporating formative assessments can enhance metacognitive abilities in mathematics education. Oral communication is heavily influenced by cultural factors (Tsegaye, 2020) which can sometimes hinder students from confidently posing problems. Additionally, individual student characteristics also play a significant role in oral communication. Therefore, an alternative approach is necessary to prepare students before they engage in direct oral problem- posing. Both online problem- posing and peer-assisted problem- posing have been proven to help students transition into oral problem- posing more effectively. This occurs as students become proficient in generating new problems; they begin to exhibit cognitive flexibility (Pelczer, Singer, & Voica, 2013). This cognitive flexibility enables them to continuously seek and integrate new knowledge leading to an improvement in their material mastery. Simultaneously, their problem-posing skills also develop as they gain more confidence and experience.

## 5. Conclusion

Training prospective mathematics teachers in problem- posing from an early stage is essential, as this skill becomes a fundamental aspect of their teaching practice. The conventional direct oral problem-posing approach, where students are required to present problems verbally has not been fully effective in enhancing material mastery and problem-posing abilities.

Implementing a combination of online problem- posing followed by direct oral problem- posing has been found to significantly improve both competencies. The anonymity offered by online communication helps reduce students' hesitation and embarrassment, allowing them to engage more confidently in problem-posing. Furthermore, since online interactions are less constrained by social norms, students are less preoccupied with criticism or the fear of making mistakes, which ultimately contributes to their enhanced problem-posing skills.

If online problem-posing exercises are challenging or not feasible, peer-assisted problem -posing may function as an alternative approach to improve both material mastery and problem-posing skills among prospective mathematics teachers. Peer-assisted learning helps students develop problem-formulation skills despite being less impactful than online problem- posing. Interaction with peers occurs in a more comfortable and informal setting, which naturally facilitates learning. Over time, as peer support is gradually reduced, students become more independent and capable of posing -problems without assistance. Additionally, this approach benefits not only the students receiving help but also those providing assistance, as they indirectly enhance their own problem-posing abilities through teaching others.

The findings of this study suggest two key areas that require attention in problem-posing training for future mathematics teachers. First, emphasis should be placed on structuring problems which primarily require cognitive development and practice. Second, attention must be given to presenting problems, which is more influenced by psychological factors such as shyness, lack of confidence, and fear of making mistakes. Addressing these psychological barriers demands more intensive training. Both online learning and peer-assisted strategies can effectively support students in developing the confidence needed to present problems. This is crucial as mathematics teachers will ultimately need to engage in direct problem posing as part of their professional teaching responsibilities.

## 6. Recommendations

Further studies should prioritize qualitative approaches to deeply explore the development of students' abilities to present problems. This aspect should be emphasized in coaching, alongside the ability to formulate problems, to ensure comprehensive improvement in problem-posing skills. On the other hand, teachers and institutions are encouraged to integrate online problem-posing methods into mathematics education. This approach provides a supportive environment where students can develop their problem-posing skills without fear of criticism or ridicule. Additionally, peer-assisted learning can serve as an effective transitional strategy to build students' confidence and foster collaboration among peers.

## 7. Limitations

The use of WhatsApp as the sole online platform may not represent the full potential of computer-mediated communication tools in education. Other platforms with advanced features might yield different results in fostering problem-posing skills.

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