MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2026, 22(7), em2855
ISSN:1305-8223 (online)
OPEN ACCESS Research Paper https://doi.org/10.29333/ejmste/18740

The effect of problem-posing activities on secondary students' mathematical problem-solving perceptions

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Received 12 December 2025 ▪ Accepted 06 May 2026

Abstract
The development of students' problem-solving skills is a key focus in mathematics education; however, limited research has examined the effect of problem-posing activities on students' perceptions. This study aimed to investigate the impact of problem-posing activities on middle school students' perceptions of problem-solving and to explore teachers' views on students' problem-solving skills. An exploratory sequential mixed-methods design was employed. In the qualitative phase, semi-structured interviews were conducted with 20 mathematics teachers using purposive sampling. Based on these findings, instructional activities were developed and implemented in a quasi-experimental pre-/post-test design with 50 eighth-grade students (23 experimental and 27 control) selected through convenience sampling in a public middle school in southern Turkey. Qualitative data were analyzed descriptively, while quantitative data were analyzed using ANCOVA. Results indicated that, based on teachers' views, students experienced difficulties in strategy use and knowledge transfer. In addition, quantitative findings revealed that problem-posing activities had a significant effect on students' problem-solving perceptions ($F[1, 47] = 30.989$, $p < .01$, $\eta p^2 = .40$). These findings suggest that problem-posing activities may contribute to the development of students' problem-solving perceptions and could be considered in instructional planning.

Keywords: mathematics, mathematics teachers, problem-posing activities, problem-solving, middle school students

INTRODUCTION

In modern knowledge societies, problem-solving is regarded as one of the fundamental skills that individuals are expected to develop throughout their education, and it is considered a key objective in national curricula. Indeed, one of the primary goals of mathematics education is to equip students with problem-solving skills (Da, 2023; Ministry of National Education [MNE], 2024; Roorda et al., 2024; Ukobizaba et al., 2021). Problem-solving is also recognized as a central competency within 21st century skills frameworks and international large-scale assessments such as PISA (Salami & Spangenberg, 2025; Tumangger et al., 2024). The literature emphasizes that mathematical problem-solving plays a pivotal role in fostering reasoning, critical thinking, and analytical thinking skills required in contemporary societies (Da, 2023; Cai, 2003; Salami & Spangenberg, 2025; Tambunan, 2019).

Furthermore, research indicates that students who are successful in problem-solving also tend to perform better in problem-posing (Alorkpa & Badu-Domfeh, 2022; Kovács et al., 2023). A systematic review examining studies conducted between 2011 and 2020 highlights that instruction in problem-posing generally has a positive effect on problem-solving performance (Calabrese et al., 2022). Accordingly, problem-posing and problem-solving can be considered mutually reinforcing processes. When well-designed and systematically implemented, problem-posing activities can

This study was derived from the master's thesis of the first author, conducted under the supervision of the second author.

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Contribution to the literature

- This study examines the effect of problem-posing activities on middle school students' perceptions of mathematical problem-solving using an exploratory sequential mixed-methods design that integrates teachers' views with experimental findings. The quantitative findings show that problem-posing activities significantly improve students' perceptions of problem-solving.
- The qualitative findings, based on teachers' views, indicate that students experience difficulties in strategy use and knowledge transfer.
- By integrating these findings, the study provides a more comprehensive understanding of both students' perceptions and instructional challenges, offering practical implications for mathematics education.

significantly enhance students' problem-solving skills (Alorkpa & Badu-Domfeh, 2022).

Recent review studies indicate that, although the number of studies on problem-posing has increased, there remains a need for new experimental research to better understand problem-posing processes and their effects on students' cognitive and affective outcomes (Cai & Rott, 2024). In particular, the literature highlights that problem-posing has become a major focus in mathematics education research since the 2010s (Ölmez et al., 2025). Bibliometric studies in the field of problem-solving also identify mathematical problem-posing as an emerging research theme closely intertwined with problem-solving (Santos-Trigo, 2024; Suseelan et al., 2022). However, a substantial proportion of existing studies focus primarily on outcomes, such as the quality of posed problems and achievement, rather than on the processes involved (Cai & Rott, 2024). Moreover, the literature emphasizes the need for systematic comparisons of the differential effects of problem-posing tasks on cognitive outcomes (e.g., metacognition, creativity, and problem-solving) and affective outcomes (e.g., attitudes, motivation, self-efficacy, and anxiety) (Ölmez et al., 2025). Recent experimental studies suggest that problem-posing can have positive effects on both cognitive (problem-solving, metacognition, critical thinking) and affective (self-efficacy, motivation, interest, anxiety) outcomes. Nevertheless, there is still a need for comprehensive, long-term studies that examine learning processes in depth (Chiu & Yang, 2024; Hermiyati et al., 2024; Ko & Park, 2024; Pan et al., 2023; Wulandari et al., 2024). In summary, although there has been a notable increase in both quantitative and qualitative research on problem-posing in recent years, much of this work remains product- and achievement-oriented. There is a clear need for studies that examine in depth the relationships between problem-posing processes and students' cognitive and affective outcomes (Cai & Rott, 2024; Ölmez et al., 2025).

Problem-Solving

Problem-solving is defined as the process through which an individual attempts to find a solution to a situation perceived as a problem (Ülküer, 1988). Each problem has its own unique structure, and not all problems can be solved using the same procedures (Carpenter et al., 1980). Given that there is no single method applicable to all problems, it becomes essential to conceptualize and systematize the problem-solving processes.

From a theoretical perspective, Dewey (1991) conceptualizes the stages of problem-solving as follows:

(1) defining the boundaries of the problem,

(2) gathering information about the problem,

(3) identifying possible solutions,

(4) evaluating the feasibility of these solutions,

(5) selecting and implementing a solution,

(6) evaluating and testing the components of the solution, and

(7) implementing the solution.

Similarly, one of the key stages in Polya's (1973) problem-solving framework, namely understanding the problem, involves classifying the numerical or verbal data presented in the problem and explaining the relationships among them. During this classification process, it is determined how the data will be used in the solution. In the planning stage, decisions are made regarding which operations will be performed with the classified data and what outcomes are expected in order to reach a solution.

Problem-solving skills encompass both cognitive and affective competencies that enable individuals to produce effective solutions by utilizing their knowledge, thinking processes, and strategies when faced with situations where the solution is not immediately apparent (Kantathanawat et al., 2025; M. Sharma et al., 2022). Problem-solving skills encompass not only cognitive strategies but also affective dimensions. In a study conducted by Yurt (2025), it was found that the effect of metacognitive awareness on problem-solving is strengthened through students' self-efficacy beliefs, highlighting the importance of considering cognitive and motivational variables together in the problem-solving process. These findings indicate that, in problem-solving instruction, it is not sufficient to focus solely on strategy teaching; students' affective characteristics should also be supported. Within the affective dimension of problem-solving skills, the perception of mathematical problem-solving is a psychological construct closely associated with achievement, encompassing students' feelings, beliefs, and evaluations regarding solving mathematical problems, including attitudes, beliefs, self-efficacy, perceived usefulness, and perceptions of difficulty or anxiety (Baran-Bulut, 2023; Şanlıdağ & Aykaç, 2021). Students with more positive perceptions of problem-solving tend to be more willing to engage in problem-solving tasks and generally demonstrate higher levels of performance (Kutluca & Tum, 2021; Şanlıdağ & Aykaç, 2021).

Problem-Posing

Within the theoretical framework of problem-solving, problem-posing emerges as a complementary and higher-order component of mathematical thinking. Problem-posing refers to generating new problems by modifying an existing problem or by using new information (Ticha & Hospesova, 2009). Polya (1973) emphasizes that, in the final stage of the problem-solving process, new problems should be derived from the solved problem, thereby situating problem-posing within the problem-solving process itself. An individual who possesses problem-posing skills, considered a higher-order skill than problem-solving in mathematics education (Cai, 2003), is able to analyze the structure of a problem, identify its components, and more readily recognize its underlying details (Siller et al., 2025; Zhang et al., 2022). Problem-posing is also associated with metacognitive processes such as planning, monitoring, and evaluation, which support deeper mathematical understanding (Alkan et al., 2023; Baumanns & Rott, 2023; Yurttaş-Kumlu & Taştepe, 2023). In this respect, problem-posing facilitates the internalization of knowledge, supports students in monitoring their own cognitive processes, and contributes to the development of deeper mathematical understanding (Çelik & Aslan, 2022; Siller et al., 2025).

Problem-posing activities are instructional practices that require students not merely to solve given problems but to generate new mathematical problems (Cai, 2022). In this process, students design and formulate their own problems based on a given situation, text, model, table, graph, or even a provided solution (Cai, 2025). According to Stoyanova and Ellerton (1996), problem-posing activities can be classified based on the nature of the task presented to students. In structured problem-posing activities, the instructor develops problem-solving methods specific to the topic, and students are expected to construct new problems that require the use of these methods. In free (unstructured) problem-posing activities, students are not provided with specific instructions or problems (Ko & Park, 2024). In semi-structured (open-ended) problem-posing activities, students are expected to generate new problems based on open-ended prompts using their existing knowledge (Stoyanova & Ellerton, 1996).

Problem-posing activities enable students to develop a deeper understanding of mathematical concepts, establish relationships among concepts, and reveal misconceptions (Cai, 2022; Kovács et al., 2023). These activities are directly related to problem-solving skills and are considered to contribute to improved problem-solving performance (Kovács et al., 2023; Sevier et al., 2025). Numerous studies indicate that problem-posing activities strengthen students' self-efficacy and beliefs about mathematics, which are associated with more positive perceptions of problem-solving (Kaur & Rosli, 2021; Krawitz et al., 2025; Schoenherr, 2024). In a study conducted with fifth-grade students engaged in goal-free problem-posing activities, it was found that such activities positively influenced students' flexible thinking, their ability to transfer learning to new situations, and their perceptions of problem-solving. Additionally, these activities significantly strengthened students' beliefs about viewing problem-solving as a process and coping with challenging problems (Ko & Park, 2024).

Problem-posing is considered an important instructional approach for supporting students' mathematical thinking, engagement, and problem-solving processes. Previous studies indicate that problem-posing activities can help students relate mathematical concepts to their own experiences, take greater responsibility in the learning process, and participate more actively in mathematical tasks (Katrancı & Şengül, 2019; van Bommel & Palmér, 2021). In addition, real-life and context-based problem-posing tasks have been associated with increased student interest and motivation toward mathematics (Antao & Morales, 2025; Salinas-Hernández et al., 2024). In addition, research shows that integrating real-life contexts into mathematics instruction significantly enhances students' academic performance, while enriched instructional materials further strengthen this effect and contribute to more positive attitudes toward mathematics (Amo-Asante et al., 2025). Research also suggests that activities involving the examination of errors and solution processes may reveal students' conceptual and procedural difficulties and support a deeper understanding of mathematical relationships (Pratama & Azizah, 2025; Qory et al., 2025). From this perspective, students' perceptions of mathematical problem-solving should be examined not as a single general construct, but as a multidimensional structure involving fear and hesitation, interest in problem-solving within and outside the classroom, willingness and happiness in engaging with problem-solving activities, and the importance attributed to problem-solving (Ersoy & Dağyar, 2022). Therefore, investigating how different types of problem-posing activities influence these dimensions can provide a more detailed understanding of the role of problem-posing in mathematics learning.

Given the need to better understand the effects of problem-posing processes on students' cognitive and affective outcomes, the present study aims to examine the effect of problem-posing activities on middle school students' perceptions of mathematical problem-solving. In addition, the study seeks to identify issues encountered in the teaching-learning process by eliciting the views of teachers, who are the implementers of the curriculum, regarding students' problem-solving skills. Based on the identified issues, problem-posing activities were designed.

Accordingly, the main research question of the study is as follows:

Do problem-posing activities have an effect on students' perceptions of mathematical problem-solving in secondary school?

The sub-questions of the study are as follows:

(1) What are the opinions of secondary school mathematics teachers regarding students' problem-solving skills?

(2) When pre-test scores are controlled, is there a significant difference between the experimental and control groups in terms of students' mathematical problem-solving perceptions and their sub-dimensions?

METHOD

Research Design

This study was designed within the framework of an exploratory sequential mixed-methods design. This design enables concepts or hypotheses emerging from qualitative data to be tested through quantitative methods, thereby providing a more in-depth and comprehensive understanding (L. Sharma et al., 2023). In the qualitative phase of the study, semi-structured interviews were conducted to elicit middle school mathematics teachers' views on students' problem-solving skills, the difficulties encountered, and classroom practices aimed at developing these skills. The findings obtained at this stage formed the basis for the development of the problem-posing activities implemented in the experimental phase.

Following the qualitative phase, a pre-/post-test quasi-experimental design with experimental and control groups was employed to examine the effect of the developed problem-posing activities on students' perceptions of mathematical problem-solving. The integration of these two phases is grounded in the pragmatic approach of mixed-methods research, which aims to provide a more comprehensive explanation of the research problem through the complementary use of different methods.

The experimental study was conducted with eighth-grade students enrolled in a public middle school located in southern Turkey. The researcher implemented the intervention in both the experimental and control groups. The mathematics teacher in both groups was the researcher. Instruction in the experimental group was enriched with problem-posing activities developed based on teachers' views obtained in the qualitative phase. In the control group, instruction was conducted in accordance with the existing mathematics curriculum and textbook, including routine classroom practices such as direct instruction, solving example problems from the textbook, teacher-guided question-answer activities, and individual exercises. No problem-posing activities or additional instructional interventions were implemented in the control group.

In the experimental study, the MPSP scale was administered to both groups as a pre- and post-test. Each administration of the scale (pre- and post-test) took approximately 30 minutes. The pre-test was conducted one week prior to the intervention, while the post-test was administered after the completion of the six-week instructional period. The experimental implementation lasted for six weeks, with three class hours per week. This research design allowed for the examination of the effect of problem-posing activities on students' perceptions of mathematical problem-solving, while the findings obtained in the qualitative phase informed the development of the instructional activities implemented during the experimental process.

Participants

The study group consisted of two distinct participant groups: mathematics teachers who participated in the qualitative interview phase and middle school students who participated in the experimental phase.

In the qualitative phase, the study group comprised 20 mathematics teachers working in different middle schools in Antalya. The teachers were selected using purposive sampling to ensure the inclusion of participants with direct experience in teaching mathematics at the middle school level. The following criteria were considered in selecting the interview participants:

(1) being a mathematics teacher working at a middle school,

(2) having at least one year of professional teaching experience,

(3) actively teaching mathematics at the middle school level during the data collection period, and

(4) voluntarily agreeing to participate in the study.

The interviews were conducted face-to-face by the researchers using a semi-structured interview form and were audio-recorded with the participants' consent.

Table 1. Demographic information of interviewed mathematics teachers

Variable		Number (f)	Percentage (%)
Gender	Female	11	55
	Male	9	45
Length of service	1-5 years	5	25
	6-10 years	9	45
	Over 10 years	6	30
Type of school of employment	General secondary school	8	40
	Imam hatip secondary school	4	20
	Regional boarding secondary school	5	25
	Private secondary school	3	15

Demographic information regarding the participating teachers is presented in **Table 1**.

An examination of **Table 1** indicates that 11 (55%) of the teachers were female and 9 (45%) were male. In terms of professional experience, 5 (25%) teachers had 1-5 years of experience, 9 (45%) had 6-10 years, and 6 (30%) had more than 10 years of experience. Regarding school type, 8 (40%) teachers were working in general middle schools, 4 (20%) in imam hatip middle schools (a school model unique to Turkey, included in the national education system, in which basic Islamic sciences courses are taught alongside science and social sciences courses), 5 (25%) in boarding regional middle schools, and 3 (15%) in private middle schools. The diversity in teachers' professional experience and school types enhances the credibility and transferability of the qualitative findings.

The study group for the experimental phase consisted of eighth-grade students enrolled in an imam hatip middle school in Antalya. The students were selected using the convenience sampling method, and two existing classes were assigned as the experimental and control groups. The distribution of students across the groups indicated that there were 23 students (46%) in the experimental group and 27 students (54%) in the control group.

Data Collection Tools

In this study, a semi-structured interview form for mathematics teachers and the MPSP scale were used as data collection instruments.

Interview form for secondary school mathematics teachers

A semi-structured interview form was developed to determine teachers' views regarding middle school students' problem-solving skills, instructional practices, and learning environments. The interview form used in this study is provided in **Appendix A**. The interview form included questions addressing students' knowledge and use of mathematical terms, problem-solving strategies, the selection and application of appropriate operations, recognizing and correcting errors, transferring prior learning, relating mathematics to daily life and other subjects, problem-posing skills, and the adequacy of instructional materials and classroom practices.

To ensure the content validity of the interview form, expert opinions were obtained from three specialists (one in mathematics education and two in curriculum and instruction). The experts evaluated the interview questions in terms of their representativeness of the intended constructs, clarity, and appropriateness. Based on their feedback, several revisions were made. In particular, some items were rewarded with greater clarity, overlapping items were combined, and minor modifications were made to ensure alignment with the aims of the study.

In cases where experts expressed differing opinions regarding the scope or wording of certain items, the researchers re-evaluated the suggestions and reached a consensus by considering the purpose and theoretical framework of the study. As a result, the final version of the interview form consisted of 21 questions. Additionally, probing questions were prepared and used during the interviews to enable a more detailed examination of each targeted domain.

The interviews were conducted by the researchers. Each interview lasted approximately 40-50 minutes. The interviews were completed within a two-month period. After obtaining the necessary permissions, the interviews were conducted face-to-face by the researchers at the teachers' schools.

To ensure the reliability of the qualitative data, interview data were analyzed using descriptive analysis. The coding process was conducted independently by two researchers, and the resulting codes were compared to calculate intercoder agreement. The intercoder reliability formula proposed by Miles and Huberman (1994), which is based on percent agreement, was used to determine the level of consistency between the two coders. This formula is calculated by dividing the number of units coded identically by the total number of coded units and is generally considered a basic indicator of reliability (Lombard et al., 2002).

The results indicated an intercoder agreement of 88%, which was considered an acceptable level of reliability for qualitative research. Following the coding process, the researchers met to discuss discrepancies, re-examined the dataset, and reached a consensus. As a result, themes were identified through joint evaluation, and the final thematic structure was established.

Furthermore, in line with the exploratory sequential mixed-methods design of the study, the qualitative findings were used to develop the problem-posing activities, which were subsequently implemented in the experimental phase. In this way, methodological integration between the qualitative and quantitative phases was ensured.

Mathematical problem-solving perception scale

The MPSP scale was developed by the researchers in a previous study (Ersoy & Dağyar, 2022). This scale assesses students' perceptions of problem-solving. It consists of 33 items, confirmed through exploratory and confirmatory factor analyses on two independent samples. The total explained variance was 66%, and Cronbach's alpha coefficient was .93.

Exploratory factor analysis revealed five underlying dimensions (Ersoy & Dağyar, 2022):

(1) (F1) fear and hesitation toward problem-solving and feeling distressed during problem-solving activities,

(2) (F2) interest in problem-solving in class and feeling proud of this,

(3) (F3) interest in problem-solving activities outside the classroom and feeling happy about it,

(4) (F4) willingness to engage in problem-solving activities in class and feeling happy about it, and

(5) (F5) giving importance to problem-solving activities.

Confirmatory factor analysis supported this five-factor structure, with fit indices indicating acceptable to excellent model fit ($\chi^2/df = 3.12$, GFI = .85, CFI = .95, NFI = .93, NNFI = .95, IFI = .95, RMSEA = .081, SRMR = .065, AGFI = .68).

Implementation of the Problem-Posing Activities in the Experimental Group

In both the experimental and control groups, instruction was delivered based on the current secondary school mathematics curriculum (MNE, 2018). However, in the experimental group, this instructional process was systematically enriched through structured problem-posing activities. These activities were carefully designed to align with weekly curriculum objectives while also addressing common difficulties in students' problem-solving skills as identified in the qualitative phase of the study. The implementation was carried out with eighth-grade students over a six-week instructional period.

Semi-structured interviews with 20 mathematics teachers revealed that students often struggled with understanding problem structures, selecting appropriate operations, avoiding computational errors, transferring prior knowledge, and connecting mathematics to real-life and interdisciplinary contexts. Drawing on these insights, a six-week set of problem-posing-based lesson plans was developed. Each weekly session incorporated a specific curriculum objective and focused on one of the commonly reported problem areas. The instructional framework followed Polya's (1973) four-stage problem-solving model: "Understanding the problem, devising a plan, carrying out the plan, and reflecting on the solution." Each session began with teacher modeling and guided practice, followed by collaborative or individual work and reflective discussions. The process was kept flexible, allowing students to move between problem-solving and problem-posing based on their needs and understanding.

Within this framework, problem-posing activities were designed in line with the active learning approach rather than as independent or isolated practices. Consistent with active learning principles, students were placed at the center of the learning process and encouraged to participate actively instead of passively receiving information. Accordingly, they were supported in generating their own mathematical problems during the understanding and reflection stages, thereby promoting cognitive engagement. Thus, the instructional process shifted from a traditional teacher-centered structure to a more dynamic environment in which student participation, interaction, and thinking processes were prioritized. This approach positioned problem-posing activities not as general classroom practices, but as a systematic instructional component grounded in active learning.

Examples of Problem-Posing Activities Based on Eighth-Grade Curriculum Objectives

Understanding problem structures (week 1)

Learning outcome: Students will be able to construct the Pythagorean relationship and solve related problems.

Students were given a standard Pythagorean problem involving a right triangle. They analyzed its components (known sides, unknown side, and their relationships) and then posed a new problem in a different context (e.g., designing a ramp or staircase) but with the same mathematical structure.

Eliminating calculation errors (week 2)

Learning outcome: Students will be able to construct the Pythagorean relationship and solve related problems.

Students solved Pythagorean problems, exchanged solutions, identified peer errors, and posed new problems that incorporated common mistakes.

Operation selection practice (week 3)

Learning outcome: Students will be able to derive the surface area formula of a right circular cylinder and solve related problems.

Students were asked to design a cylindrical-shaped object. Rather than being given a direct question, they had to create appropriate surface area-related questions and justify which mathematical operations were needed.

Real-life problem-posing (week 4)

Learning outcome: Students will be able to derive the surface area formula of a right circular cylinder and solve related problems.

Students identified objects from daily life (e.g., cans and pipes) and designed problems involving surface area, such as calculating the amount of label material required.

Transferring prior knowledge (week 5)

Learning outcome: Students will be able to derive the volume formula of a right circular cylinder and solve related problems.

Students reviewed volume concepts and were asked to generate problems involving the integration of surface area and volume (e.g., comparing material cost and capacity of cylindrical containers).

Interdisciplinary problem-posing (week 6)

Learning outcome: Students will be able to derive the volume formula of a right circular cylinder and solve related problems.

Using a science context like "measuring rainfall in a cylindrical gauge," students generated mathematical problems that combined concepts from both subjects.

Supporting Teaching and Assessment

These structured, curriculum-aligned, and needs-responsive activities enabled eighth-grade students to engage deeply with mathematical content as both problem-solvers and problem-posers. The integration of teacher feedback ensured that the instructional design remained relevant to real classroom challenges, while the use of problem-posing strategies empowered students to take ownership of their learning and develop more positive perceptions of problem-solving. In addition to supporting the mathematics textbook, the developed activities were designed as complementary instructional components that enhanced lesson effectiveness through the integration of problem-posing practices enriched with various strategies, methods, and techniques, as well as the implementation of alternative assessment tools.

Data Analysis

Since both qualitative and quantitative research methods were used in this study, different analysis methods were employed to analyze the data. Secondary school mathematics teachers' opinions about students' problem-solving skills were examined using descriptive analysis. In the qualitative phase, the interview data were transcribed verbatim, and the responses were coded systematically. The codes were organized into categories and themes based on the research questions. The analysis process aimed to identify recurring patterns and meaningful statements related to teachers' views on students' problem-solving skills and the role of problem-posing activities. In the experimental part of the study, ANOVA, ANCOVA, and t-test analyses were performed. These analyses were carried out using the SPSS 23.0 software package. Before conducting parametric tests, normality, homogeneity of variances, and other statistical assumptions were checked. In the quantitative phase, ANCOVA was used to control pre-test scores as covariates to increase internal validity.

Prior to conducting ANCOVA, the assumptions required for the analysis were tested. The normality of the data was assessed using skewness-kurtosis values and the Shapiro-Wilk test for both the experimental and control groups. In addition, the assumptions of linearity between the covariate and the dependent variable and the homogeneity of regression slopes were examined. An ANOVA test confirmed that the homogeneity of regression slopes assumption was satisfied. All assumptions were satisfied.

Validity and Reliability

To ensure the validity and reliability of the qualitative phase, data analysis was conducted independently by multiple researchers, comprehensive and systematic coding procedures were employed, and themes were meticulously developed to support the trustworthiness of the analysis. In this process, the researchers first read the interview transcripts several times to become familiar with the data and to develop an initial coding framework. The researchers were actively involved in the coding and interpretation process while attempting to minimize potential bias through continuous comparison of codes and themes. Inter-coder agreement was examined during the coding process to enhance reliability. Discrepancies between coders were re-examined and discussed until a consensus was reached. These procedures were followed to strengthen the internal validity and credibility of the qualitative findings.

In addition, the research context, participants, and data collection procedures were described in detail to enhance the external validity and transferability of the findings.

Triangulation was ensured through the use of an exploratory sequential mixed-methods design, in which qualitative findings informed the development of the quantitative intervention, and the quantitative results were used to examine the effects of the intervention. This integration of qualitative and quantitative data enhanced the credibility, confirmability, and overall trustworthiness of the study.

In the quantitative phase, the intervention was implemented by the researcher, who served as the mathematics teacher in both the experimental and control groups. This approach ensured consistency in instructional delivery across groups and maintained procedural control throughout the implementation process.

In the quantitative phase, the validity and reliability of the MPSP scale were based on evidence reported in the original scale development study (Ersoy & Dağyar, 2022). Additionally, assumptions for parametric tests were checked before analysis. The study also controlled for potential confounding variables using ANCOVA to enhance internal validity.

FINDINGS

Examination of Secondary School Mathematics Teachers' Opinions on Students' Perceptions of Problem-Solving

In the semi-structured interview study, teachers' views were collected comprehensively across ten thematic dimensions related to students' problem-solving skills. These themes included students' understanding and use of mathematical terms, their familiarity with and use of problem-solving strategies, their ability to select appropriate operations and avoid errors, their capacity to detect and correct mistakes, and their transfer of learning outcomes to new contexts. In addition, teachers' opinions were examined regarding students' ability to associate mathematical problems with real-life experiences, modify existing problems, and create new problems. The interviews also explored teachers' evaluations of the adequacy of mathematics textbooks in supporting problem-solving skills, as well as the extent to which problem-solving strategies, methods, and techniques were implemented in classroom instruction and the extent to which alternative assessment tools were utilized. These ten themes provided a comprehensive framework for analyzing teachers' perspectives on students' problem-solving development and instructional practices supporting it.

As seen in **Table 2**, teachers reported that the majority of students were able to make correct connections between mathematical terms and operations in problem situations.

Table 2. Teachers' perspectives on students' mathematical problem-solving skills: Descriptive analysis of qualitative data

Theme	Teachers' answers
1. Understanding and use of mathematical terms	"The majority of students confuse the terms and their meanings." (teacher 1) "Most students are familiar with the meanings of the terms without confusing them." (teacher 4) "Most students are familiar with the similarities and differences between the terms based on their meanings." (teacher 5) "The majority of students confuse the operational equivalents of the terms and do not correctly make the connections between the terms and operations." (teacher 2) "Most students can develop operational connections by revealing the similarities and contrasts between the terms in the problem." (teacher 8) "Students in general can correctly make the connections between the operations and terms in the problem." (teacher 16)
2. Familiarity and use of problem-solving strategies	"The majority of students are not familiar with the strategies." (teacher 18) "Most students confuse the strategies with each other." (teacher 9) "The majority of students cannot identify or find appropriate strategy for the problem." (teacher 19) "Most students are not fully able to find the appropriate strategy for the problem, or the strategies are confused." (teacher 1)
3. Selection of operations and errors	"The students in general sometimes experience confusion in choosing the correct operations." (teacher 12) "The majority of students cannot identify the correct operations to be used for solving the problem." (teacher 20) "Most students can correctly identify the operations required to solve the problem." (teacher 4) "Most students sometimes make errors in problem-solving that affect the result." (teacher 13) "The majority of students make errors in the problem-solving processes and cannot find the solution." (teacher 5) "Most students make small errors in problem-solving that do not affect the result." (teacher 15)

Table 2 (Continued).

Theme	Teachers' answers
4. Error detection and correction ability	"Most students are able to eliminate some of the procedural errors that prevent them from finding the solution." (teacher 13) "The majority of students are unable to eliminate the procedural errors they make while solving the problem." (teacher 7) "Most students can partially correct their procedural errors but cannot find the correct solution." (teacher 12) "The majority of students cannot correct their procedural errors." (teacher 5) "Most students can fully correct their procedural errors." (teacher 3)
5. Transfer of learning outcomes	"Most students are able to transfer some previous unit learning outcomes to the new topic but are unable to transfer other previous unit learning outcomes." (teacher 12) "The majority of students cannot transfer any of the previous unit learning outcomes to the new topic." (teacher 16) "Most students are able to transfer previous unit learning outcomes to the new topic." (teacher 17) "Most students can transfer some unit learning outcomes from previous years to the new topic but are unable to transfer other unit learning outcomes." (teacher 11) "The majority of students cannot transfer unit learning outcomes from previous years to the new topic." (teacher 5) "Most students can transfer unit learning outcomes from previous years to the new topic." (teacher 4)
6. Associating problems with real-life experiences	"Most students can only partially establish a connection between some of the unit learning outcomes related to problem-solving and daily life experiences." (teacher 12) "The majority of students cannot establish a connection between unit learning outcomes related to problem-solving and daily life experiences." (teacher 4) "Most students can establish a solution-oriented connection between unit learning outcomes related to problem-solving and daily life experiences." (teacher 4)
7. Modifying current problems and creating new problems	"The majority of students can only make simple numerical changes to a current problem." (teacher 14) "Most students cannot make a meaningful change to a current problem." (teacher 3) "The majority of students can make procedural changes to a current problem in addition to numerical changes." (teacher 3) "The majority of students can only pose simple or incomplete problems using the ready-made information provided." (teacher 12) "Most students are unable to pose a new problem." (teacher 6) "The majority of students can pose problems consisting of several steps using the ready-made information provided." (teacher 2)
8. Adequacy of mathematics textbooks for problem-solving skills	"There are abundant examples and exercises aimed at students' problem-solving skills in some units of mathematics textbooks, whereas in other units, they are almost non-existent." (teacher 11) "There are a satisfactory number of examples and exercises aimed at students' problem-solving skills in mathematics textbooks." (teacher 6) "There are hardly any examples or exercises aimed at students' problem-solving skills in mathematics textbooks." (teacher 3) "There are abundant visual or audio examples and exercises aimed at students' problem-solving skills in some units on the EBA platform, whereas in other units, they are almost non-existent." (teacher 11) "There are hardly any visual and audio examples and exercises aimed at students' problem-solving skills on the EBA platform." (teacher 5) "There are a satisfactory number of visual and audio examples and exercises aimed at students' problem-solving skills on the EBA platform." (teacher 4)
9. Use of problem-solving strategies, methods, and techniques in teaching	"Only one or two of the problem-solving strategies are used during lessons, but reinforcement is rarely given." (teacher 10) "Problem-solving strategies are not used during lessons." (teacher 7) "Problem-solving strategies are used consistently during lessons and the required amount of reinforcement is given." (teacher 3) "Only one or two methods and techniques are included in addition to the presentation method during lessons." (teacher 13) "Only the presentation method is used during lessons, and no other methods or techniques are included." (teacher 5) "Many different methods and techniques are used during lessons with the required amount of interest for the students." (teacher 2)

Table 2 (Continued).

Theme	Teachers' answers
10. Use of alternative assessment tools related to problem-solving skills	"A sufficient variety of question types aimed at problem-solving skills are used in the measurement and evaluation activities conducted for the unit learning outcomes." (teacher 11) "Standardized multiple-choice questions aimed at problem-solving skills are used in the measurement and evaluation activities conducted for the unit learning outcomes." (teacher 6) "There are hardly any questions aimed at problem-solving skills in the measurement and evaluation activities conducted for the unit learning outcomes." (teacher 3)

However, teachers stated that students often experienced difficulties in identifying and applying appropriate problem-solving strategies. It was indicated that students sometimes made procedural errors during problem-solving. Teachers also noted that students were able to partially detect and correct some of their procedural errors, although these corrections did not always lead to the correct solutions.

Most teachers reported that students were able to transfer some previously learned outcomes to new problem situations, whereas they had difficulty transferring certain other learning outcomes. Similarly, teachers expressed that students could partially associate problem-solving outcomes with daily life contexts. It was also stated that students were able to establish connections between problem-solving-related outcomes and other subject areas in a limited manner.

Regarding problem-posing, teachers indicated that students were generally able to pose only simple or incomplete problems using given information. In addition, teachers reported that mathematics textbooks included limited examples and exercises specifically aimed at developing students' problem-solving skills. In relation to digital resources, teachers stated that some units on the educational informatics network (EBA) platform included various visual and audio materials related to problem-solving, while in other units such resources were limited.

Teachers further reported that during lessons, only one or two problem-solving strategies were generally used, and reinforcement of these strategies was limited. It was also stated that instructional processes mostly relied on one or two teaching methods and techniques in addition to lecture-based instruction. Finally, teachers indicated that measurement and evaluation activities included a variety of question types related to problem-solving skills.

The Effect of Instruction Based on a Problem-Posing Activities on Students' Perceptions of Mathematical Problem-Solving

In the study conducted with a quasi-experimental model with a pre-/post-test control group, a single-factor ANOVA (ANCOVA) analysis was performed, in which the pre-test was controlled as a covariate in order to determine whether instruction based on problem-posing activities implemented in the experimental group was effective in improving students' problem-solving perceptions. ANCOVA allows the estimation of the treatment effect in an experimental study by controlling for the influence of extraneous variables through linear regression, based on a covariate that is related to the dependent variable (Streiner, 2019).

In the study, the problem-posing activities applied to the experimental group constituted the independent variable, while students' perceptions of mathematical problem-solving constituted the dependent variable, and the pre-test scores of the MPSP scale, administered to both groups at the beginning of the study, served as the covariate. To select the control and experimental groups at the school where the experimental study was conducted, the MPSP scale developed by the researchers was administered to eighth-grade students (pre-existing groups). In this way, appropriate control and experimental groups were selected by examining the similarity of pre-test scores between classes.

The results of the independent samples t-test conducted to determine whether there was a significant difference between the pre-test scores of the experimental and control groups indicated that the mean pre-test perception score of the experimental group was 3.02, while that of the control group was 2.72. The analysis revealed that this difference was not statistically significant ($t[48] = 0.63$, $p > .05$) (Büyüköztürk, 2018). This finding suggests that the experimental and control groups were comparable in terms of their mathematical problem-solving perceptions prior to the intervention.

The post-test descriptive analysis results of the experimental study indicated that the mean post-test score of the MPSP scale for the experimental group (mean [M] = 4.06) was higher than that of the control group (M = 3.31). Furthermore, the results of Levene's test showed that the assumption of homogeneity of variances was met ($F[1, 48] = .328$, $p > .05$). These findings suggest that students in the experimental group demonstrated higher levels of perceptions of mathematical problem-solving compared to those in the control group.

The results of the ANCOVA conducted by controlling the pre-test scores of the MPSP scale for the experimental and control groups are presented in **Table 3**.

As shown in **Table 3**, when pre-test scores were controlled, a statistically significant difference was

Table 3. ANCOVA test results

Source of variance	Sum of squares	df	Mean square	F	Significance	ηp²
Perception	2.592	1	2.592	10.488	.002	
Group	7.658	1	7.658	30.989	.000	0.40
Error	11.615	47	.247			
Total	690.041	50				

Table 4. ANCOVA results by MPSP sub-dimensions

Source of variance	Sum of squares	df	Mean square	F	Significance	ηp²
Fear & hesitation (F1)						
Perception	2.360	1	2.360	2.218	.143	
Group	1.732	1	1.732	1.628	.208	.03
Error	50.010	47	1.064			
Interest & pride (in-class) (F2)						
Perception	4.381	1	4.381	6.061	.018	
Group	9.719	1	9.719	13.444	.001	.22
Error	33.979	47	.723			
Interest (out-of-class) (F3)						
Perception	4.660	1	4.660	5.737	.021	
Group	12.878	1	12.878	15.857	.000	.25
Error	38.171	47	.812			
Willingness & happiness (F4)						
Perception	2.008	1	2.008	2.335	.133	
Group	1.670	1	1.670	1.942	.170	.04
Error	40.411	47	.860			
Importance of problem-solving (F5)						
Perception	1.269	1	1.269	0.999	.323	
Group	0.297	1	0.297	0.234	.631	.00
Error	59.663	47	1.269			

found between the post-test MPSP scores of the experimental and control groups in favor of the experimental group ($F[1, 47] = 30.989$, $p < .01$). The adjusted mean score of the experimental group ($M = 4.06$) was higher than that of the control group ($M = 3.31$).

To determine the magnitude of the difference between the groups, the effect size was calculated as 0.40, and the partial eta squared (ηp^2) value obtained from the ANCOVA analysis indicated a large effect according to conventional interpretation criteria. This value demonstrates that the intervention had a strong and substantial effect on students' perceptions of mathematical problem-solving.

In addition to the overall comparison, further analyses were conducted to determine which specific sub-dimensions of students' mathematical problem-solving perceptions were influenced by the intervention. The results of the ANCOVA analyses performed at the level of MPSP sub-dimensions are presented in **Table 4**.

As shown in **Table 4**, statistically significant differences were found between the experimental and control groups in favor of the experimental group in some sub-dimensions, while no significant differences were observed in others. Specifically, significant effects were identified in the dimensions of interest in problem-solving in class and feeling proud of it ($F = 13.44$, $p < .01$, $\eta p^2 = .22$) and interest in problem-solving activities outside of class ($F = 15.86$, $p < .001$, $\eta p^2 = .25$). These findings indicate that problem-posing activities were particularly effective in enhancing students' interest in problem-solving processes both within and beyond the classroom context. However, no significant differences were found in the dimensions of fear and hesitation, willingness and happiness in class, and importance of problem-solving ($p > .05$), suggesting that the intervention had a more selective rather than a uniform impact across all sub-dimensions.

When the structure of the implemented problem-posing activities is examined in relation to these findings, it can be seen that different types of activities contributed to different dimensions of students' perceptions. For example, activities such as real-life problem-posing (week 4) and interdisciplinary problem-posing (week 6) required students to connect mathematical concepts with daily life contexts, which may explain the observed increase in students' interest and positive emotional engagement in problem-solving.

In contrast, although activities such as error analysis, in which students examined incorrect solutions, identified the sources of errors, and evaluated solution steps systematically (week 2), as well as structure analysis activities (week 1), supported conceptual understanding, their impact on more stable perceptions, such as the importance attributed to problem-solving, remained relatively limited.

Overall, these findings indicate that instruction based on problem-posing activities has a positive effect on students' perceptions of mathematical problem-solving, and that, when pre-test differences are controlled, the experimental group achieved higher levels of perception compared to the control group.

DISCUSSION

In this section, the findings obtained from teacher interviews and the experimental study are discussed in relation to the relevant literature.

Teachers' perceptions that students are generally able to establish procedural relationships but experience difficulty in selecting appropriate strategies are largely consistent with research on problem-solving strategies and the challenges encountered in problem-solving. The literature indicates that while students can reach a certain level in performing operations and establishing basic relationships, they experience significant difficulties in selecting, diversifying, and flexibly applying appropriate problem-solving strategies in complex situations (Arsuk & Memnun, 2020; Baş & Sağırlı, 2021; Güner & Erbay, 2021; Ling & Mahmud, 2023; Roorda et al., 2024; Tafari et al., 2024; Umam et al., 2025). This suggests that such difficulties may be related not only to cognitive processes but also to limited opportunities for strategy use in learning environments.

Teachers' views on students' errors during problem-solving are consistent with findings from both national and international studies. The literature indicates that students make errors at various stages of the problem-solving process, including understanding the problem, translating it into a mathematical model, performing procedural steps, and expressing the final answer; moreover, although students may detect and correct some procedural errors, conceptual deficiencies and inappropriate strategies often lead to incorrect final solutions (Billa & Manurung, 2025; Domondon, 2025; Hadiyanti & Manurung, 2025; Noutsara et al., 2021; Saputra et al., 2025; Umam et al., 2025). Research conducted with middle school students and pre-service teachers also reveals that a limited number of strategies, such as guess-and-check, systematic listing, and drawing diagrams, are frequently used, whereas strategy diversity and flexibility remain restricted (Arsuk & Memnun, 2020; Baş & Sağırlı, 2021; Koç Koca & Gürbüz, 2021). Taken together, these patterns point to a tendency for students to rely on familiar procedures, which may constrain their ability to adapt strategies across different problem contexts.

Teachers' opinions that some learning outcomes related to problem-solving can be transferred while others cannot, that connections to daily life often remain partial, and that links across disciplines can be established, are generally supported by national and international research on knowledge transfer and problem-solving. The literature emphasizes that transferring knowledge and skills across topics and disciplines is challenging and that students may fail to apply prior knowledge in new contexts despite possessing it (De Rosa & Van Horne, 2024; Djudin, 2023; Fathulkhair et al., 2025). This situation can be explained by the fact that students often acquire knowledge in a context-bound manner and therefore experience difficulty recognizing when and how to use this knowledge in different or unfamiliar situations; in particular, limited opportunities to engage in real-life problems and to make explicit connections between concepts may restrict the transfer process.

In studies on problem-based learning, teachers report that while establishing connections between problem-solving outcomes and real-life situations is an intended objective, students often form only superficial or partial connections with everyday contexts. Furthermore, although students can recognize such real-life connections, they often struggle to explain, generalize, and transfer these relationships to new contexts (Kristianti & Safira, 2023; Kwangmuang et al., 2021; Ling & Mahmud, 2023). These findings are consistent with research emphasizing that context-based mathematics instruction, supported by enriched instructional materials, plays a critical role in improving students' ability to connect mathematical knowledge with real-life situations and fostering more positive attitudes toward mathematics (Amo-Asante et al., 2025). Conversely, interventions aimed at transferring mathematical knowledge to disciplines such as physics or to interdisciplinary problems demonstrate that enhancing students' ability to establish cross-disciplinary connections significantly improves their problem-solving performance (Djudin, 2023; Kwangmuang et al., 2021; Ling & Mahmud, 2023). In line with these findings, the present study demonstrates that when students are provided with structured opportunities to generate their own problems and explicitly relate them to real-life or interdisciplinary contexts, they are more likely to move beyond superficial connections and develop a deeper understanding that can be applied to new situations.

Teachers' observations that students can construct only simple or incomplete problems based on given information, that problem-solving activities in textbooks are insufficient in both quantity and quality, and that there is an imbalance in content distribution across digital platforms such as the EBA are broadly supported by both national and international literature. Research on problem-solving indicates that the majority of students remain at a low level in both problem-posing and solving, often producing incomplete, incorrect, or partial solutions in novel situations (Jaenudin et al., 2025; Salwa et al., 2025; Wahyuni et al., 2025). A study on problem-posing found that most middle school students tend to accept given information as is and generate structurally simple problems, rarely modifying, restructuring, or increasing complexity (Guo et al., 2024). Similarly, other studies report that even when a context is provided, students struggle to formulate and enrich problems, often relying on superficial and algorithmic models (Malik & B, 2025). This shows that students cannot go beyond simple problem structures because they are not sufficiently exposed to different types of and more complex problems during instruction.

Analyses of mathematics textbooks from different countries reveal that the proportion of problem-solving objectives is relatively low and should be increased, and that the sections devoted to problem-solving are limited, with most tasks focusing on procedural exercises, while opportunities for real-life contexts and mathematical modeling remain insufficient (Masina & Mosvold, 2023; Nepal et al., 2024; Qocayeva, 2025; Shaqiri & Iljazi, 2024). These findings collectively suggest that instructional materials tend to prioritize procedural knowledge over higher-order problem-solving processes, which aligns with the challenges identified in the present study. In addition, research on instructional materials in mathematics education indicates that although traditional resources such as textbooks and basic classroom tools are generally available, digital technologies are often limited in many educational contexts (Sam et al., 2022). The insufficient integration of technological resources may restrict the concretization of mathematical concepts and limit opportunities for enriched problem-solving and problem-posing practices, thereby contributing to the persistence of predominantly procedural instruction. Taken together, these findings suggest that current instructional materials and learning environments may not adequately support the development of higher-order problem-solving skills.

Teachers' views regarding the limited use of diverse strategies and instructional methods during lessons, as well as the insufficiency of reinforcement activities, are clearly consistent with findings in the literature. Similarly, the limited diversity of question types in assessment aligns with research indicating the dominance of low-level and routine questions. In Turkey, most solved problems in middle school mathematics textbooks are procedural and based on single, standard solution methods, with limited opportunities for higher-order strategies and problem-posing (Korkmaz et al., 2024). This situation, in turn, reinforces the limited use of strategies in classroom practice. Studies across various countries show that mathematics instruction is still largely conducted through traditional exposition and practice, with teachers experiencing difficulties in integrating problem-solving into instruction, and that activities such as discussion and strategy comparison are often underutilized (Noura et al., 2025; Roorda et al., 2024). Students are also reported to underutilize key stages of problem-solving, particularly planning and evaluating solutions, partly due to the lack of systematic reinforcement of these stages in teaching materials and instructional practices (Kaitera & Harmoinen, 2022; Sukmaningthias et al., 2024). Research further demonstrates that classrooms employing project-based, problem-based, and collaborative approaches achieve significantly higher levels of success and problem-solving skills compared to those relying solely on traditional instruction (Rong & Wimuttipanya, 2025; Ukobizaba et al., 2021). Similarly, experimental evidence indicates that problem-solving-based instruction is more effective than alternative approaches in enhancing higher-order thinking skills such as communication, creativity, and logical reasoning (Tambunan, 2019). In this context, the predominance of routine and procedural practices not only limits students' exposure to diverse strategies but also reduces opportunities for them to plan, discuss, and evaluate different solution approaches, which may lead to a more passive and narrow engagement with the problem-solving process.

Analyses of textbooks and examinations across countries also highlight that routine, operation-based questions remain highly prevalent, whereas items requiring higher-order reasoning and problem-solving are relatively scarce (Korkmaz et al., 2024; Ladyawati & Maftuh, 2025; Sibiya et al., 2025). Similarly, studies based on teachers' views indicate that current curricula and instructional materials may be insufficient in developing higher-order skills and emphasize that textbooks predominantly include rote-based activities while requiring greater inclusion of higher-order questions and modeling practices (Yurt, 2022). On the other hand, review studies on assessment tools indicate that although multiple-choice questions still dominate, the use of open-ended, performance-based, and PISA-like contextual tasks is increasing, and their combined use enhances students' problem-solving skills (Rosyidi et al., 2024; Ukobizaba et al., 2021). This contrast suggests that while assessment practices are gradually diversifying, instructional materials have not progressed at the same pace, which may limit students' opportunities to consistently engage with higher-order problem-solving tasks.

The finding that problem-posing-based instructional activities have a positive effect on students' perceptions of mathematical problem-solving is strongly supported by the literature. Studies show that middle school students' attitudes toward problem-posing have a direct and positive effect on their attitudes toward problem-solving, with self-confidence partially mediating this relationship (Çelik et al., 2024). Additionally, goal-free problem-posing activities have been found to enhance students' values, motivation, and beliefs about mathematics and positively influence process-oriented problem-solving attitudes (Ko & Park, 2024). These findings collectively indicate that problem-posing-based instruction positively influences students' perceptions at both cognitive and affective levels. This implies that engaging students in generating their own problems may not only strengthen their understanding of problem structures but also increase their confidence and willingness to engage in problem-solving tasks.

Considering that the problem-posing process is an effective tool for making sense of mathematical knowledge (Cai & Hwang, 2020), instructional designs based on problem-posing may enable students to adopt the perspective of the problem-poser and better understand the coherence between given information and mathematical operations. Cankoy (2010) demonstrated that problem-posing-based problem-solving instruction significantly improves students' levels of problem comprehension and problem-solving skills. Similarly, Doğuz and Genç (2022) emphasized the importance of providing environments in which students can pose problems and of evaluating the problems they generate. Through problem-posing, students can approach standard topics from different perspectives and develop a deeper understanding of problems (Katrancı, 2022). Consistently, studies have shown that participants who correctly formulate their own problems in free and semi-structured problem-posing activities are also more likely to solve these problems accurately (Doğuz & Genç, 2022). This suggests that when students create their own problems, they better understand what a problem consists of, which in turn helps them solve problems more accurately.

The finding that problem-posing activities have a large effect on students' perceptions of problem-solving is widely supported in the literature (Kul & Çelik, 2020; Rosli et al., 2014; Wang et al., 2022), and experimental studies consistently report that such activities enhance students' problem-solving skills (Akben, 2020; Asfar et al., 2019; Kopparla et al., 2018). However, the findings of the present study indicate that this effect is not uniform across all dimensions of students' perceptions but rather varies depending on the specific dimension. In line with the quantitative findings, statistically significant improvements were observed particularly in the dimensions related to students' interest in problem-solving, both in-class and out-of-class, whereas no significant effects were found in the dimensions of fear and hesitation, willingness and happiness, and the importance attributed to problem-solving. This pattern suggests that problem-posing activities may be more effective in increasing students' interest than in changing more stable affective factors such as anxiety or perceived importance, and that these effects are dimension-specific and closely related to how problem-posing activities are structured and implemented within the instructional process.

In addition, an examination of the structure of the problem-posing activities implemented in this study indicates that different types of activities influenced different dimensions of students' perceptions. In particular, real-life and interdisciplinary problem-posing activities appear to have increased students' interest in problem-solving both within and beyond the classroom. This finding is consistent with studies showing that tasks connected to real-life contexts enhance students' motivation; however, the present study further demonstrates that this effect is particularly evident in the interest dimension rather than across all perception dimensions (Antao & Morales, 2025; Salinas-Hernández et al., 2024). Similarly, activities that required students to select operations and construct their own problems promoted active participation and a sense of responsibility in the learning process. This result aligns with research emphasizing that problem-posing fosters student engagement and autonomy; however, in this study, this effect did not extend to the willingness and happiness dimension (Katrancı & Şengül, 2019; van Bommel & Palmér, 2021).

On the other hand, activities in which students examined incorrect solutions, identified errors, and evaluated solution steps contributed to the development of conceptual understanding. This finding is in line with studies indicating that analyzing errors and solution processes strengthens both conceptual and procedural knowledge (Pratama & Azizah, 2025; Qory et al., 2025). Nevertheless, the impact of these activities on more stable perceptions, such as the importance attributed to problem-solving, remained limited. Overall, these findings suggest that activities connected to real-life contexts and those that actively engage students are more effective in increasing interest, whereas activities focused on analysis and evaluation primarily support the development of understanding.

This pattern suggests that the effects of problem-posing activities are not uniform but vary depending on both the nature of the activity and the targeted dimension of perception. In line with this, the literature indicates that such activities tend to be more effective when implemented in structured and long-term interventions, whereas shorter or less structured implementations may yield weaker effects (Wang et al., 2022). Moreover, although the positive effects of problem-posing activities are well established, their impact may vary depending on factors such as intervention duration, level of structure, and instructional approach (Kul & Çelik, 2020; Pratiwi et al., 2022; Xu et al., 2023). In this respect, the present study provides a more detailed understanding by showing how specific types of problem-posing activities are associated with particular dimensions of students' perceptions.

CONCLUSION

This study provides important insights into students' perceptions of mathematical problem-solving and the role of problem-posing activities in mathematics instruction. Overall, the results suggest that while students possess a basic understanding of mathematical concepts, they experience persistent difficulties in applying problem-solving strategies, relating mathematical knowledge to real-life contexts, and generating new problems.

The findings further highlight that traditional instructional practices and resources may not sufficiently support the development of higher-order problem-solving skills. In this context, the present findings indicate that problem-posing activities offer a meaningful instructional approach by actively engaging students in the construction and transformation of problems.

Importantly, the results indicate that such activities contribute particularly to students' interest and engagement in problem-solving, both inside and outside the classroom. However, changes in affective dimensions such as fear, hesitation, and perceived importance of problem-solving appear to require more sustained and long-term instructional efforts.

Overall, these findings suggest that instructional designs grounded in students' learning difficulties and supported by active learning approaches can play a critical role in improving students' problem-solving perceptions. Therefore, integrating problem-posing activities into mathematics instruction may not only enhance students' engagement but also support the development of more positive and meaningful perceptions toward problem-solving across contexts.

Limitations

Several limitations should be considered when interpreting the findings of this study.

First, the study was conducted with a relatively limited sample size, which may restrict the generalizability of the results. Therefore, future studies involving larger samples and different school contexts are expected to make further contributions to the literature.

Second, students' mathematical problem-solving skills were not assessed through a direct performance-based measurement tool; instead, a self-report scale measuring students' perceptions of mathematical problem-solving was employed. Consequently, the findings reflect students' perceptions and evaluations rather than their actual problem-solving performance. Future research may benefit from employing performance-based tests or practice-oriented assessment tools to obtain more comprehensive insights into students' actual problem-solving abilities.

Third, the data were collected within a specific time frame, and the study has a cross-sectional nature. This limits the ability to examine the long-term effects of problem-posing activities on students' perceptions of mathematical problem-solving. Longitudinal studies are therefore recommended to better understand the sustained impact of such instructional interventions.

Additionally, the qualitative findings are based solely on teachers' perspectives. While teacher views provide valuable insights into classroom practices, they do not directly reflect students' experiences in the problem-solving process. Future research incorporating student interviews or student-centered qualitative data collection methods may provide a more comprehensive understanding of the problem-solving process.

Recommendations

Based on the findings of the study, the following recommendations are proposed.

Considering that both teacher perspectives and findings related to problem-posing based instruction indicate positive effects on students' perceptions of mathematical problem-solving and given that such activities are currently implemented to a limited extent in mathematics teaching, it is recommended that greater emphasis be placed on diverse instructional approaches, methods, and techniques in mathematics education.

Furthermore, it is suggested that the number of studies focusing on problem-posing activities that can positively influence students' perceptions of mathematical problem-solving be increased in the literature, and that both qualitative and quantitative research designs be employed to ensure greater consistency and coherence across studies. In addition, providing in-service training for teachers on various problem-solving and problem-posing methods and techniques may contribute to improving students' problem-solving perceptions.

Finally, curriculum developers and textbook authors are encouraged to increase both the quantity and diversity of problem-posing and problem-solving activities in instructional materials.

Author contributions: ME: conceptualization, methodology, investigation, data curation, formal analysis, writing – original draft; **MD:** conceptualization, methodology, validation, supervision, writing – review & editing. Both authors reviewed the results and approved the final version of the manuscript.

Funding: No funding source is reported for this study.

Ethical statement: This study was approved by the Social and Human Sciences Scientific Research and Publication Ethics Committee at Akdeniz University on 23 December 2020 with approval number 31.12.2020-138704. Participation in the study was voluntary. Informed consent was obtained from all teacher participants, and parental consent was obtained for the student participants. Participants were informed about the purpose of the study and their right to withdraw from the study at any time. All data were anonymized prior to analysis, kept confidential, and used solely for research purposes. No personally identifiable information was collected or disclosed.

AI statement: Generative AI tools were used solely to support language editing and reference checking during manuscript preparation. All AI-generated suggestions were critically reviewed and revised by the authors. The authors take full responsibility for the content of the manuscript. No AI tools were used in the design of the study, data collection, data analysis, interpretation of results, or formulation of conclusions.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A: INTERVIEW FORM

1. To what extent do your students know the basic concepts and terms used in mathematics? What are your general observations on this issue?
2. Are your students able to use mathematical concepts and terms correctly while solving problems? What are your views on this issue?
3. To what extent do your students know problem-solving strategies (e.g., estimation, constructing tables, drawing diagrams)?
4. Are your students able to select an appropriate problem-solving strategy when faced with a problem?
5. Are your students able to select the necessary mathematical operations correctly while solving problems?
6. Are your students generally able to perform the required operations accurately and without errors during the problem-solving process?
7. Are your students able to recognize the errors they make while solving problems?
8. Are your students able to correct the errors they identify and reach the correct solution?
9. Are your students able to use knowledge acquired in other mathematics topics at the same grade level while solving problems?
10. Are your students able to use mathematical knowledge learned in previous years while solving problems?
11. Are your students able to relate mathematical problems to real-life situations?
12. Are your students able to use knowledge learned in other subjects while solving problems?
13. Are your students able to generate a new problem by modifying certain elements of a given problem?
14. Are your students able to generate a completely new problem using given information?
15. To what extent do you find the problem-solving activities in mathematics textbooks adequate?
16. To what extent do you find the problem-solving content available on EBA adequate?
17. How frequently do you use problem-solving strategies in your lessons?
18. Do you use different instructional methods and techniques to improve problem-solving skills in your lessons?
19. Which measurement and evaluation tools do you use to assess problem-solving skills?
20. To what extent are your students engaged in and willing to solve problems presented during lessons?
21. Do your students tend to give up easily when solving a problem?

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