Eduvest – Journal of Universal Studies
Volume 6 Number 1, January, 2025
p- ISSN 2775-3735- e-ISSN 2775-3727

Learning Design: Integration of Problem Posing and Problem Solving on Students' Mathematical Creativity in the SPLSV Material

Riski Anan Tama, Atmini Dhoruri
Universitas Negeri Yogyakarta, Indonesia
Email: riskianan.2023@student.uny.ac.id, atmini@uny.ac.id

ABSTRACT

This research aims to develop an innovative learning design that integrates problem-solving and problem-posing approaches to enhance students' mathematical creativity. The research method used is "Analysis, Design, and Development" (ADD). The analysis stage includes problem identification, theoretical studies, and determination of creative thinking indicators, namely fluency, flexibility, originality, and elaboration. The design stage formulates measurable learning objectives, while the development stage produces a learning design based on the integration of problem solving and problem posing. The results of the research are a learning design prepared in several stages: (1) orientation, which introduces the basic concepts of SPLSV and the importance of problem-solving and problem-posing approaches; (2) problem solving, which includes understanding the problem, planning the solution, implementing the solution, and re-examining the solution; (3) problem posing, which involves students in designing new problems, solving them, and developing or modifying problems to make them more challenging; and (4) reflection, where students evaluate their learning and identify the creativity indicators that have been developed. The conclusion of this study is that a learning design integrating problem solving and problem posing is expected to provide a relevant and innovative learning experience that improves students' creative thinking skills in mathematics learning. This design has the potential to serve as a practical guide for teachers and contribute to the development of a curriculum that emphasizes mathematical creativity.

KEYWORDS *creativity, problem posing, problem solving, learning framework*

INTRODUCTION

The rapid development of technology and social change requires individuals to produce creative solutions and think critically when dealing with problems. In this sense, students need to ask critical questions, conduct research, think critically, and become competent problem solvers and creative thinkers (Biçer et al., 2021). Similarly, the education system must train individuals who understand everyday problems, find creative solutions to those at hand, and select the best ideas for implementation (Van et al., 2020). Creative thinking skills are among the essential 21st-century competencies required across fields, including science, technology, engineering, and mathematics (STEM).

In mathematics education, creative thinking skills are closely associated with problem solving and problem posing as interrelated components (Silver, 1997). Guzman (2018) emphasizes the special importance of problem solving in mathematics study and notes that it can serve as a teaching method to foster deeper conceptual understanding.

Regarding problem posing, Kar et al. (2019) state that it enhances students' creative thinking skills. Moreover, problem posing in mathematics instruction is increasingly recognized as a valuable tool that supports effective classroom practices and improves teacher-student interactions (Ozdemir & Sahal, 2018). However, the relationship between problem posing and problem solving in developing mathematical creativity remains incompletely understood, with some studies yielding conflicting findings on its complexity (Bonotto & Dal Santo, 2015).

Previous research indicates that students with strong problem-solving skills tend to excel in problem posing, and vice versa (Arıkan & Ünal, 2015). Yet, other studies reveal no clear correlation between the two. For instance, Crespo (2003) argues that there is no strong evidence of a consistent link between problem solving and problem posing. These findings suggest that the relationship between problem posing and problem solving is complex and warrants further investigation. Additionally, most prior studies have focused on one aspect in isolation, with insufficient attention to their integration in mathematics learning.

Integrating these approaches in learning design offers a more holistic strategy for fostering students' mathematical creativity and developing both skills simultaneously, thereby clarifying their interplay in enhancing creativity. This integration enables students not only to solve given problems but also to formulate new ones, allowing deeper exploration of mathematical concepts and more meaningful understanding.

Consequently, it cultivates fluency, flexibility, and originality—the core dimensions of mathematical creativity. Research also supports this integration, showing that problem posing stimulates creative processes through ideation, evaluation, and information reorganization, while problem solving helps students generate innovative, valuable solutions (Singer & Voica, 2015). Nevertheless, despite these benefits, most studies have examined one approach in isolation rather than their combined role in mathematical creativity.

This study aims to develop an innovative learning design integrating problem posing and problem solving in mathematics instruction, particularly for SPLSV (Two-Variable Linear Equation System) material. By merging these approaches, it addresses limitations in prior research that often treated the skills separately. This synergistic integration is expected to significantly enhance students' creative thinking, especially in mathematics. Mathematical creativity is defined here as students' ability to produce original, relevant, and effective mathematical ideas in problem solving. The resulting learning design will provide a foundation for curriculum development emphasizing creative thinking and practical guidance for teachers implementing active, student-centered instruction.

METHOD

This research employed Design and Development Research (DDR), which focuses on designing, developing, and evaluating products or interventions (e.g., teaching media, learning designs or models, or learning tools) to ensure their effectiveness and alignment with user needs. DDR was applied here through a task design cycle in mathematics, based on iterative evaluation of research products and tools (Richey & Klein, 2007). The cycle integrated problem solving and problem posing to foster creative thinking skills.

The learning products were developed following three steps of the learning model development process: Analysis, Design, and Development (Branch, 2010).

1. Analysis was conducted by identifying problems related to creativity, SPLSV potential, theoretical foundations, integration needs, and objectives.
2. Design involved determining aspects of creative thinking, formulating measurable learning objectives, and creating a learning design that integrated problem solving and problem posing.

3. Development entailed producing the learning design based on this integration, tailored to creative thinking aspects.

RESULT AND DISCUSSION

Analysis

Creative thinking is a key skill of the 21st century, but learning mathematics in schools is still dominant with a procedural approach that limits students' exploration of creative ideas. SPLSV material, which actually has great potential to train creativity through real-life contexts, is often taught with a single-resolution method that is inflexible. Problem-solving and problem-posing approaches offer effective solutions by encouraging analysis, innovation, and reflection, but their separate uses are often less than optimal in developing creativity.

Saygili (2017) argues that "Problem-solving strategies are based on discovering, analyzing and on the struggle to produce a formula to solve". Saygili's opinion means that the problem solving approach is based on discovering, analyzing, and producing formulas to solve problems. So, it takes a conditional time in its implementation. Because, problem-solving processes need to be carried out systematically, starting from the problem formulation process to the evaluation process and problem-solving results.a While the term problem posing in mathematics education refers to two processes: the process of developing new problems and the process of resolving the given problem. Submitting a problem can be started with different stimuli. To stimulate problems, proposing different situations as well as their cues can be used (Cai et al., 2022).

SPLSV learning today also faces obstacles, such as the teacher's conventional methods, abstract questions, and assessments that focus only on the final outcome. Therefore, the integration of problem solving and problem posing is needed to improve students' creative thinking skills through relevant, contextual, and innovative learning experiences, while helping teachers implement more effective strategies.

Design

In this phase, the development of learning design begins with determining the aspect of creative thinking, the aspect used refers to the opinion of Wechsler (2006) who states that the indicators of creative thinking consist of fluency, flexibility, originality, and elaboration. Next, formulate specific and measurable learning objectives based on the indicators that have been set, namely: 1) produce various correct answers in solving SPLSV, 2) Solve SPLSV problems in more than one way. 3) Generate a unique problem or solution based on the given problem. 4) Prepare a complete solution with clear and logical steps.

Furthermore, learning activities or designs are designed to facilitate the development of students' creative thinking skills. The learning process is designed by integrating problem solving and problem posing. With a variety of activities that combine problem posing and problem solving approaches, students are invited to not only solve the given problems, but also formulate new, more complex problems. Thus, students are expected not only to master mathematical concepts, but also develop creative thinking skills in accordance with the purpose of preparing learning designs where creative thinking itself is an important skill in the 21st century.

Development

Based on the results of the analysis phase, the indicators of creative thinking developed refer to the opinion of Wechsler (2006), namely fluency, flexibility, originality, and elaboration. This learning design is designed to provide opportunities for students to not only solve a given problem but also formulate new problems, expand ideas, and come up with solutions with a variety of approaches.

The learning process in this design is designed systematically, starting with an orientation to introduce basic concepts of SPLSV to more complex activities such as formulating new problems and developing solutions. The problem solving approach helps students understand and solve problems, while the problem posing approach trains students to ask new, more challenging questions or problems. Through this activity, students are actively involved in learning, so they can build a deep understanding of concepts while honing their creativity. The design that has been developed is then explained in more detail in Table 1, which contains the learning stages, activity descriptions, and creativity indicators that are the focus of development at each stage.

Table 1. Learning Design on One-Variable Linear Equation Material

Learning Stage	Activity description	Improved Creativity Indicators
Introduction (Orientation)	• The teacher introduces SPLSV (definition, general form, example). • Explain the importance of problem solving and problem posing. • Convey learning objectives.	
Problem Solving: Understanding Problems	• The teacher gives the SPLSV problem: 1. ("Ani's age is 5 years younger than Budi's age. The total age of the two of them is 27 years old. How old is Ani.?" 2. "A rectangle is 5 cm long more than its width. If the circumference of the rectangle is 38 cm, what is the length and width of the rectangle.?").	**Eloquence:** Identifying the components of the equation and thinking about how to solve them, smoothness in generating many relevant initial ideas or approaches is essential.
Problem Solving: Planning Solutions	• The teacher asks the students to plan the completion steps • Students are looking for more than one way to solve the equation.	**Flexibility**: Try different settlement methods.
Problem Solving: Solving Problems	• Students apply the created plan and find solutions. • Students explain the process and reasons for choosing a particular method.	**Elaboration**: Expand the explanation with detailed and alternative reasons.
Problem Solving: Revisiting Solutions	• Students verify the solution by re-entering the value into the equation. • The teacher invited a discussion about other more efficient approaches.	**Originality**: Finding methods that are unique or rarely used.
Problem Posing: Proposing a New Problem	• The teacher invites students to create new problems based on previous problems, for example: Based on the following problem: *"Ani's age is 5 years younger than Budi's age. The total age of the two of them is 27 years old. How old is Ani.?"*	**Flexibility**: Generates a variety of problems. **Originality**: Creating a new or different issue.

Learning Stage	Activity description	Improved Creativity Indicators
	Make a new question that is still related to Ani and Budi's age, but has a different context or condition. • Students create new problems related to SPLSV with constant/coefficient variations. • Students make other contextual problems.	
Problem Posing: Solving and Developing New Problems	• Students solve the created problem and share solutions. • Discussions to develop or modify problems to make them more challenging.	**Fluency & Elaboration**: Generate a variety of solutions and add new information to increase complexity.
Reflection and Closing	• The teacher facilitates discussion for reflection on learning. • Students identify the indicators of creativity they develop. • The teacher provides feedback and summarizes the learning.	

Implementation Notes: 1) This learning is expected to encourage students to actively participate and develop creative thinking skills through real mathematical exploration. 2) Teachers should provide enough scaffolding to support students in finding different ways to solve and pose problems, while also making room for individual creativity.

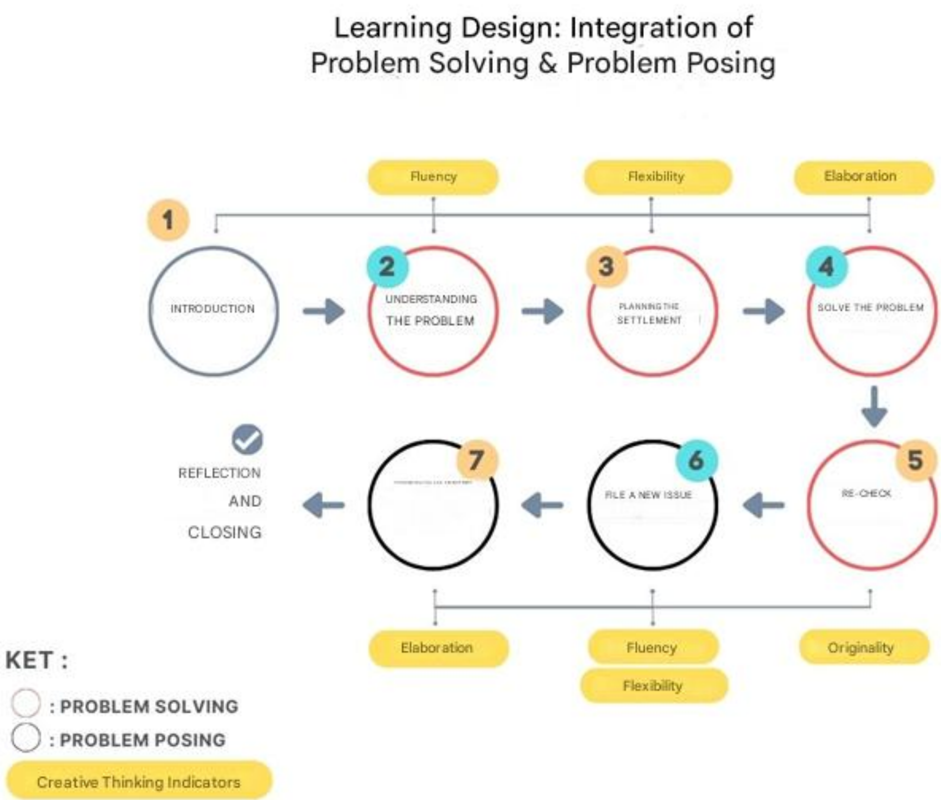

Figure 1. Learning Design Chart.

This article presents an innovative learning design that integrates problem solving and problem posing approaches as an effort to improve students' creative thinking skills. This design has been systematically designed, but has not yet been implemented in a classroom context. The focus of this design is on the active involvement of students in the learning process. Student engagement is considered crucial in maximizing the learning experience and is influenced by the teaching methods used (Barlow & Brown, 2020). Previous research has shown that student engagement in learning is not solely determined by individual factors, but is also influenced by the learning design applied (Alrajeh & Shindel, 2020; Rimm-Kaufman et al., 2015).

This learning design is designed with the aim that by actively involving students in the process of problem posing and problem solving, students will be able to develop better creative thinking skills. Thus, the learning design presented in this article is expected to be a reference for educators in designing more effective and attractive learning for students.

The first stage in the learning design design is the introduction, where the teacher provides initial orientation on the SPLSV material. At this stage, students are introduced to the definitions, general forms, and simple examples of SPLSV. The teacher also explained the importance of problem solving and problem posing approaches in learning, as well as conveying the learning objectives to be achieved. This stage aims to prepare students conceptually and build their motivation to be actively involved in the learning process. After orientation, the learning stage continues to the application of problem solving.

Problem solving is one of the most important aspects in mastering the material and concepts in mathematics learning. In the context of education, problem solving not only serves as a tool to achieve answers, but also as an effective method for building a deeper understanding of complex mathematical concepts. Mudaly (2021) explains that the problem-solving process allows students to be actively involved in learning, where they not only look for solutions, but also seek to understand the structure and relationships between the concepts involved. This shows that problem solving can contribute significantly to mastery of concepts, as students learn to relate new information to existing knowledge.

However, research from Mudaly (2021) also shows that students have had difficulty several times seeing the relationship between the information provided in the problem and the mathematical knowledge they have learned before. If these relationships are not explicit, students may not be able to relate new information to existing knowledge, thus hindering the problem-solving process (Vale & Barbosa, 2018). Therefore, it is important for educators to help students develop skills in connecting different concepts through integrated problem-solving practices. By giving students, the opportunity to first solve problems (problem solving) and then formulate problems (problem posing), they can be more involved in the learning process. This allows them to develop a deeper understanding of mathematical concepts, as well as improve skills in identifying and formulating problems creatively.

Problem solving in this design serves as a strong foundation to build an understanding of SPLSV concepts. By solving the various problems presented, students are actively involved in the process of knowledge construction. Polya (1972) in her famous book, "How to Solve It", has formulated systematic steps in problem solving that can serve as a guide for students. Through the stages of understanding the problem, planning the solution, executing the plan, and re-examining it, students are trained to think logically and analytically. In the first step, students are given SPLSV problems based on real contexts, such as calculating the age or dimensions of a geometric shape. Students are invited to identify the important elements of the problem, such as variables, coefficients, and constants, and think about how the problem can be solved. This activity is designed to train students' fluency in understanding various forms of problems.

The next step is to plan for troubleshooting. At this stage, students are directed to formulate a solution strategy that involves various methods, such as substitution or elimination, as well as consider alternative solutions. This stage encourages students to be flexible in choosing and trying various approaches that suit the problems they are facing. After planning, students apply the plan that has been created to find a solution. In this process, they are asked to explain the steps taken in detail and provide a logical reason for the method chosen. This activity emphasizes the elaboration aspect, where students not only solve problems but also expand their understanding of the concepts used.

The last step in problem solving is to re-examine the solution that has been obtained. Students are required to verify the completion results by entering the values into the equation and evaluating the accuracy of the solution. In addition, teachers facilitate discussions to explore other approaches that may be more efficient. This activity hones students' originality in finding unique and rarely used methods or solutions.

After completing the problem solving process, students are directed to implement problem posing strategies. Problem posing is defined as a learning method that aims to make students be able to create new problems based on the context or information provided. The process plays an important role in increasing innovation and originality which is a key aspect in students' mathematical creativity. Problem posing leads students to think more deeply and differently than traditional problem solving, where they not only provide a solution to a problem, but also engage in the process of creating new problems that are relevant and contextual.

In practice, problem posing activities allow students to identify variations of problems that may arise from the same situation. This is in line with the opinion of Silver (1997), who stated that problem posing can enrich creative thinking skills by encouraging students to create various forms of problems from one main idea. Through this activity, students hone their originality skills as they must formulate unique and unprecedented problems. Thus, problem posing not only improves mathematical thinking skills but also develops innovative skills that are useful in real-world situations.

In the problem posing stage in the learning design that has been made, students are asked to design new problems based on the questions that have been given previously. For example, students can change the value of a constant or coefficient in an SPLSV problem or create an entirely new contextual problem. This activity aims to train students' fluency and flexibility in generating a variety of problems. In addition, students are also invited to solve problems they have created themselves and discuss the results with classmates. This process helps students reinforce the aspects of elaboration and originality, as they have to devise logical solutions while modifying the problem to make it more challenging.

The final stage in learning is reflection and closing. At this stage, the teacher facilitates the discussion to help students evaluate the learning that has been done. Students are asked to identify the indicators of creativity that they have developed during the learning process, such as fluency in generating ideas, diversity of solution methods, uniqueness in creating problems, and clarity in formulating solutions. Teachers provide constructive feedback to reinforce students' understanding while also summarizing overall learning.

In its application, the learning approach integrates problem solving and problem posing starting with students solving problems given by teachers (problem solving). At this stage, students are directed to understand the problem, find solutions, and solve the problem. After that, students are instructed to propose new problems (problem posing), which can be in the form of modifications of previously solved problems or creating new problems with different situations as a continuation of the proposed problem solving.

Both approaches focus on problem-solving by actively engaging students, so that information comes not only from teachers, but also from students. Students are expected to be able to build new knowledge based on available information and their previous knowledge. The difference between the two is that in problem solving, the teacher offers learning problems for students to solve. Meanwhile, in problem posing, students are given the opportunity to offer or formulate learning problems. This approach provides benefits in strengthening the concepts learned, enriching the understanding of basic concepts, and improving students' ability to learn independently.

CONCLUSION

This research developed an innovative learning design integrating problem solving and problem posing to enhance students' creative thinking skills in *SPLSV* (Two-Variable Linear Equation System) material, structured around a preliminary stage, problem solving (understanding the problem, planning, solving, and re-examining), problem posing (proposing and developing new problems), and reflection-closing. The design followed the Analysis, Design, and Development (ADD) methodology, aiming to deepen conceptual understanding while fostering creativity. For future research, longitudinal studies could evaluate the design's long-term impact on students' mathematical creativity across diverse grade levels and subjects.

REFERENCES

Arıkan, E. E., & Ünal, H. (2015). Investigation of problem solving and problem posing abilities of seventh-grade students. Educational Sciences: Theory and Practice, 15 (5), 1403–1416. https://files.eric.ed.gov/fulltext/EJ1101279.pdf

Alrajeh, T. S., & Shindel, B. W. (2020). Student engagement and math teachers support. Journal on Mathematics Education, 11(2), 167–180. https://doi.org/10.22342/jme.11.2.10282.167-180

Barlow, A., & Brown, S. (2020). Correlations between modes of student cognitive engagement and instructional prac tices in undergraduate STEM courses. International Journal of STEM Education, 7(1), 1–15. https://doi.org/10.1186/ s40594-020-00214-7

Bicer, A., Marquez, A., Colindres, K. V. M., Schanke, A. A., Castellon, L. B., Audette, L. M., et al. (2021). Investigating creativity-directed tasks in middle school mathematics curricula. Thinking Skills and Creativity, 40, 1–19.

Bonotto, C., & Dal Santo, L. (2015). On the relationship between problem posing, problem solving, and creativity in the primary school. https://doi.org/10.1007/978-1-4614-6258-3_5

Crespo, S. (2003). Learning to pose mathematical problems: Exploring changes in preservice teachers' practices. Educational Studies in Mathematics, 52(3), 243–270. 10.1023/A:1024364304664

Kar, T., ¨ Ozdemir, E., ¨ Oçal, M. F., Güler, G., & ˙ Ipek, A. S. (2019). Indicators of prospective mathematics teachers' success in problem solving: The case of creativity in problem posing. In M. Graven, H. Venkat, A. Essien, & P. Vale (Eds.), 2. Proceedings of the 43rd conference of the International Group for the Psychology of Mathematics Education (pp. 456–463). PretoriaSouth Afric: PU. s.

Mudaly, V. (2021). Constructing mental diagrams during problem-solving in mathematics. Pythagoras, 42(1), a633. https://doi.org/10.4102/pythagoras.v42i1.633

Ozdemir, A. S., & Sahal, M. (2018). The effect of teaching integers through the problem posing approach on stu dents' academic achievement and mathematics attitudes. Eurasian Journal of Educational Research, 18(78), 1–21. https://doi.org/10.14689/ejer.2018.78.6

Polya, G. (1973). How To Solve it: A New Aspect of Mathematical Method. New Jersey, USA: Pricenton University Press.

Richey, C. Rita & Klein D James. (2007). Design Development and Research. New Jersey: Lawrence Erlbum Associates.

Rimm-Kaufman, S. E., Baroody, A. E., Larsen, R. A., Curby, T. W., & Abry, T. (2015). To what extent do teacher–student interaction quality and student gender contribute to fifth graders' engagement in mathematics learning? Journal of Educational Psychology, 107(1), 170–185. https://doi.org/10.1037/a0037252

Schunk, D. H. (2012). Learning Theories: An Educational Perspective (6th ed.). Pearson.

Silver, E. A. (1997). Fostering creativity through instruction rich in mathematical problem solving and problem posing. ZDM : The International Journal on Mathematics Education, 29(3), 75–80. https://www.emis.de/journals/ZDM/zdm973a3.pdf

Singer, F. M., & Voica, C. (2015). Is problem posing a tool for identifying and developing mathematical creativity? In F. M. Singer, N. F. Ellerton, & J. F. Cai (Eds.), Mathematical problem posing (pp. 141–174). New York, NY: Springer. https://www.researchgate.net/publication/283517802_Is_Problem_Posing_a_Tool_for_Identifying_and_Developing_Mathematical_Creativity#fullTextFileContent

Vale, I., & Barbosa, A. (2018). Mathematical problems: The advantages of visual strategies. Journal of the European Teacher Education Network, 13, 23–33.

van Hooijdonk, M., Mainhard, T., Kroesbergen, E. H., & van Tartwijk, J. (2020). Creative problem solving in primary education: Exploring the role of fact finding, problem finding, and solution finding across tasks. Thinking Skills and Creativity, 37, 1–10.

Wechsler. (2006). Validity of the Torrance Tests of Creative Thinking to the Brazilian Culture. Creativity Research https://doi.org/10.1207/s15326934crj1801