Problem-Posing in Prospective Primary School Teacher: Perspective Commognitive

Enditiyas Pratiwi[1*)] , A.Wilda Indra Nanna[2] , Desi Rahmatina[3] , Moh. Zayyadi[4], Muhammad Noor Kholid[5]
[1,2]Universitas Borneo Tarakan
[3]Universitas Maritim Raja Ali Haji
[4]Universitas Madura
[5]Universitas Muhammadiyah Surakarta
*) endityasp@borneo.ac.id

Abstract
This research explores the problem-posing abilities of students, especially prospective primary school teachers, which are demonstrated through problem-posing creativity produced through worksheets. In exploring students' problem-posing abilities, descriptive research with a qualitative approach was used. The subjects in the research were prospective primary school teacher students who had taken a number concept course which was chosen based on the problem-posing strategy that emerged after solving the given problem. Furthermore, subjects were interviewed in-depth to find out cognitive by looking at four indicators, namely word use, visual mediator, narrative and routine. The research results showed that there were no subjects with imitation strategies and subjects with reformulation strategies and reconstruction strategies did not give rise to problem-posing using visual mediators. This is because the subject is not used to problem-posing mathematical models in the form of diagrams or symbols.
Keywords: commognitive, cognitive, communication, creative thinking, problem-posing

Introduction

Problem-posing is often defined as a practice of generating new problems from existing situations or experiences or even from entirely new situations. Problem-posing is stated as a process of building a new problem through providing information, questions or problems (Cai et al., 2015). In addition, problem-posing has the potential to improve the mathematics learning process, making it an important part of mathematics practice in schools (Cai et al., 2015). Even Cai et al. (2019) have explored ways that can help teachers in the teaching and learning process by using problem-posing. Problem-posing is also a critical aspect that can be carried out by teachers, such as bringing out problem-posing abilities in students and helping students develop better problem-posing abilities (Olson & Knott, 2013). It is not only the problems that teachers pose during teaching that make problem-posing very important, but the way teachers use these problems also makes problem-posing an important component of teaching. An educator's ability to create problem-posing can encourage active participation in learning activities, in this case, students need to be allowed to create their mathematical problems in the subjects being studied. Several studies have looked at the effectiveness of problem-posing by using Android applications (Indiati et al., 2021), seen whether mathematics learning includes problem-posing (Passarella, 2021), how to teach mathematics using problem-posing (Zhang & Cai, 2021) which is the answer to the question in research by Cai & Hwang (2021) and Jia & Yao (2021) who argue that it is important to include problem-posing in the learning curriculum. However, there has been no research that focuses on students' problem-posing abilities in solving problems. Even though problem-posing skills are very important for students. However, there are still many students who do not realize the importance of this ability (Muhtarom et al., 2020).

Problem-posing can encourage students to participate in mathematical activities, allowing them to use many methods in solving problems and find solutions not just in one way (Silver & Cai, 2005). Brown and Walter (2005) point out the importance of problem-posing carried out by students and suggest seeing themselves as problem-makers rather than waiting for problems from external sources. By having the ability to create these problems, there is a process of reflection on the actions taken so that higher mathematical thinking can be developed (Sfard, 2008). Furthermore, Suarsana et al., (2019) stated that mathematical problem-solving abilities using problem-posing learning have a very significant influence. Problem-solving and problem-posing abilities have become important cognitive activities in the mathematics teaching and learning process. So, it is necessary to test students' abilities in solving and problem-posing mathematics (Rosli et al., 2013). Therefore, it can be said that the ability to think and understand mathematically meaningfully is a goal of current education (Kaya, 2016), which can help in the problem-solving process and Sfard (2008) also says that a person's thinking ability is a form of communication or what is referred to as commognitive.

The advantage of commognitive is that it can show that the communication that occurs in the mathematics learning process does not only act as a form of thinking, but Sfard (2008) positions communication and thinking as processes that are interrelated so that they cannot be separated from one another. Commognitive will specifically be seen and analyzed through word use (mathematical terms in everyday life), visual mediators (graphs, diagrams, symbols, physical props), endorsed narrative (written or spoken text, such as definitions, theorems and evidence, which describes objects, processes and relationships between them) and routines (practices carried out regularly and well defined by a person). In addition, commognitive is a discursive theory whose theoretical potential can explain thinking during mathematical problem-solving (Mahlaba & Mudaly, 2022).

Because there is an intersection in cognitive to look at problem-posing abilities more deeply, the focus of the research is to explore students' problem-posing abilities. The ability referred to in research is student creativity in posing mathematical problems. Apart from that, specifically, problem-posing will be analyzed using a cognitive perspective. Then, because the results of Olson & Knott (2013) research show that there are quite a lot of problem-posing activities among teachers, but their relevance to the higher education environment is quite limited, the problem-posing ability profile is specifically for students, namely in this case prospective school teacher base.

Research Method

The main aim of this research is to explore students' problem-posing abilities based on cognition. Therefore, this research uses descriptive qualitative research. This research was carried out at a university in North Kalimantan in the Primary School Teacher Education Study Program. The research was conducted on students who had taken the Number Concepts course. The students involved in this study were students who mostly came from remote areas. In addition, student involvement in the study was carried out at the end of the semester so that the hope was that the number material had been mastered.

The instruments used in the research were test sheets and interview guides. Test sheets are used to collect data about students' ability to be creative in problem-posing. An interview guide was used to confirm the data obtained through the test sheet. Prospective primary school teachers are asked to complete a test sheet in the form of problem-posing creativity, where the results of the answers are analyzed to determine three problem-posing strategies. The strategy in question is whether to solve it, carrying out (1) reformulation strategies; (2) reconstruction strategies; and (3) imitation strategies (Stoyanova, 2005). These three strategies are the criteria for determining research subjects after finding potential research subjects with reformulation strategies, reconstruction strategies, and imitation strategies. Each of these strategies was taken by three people as research subjects to represent and followed up through in-depth semi-structured interviews to confirm and dig deeper into cognitive-based problem-posing abilities. The commognitive indicators in question are word use, visual mediator, narrative and routine (Sfard, 2008). Students' problem-posing abilities based on cognition will be explained after carrying out the data reduction process.

Results and Discussion

Problem-posing plays an effective role not only in learning mathematical concepts but also in improving the ability to solve problems so that it can be widely used to solve mathematical problems (Akben, 2020). Based on the results of problem-posing creativity compiled on student answer sheets for prospective elementary school teachers, two subject strategies were found with several types which will be explained further. The following are questions given to the subject to work on.

"Make as many questions as possible using the following calculation: 2 x 14 + 7: 5 – 10"

Reformulation Strategies

The results of the subject test sheet are said to fall into the reformulation strategy when the problem-posing carried out results in a rearrangement of the problem structure but does not change the nature of the problem. In other words, the problem-posing results are still identical to the problem given and differ from the initial problem only in the presentation of information in the problem formulation. The subject is reformulated in different ways, as shown in the following example.

In the first subject (S1), the reformulation that appears in the test results sheet is adding brackets to emphasize the order of calculation operations.

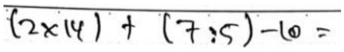


Figure 1. Reformulation Type 1

S1 solves the problem by rearranging the questions given. S1 adds brackets to the multiplication and division calculation operations but still allows addition and subtraction calculation operations. This was confirmed through the following interview with the question, "What questions did you formulate?"

S1: First I paid attention to the arithmetic operations in the problem. I saw the arithmetic operations of multiplication and division (word use). As I know, in the order of solving problems, the calculation operations of multiplication and division are preferred (routine). Therefore, I added brackets to the numbers that contain multiplication and division calculation operations (narrative).

In the second subject (S2), the reformulation that appears in the test result sheet is to maintain the identity of the problem by presenting an equivalent form of mathematical operation.

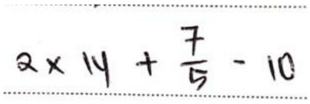
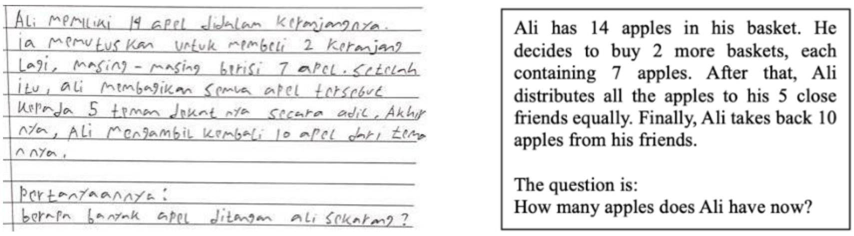

$2 \times 14 + \frac{7}{5} - 10$

Figure 2. Reformulation Type 2

S2 solves the problem by making special changes to the division calculation operation. S2 changes the division symbol ":" to "/." This was confirmed through the following interview with the question "What questions did you formulate?"

S2: I composed the problem without changing the numbers or the sequence of calculation operations (narrative), I only changed the form of the division calculation operation (routine).

In the third subject (S3), the reformulation that appears in the test result sheet is changing the mathematical model into story problems that are connected to everyday life.


Ali memiliki 14 apel didalam keranjangnya. ia memutuskan untuk membeli 2 keranjang lagi, masing-masing berisi 7 apel. setelah itu, ali membagikan semua apel tersebut kepada 5 teman dekat nya secara adil, Akhir nya, Ali mengambil kembali 10 apel dari teman nya.

Pertanyaannya:
berapa banyak apel ditangan ali sekarang?

Ali has 14 apples in his basket. He decides to buy 2 more baskets, each containing 7 apples. After that, Ali distributes all the apples to his 5 close friends equally. Finally, Ali takes back 10 apples from his friends.

The question is:
How many apples does Ali have now?

Figure 3. Reformulation Type 3 and the Translation

S3 solves problems by creating story questions. This was confirmed through the following interview with the question "What questions did you formulate?"

S3: I use the same numbers and calculation operations (routine), but present the questions in the form of story questions (narrative).

Reconstruction Strategies

The problem-posing strategy is called reconstruction when the results of problem-posing are obtained through modifications made to the initial problem and these modifications will change the nature of the problem. The test results sheet for subjects categorized as reconstruction is shown below.

In the fourth subject (S4), the reconstruction that appears in the test result sheet is by changing the number sequence of the arithmetic operations.

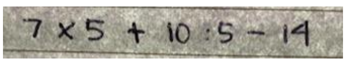

$7 \times 5 + 10 : 5 - 14$

Figure 4. Reconstruction Type 1

This was confirmed through the following interview with the question “what questions did you formulate?”

*S4: I tried to create a new problem by changing the arrangement of numbers (**narrative**), but still using the same numbers and the same sequence of calculation operations (**routine**).*

In the fifth subject (S5), the reconstruction that appears in the test result sheet is by changing the numbers but the order of the calculation operations that appear remains the same.

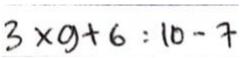


Figure 5. Reconstruction Type 2

This was confirmed through the following interview with the question “What questions did you formulate?”

S5: I created a new problem using the same calculation operations (routine), but I changed the numbers (narrative).

In the sixth subject (S6), the reformulation that appears in the test result sheet is by asking simple calculation questions by taking several numbers and one or two operations given in the question.

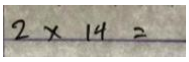


Figure 6. Reconstruction Type 3

This was confirmed through the following interview with the question "What questions did you formulate?"

S6: Because I made the question free, I tried to compose it using the numbers and operations contained in the question (narrative), but only used two numbers and one arithmetic operation.

The research subjects were taken based on three problem-posing strategies, namely (1) reformulation strategies, 2) reconstruction strategies, and (3) imitation strategies (Stoyanova, 2005), but based on research results the only strategies that emerge are reformulation strategies and reconstruction strategies. Strategies that do not appear in prospective subjects are imitation strategies, if the results of the problem-posing that are prepared are obtained from evidence with the addition of structures that are relevant to the problem, and the results of the problem- posing resemble those that have been encountered or problem-solving that has been done before. In other words, imitation strategies take into account two important things, namely that the results of problem-posing have an expanded structure and that someone has faced the same type of problem before. The research results of Kadir et al. (2018) show that the lowest percentage of problem-posing strategies are imitation strategies which are caused by students' difficulties in expanding and connecting the questions given to the material they have studied. In addition, Chapman (2012) said that involvement in problem-posing makes prospective teachers aware of the limitations of their mathematical knowledge in teaching.

The reformulation strategies and reconstruction strategies that emerged in this research do not entirely give rise to the problem-posing methods found by Stoyanova (2005). This is because problem-posing is difficult, especially for beginners, in structuring mathematical solutions correctly when posing a new problem (Kojima et al., 2011). Even though problem- posing is an important activity in problem-solving. Reformulation strategies and reconstruction strategies do not give rise to a **visual mediator**, which is the ability to rearrange the questions given in the form of pictures. The use of visual mediators is mathematical thinking or communication, and visual mediators are used as objects for thinking or communicating. Communication related to operations on visual mediators will occur automatically and in a tangible way (Sfard, 2008). For example, Viirman (2015) stated that visual mediators can be built by displaying diagrams. This happens because building visual mediators from a given mathematical model is not a routine activity carried out by student teachers when solving problems. However, in word use, narrative and routine, prospective teacher students can show it.

In word use, statements in mathematical models can be understood so they can be converted into story problems. Then in narrative, student teacher candidates when composing new questions can provide clear explanations and statements so that their thinking can be justified. This happens because student teachers can use their old knowledge by thinking about strategies for developing problem-posing. This is in line with Ge & Land (2004) which states that the subject's ability to use experience regarding how and when to apply the knowledge they have is considered as increasing student competence in the act of recognizing the information provided. Next, in the routine, prospective teacher students think about routine procedures in problem-posing. Prospective student teachers can demonstrate their ability to use appropriate and clear ideas to develop problem-posing. In line with Ben-Yehuda et al. (2005) which states that the ability to switch ideas can help in correcting mistakes by reflecting on previously used methods or ideas, thereby causing the formation of new methods or ideas in solving problems.

Conclusion and Suggestion

Based on the research results, it is known that only two problem-posing strategies can emerge by research subjects, namely reformulation strategies and reconstruction strategies. Furthermore, the commognitive indicators that appear in reformulation strategies and reconstruction strategies contain word use, narrative, and routine but do not display visual mediators. This shows that prospective teacher students have not been able to construct problem-posing using diagrams or symbols. Student teacher candidates are not yet accustomed to problem-posing problems so they cannot think and write down ideas related to visual mediators.

References

Ben-Yehuda, M., Lavy, I., Linchevski, L., & Sfard, A. (2005). Doing wrong with words: What bars students' access to arithmetical discourses. *Journal for Research in Mathematics Education*, *36*(3), 176–247. https://doi.org/10.2307/30034835

Brown, S., & Walter, M. (2005). *The art of problem posing*. Lawrence Erlbaum.

Cai, J., Chen, T., Li, X., Xu, R., Zhang, S., Hu, Y., Zhang, L., & Song, N. (2019). Exploring the impact of a problem-posing workshop on elementary school mathematics teachers' conceptions on problem posing and lesson design. *International Journal of Educational Research*, *102*, 01404. https://doi.org/10.1016/j.ijer.2019.02.004

Cai, J., & Hwang, S. (2021). Teachers as redesigners of curriculum to teach mathematics through problem-posing: conceptualization and initial findings of a problem - posing project. *ZDM – Mathematics Education*, *53*(6), 1406–1416. https://doi.org/10.1007/s11858-021-01252-3

Cai, J., Hwang, S., Jiang, C., Silber, S., Hansen, R., Hana, G. M., Milinkovic, J., Abramovich, S., Cho, E. K., Ellerton, N. F., & Singer, F. M. (2015). *Mathematical Problem Posing* (F.M. Singer, N. F. Ellerton, & J. Cai (eds.)). Springer New York Heidelberg Dordrecht London.

Chapman, O. (2012). Prospective elementary school teachers' ways of making sense of mathematical problem solving. *PNA*, *6*(4), 135–146.

Ge, X., & Land, S. M. (2004). A conceptual framework for scaffolding III-structured problem- solving processes using question prompts and peer interactions. *Educational Technology Research and Development*, *52*(2), 5–22. https://doi.org/10.1007/bf02504836

Indiati, I., Supandi, S., Ariyanto, L., & Kusumaningsih, W. (2021). The effectiveness of the problem-posing method based on android applications in mathematics learning. *Ilkogretim Online-Elementary Education Online*,*20*(1), 1440–1450. https://doi.org/10.17051/ilkonline.2021.01.137

Jia, S., & Yao, Y. (2021). 70 Years of problem posing in Chinese primary mathematics textbooks. *ZDM – Mathematics Education*, *53*(4), 951–960. https://doi.org/10.1007/s11858-021-01284-9

Kadir, Adelina, R., & Fatma, M. (2018). Enhancing students' mathematical problem posing skill through writing in performance tasks strategy. *Journal of Physics: Conference Series*, 012022.

Kaya, D. (2016). Elementary Mathematics Teachers' Perceptions and Lived Experiences on Mathematical Communication. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(6), 1619–1629. https://doi.org/10.12973/eurasia.2014.1203a

Kojima, K., Miwa, K., & Matsui, T. (2011). Study on the Effects of Learning Examples through Production in Problem Posing. *Proceedings of the 19th International Conference on Computers in Education*.

Mahlaba, S. C., & Mudaly, V. (2022). Exploring the relationship between commognition and the Van Hiele theory for studying problem-solving discourse in Euclidean geometry education. *Pythagoras-Journal the Association for Mathematics Education of South Africa*, *43*(1), 1–11.

Muhtarom, M., Shodiqin, A., & Astriani, N. (2020). Exploring senior high school student's abilities in mathematical problem posing. *Journal of Research and Advances in Mathematics Education*, *5*(1), 69–79. https://doi.org/10.23917/jramathedu.v5i1.9818

Olson, J. C., & Knott, L. (2013). When a problem is more than a teacher's question. *Educ Stud Math*, *83*, 27–36. https://doi.org/10.1007/s10649-012-9444-4

Passarella, S. (2021). Mathematics Teachers' Inclusion of Modelling and Problem Posing in Their Mathematics Lessons: An Exploratory Questionnaire. *European Journal of Science and Mathematics Education*, *9*(2), 43–56.

Rosli, R., Goldsby, D., & Capraro, M. M. (2013). Assessing students' mathematical problem- solving and problem-posing skills. *Asian Social Science*, *9*(16), 54–60. https://doi.org/10.5539/ass.v9n16p54

Sfard, A. (2008). *Thinking As Communicating Human Development, The Growth of Discourse, and Mathematizing*.

Silver, E. A., & Cai, J. (2005). Assessing students' mathematical problem posing. *Teaching Children Mathematics*, *12*, 129–135. https://doi.org/10.5951/TCM.12.3.0129

Stoyanova, E. (2005). Problem-posing strategies used by years 8 and 9 students. *Australian Mathematics Teacher*, *61*(3), 6–11.

Suarsana, I. M., Lestari, I. A. P. D., & Mertasari, N. M. S. (2019). The Effect of Online Problem Posing on Students' Problem-Solving Abilitiy in Mathematics. *International Journal of Instruction*, *12*(1), 809–820.

Viirman, O. (2015). Explanation, motivation and question posing routines in university mathematics teachers' pedagogical discourse: a commognitive analysis. *International Journal of Mathematical Education in Science and Technology*, *46*(8), 1165–1181. https://doi.org/10.1080/0020739X.2015.1034206

Zhang, H., & Cai, J. (2021). Teaching mathematics through problem-posing: insights from an analysis of teaching cases. *ZDM – Mathematics Education*, *53*(4), 961–973. https://doi.org/10.1007/s11858-021-01260-3