

PROSPECTIVE TEACHERS CONCEPTION OF MATHEMATICAL CREATIVE THINKING

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Abstract

The purpose of this study was to describe the initial conception of prospective teachers about creative thinking in mathematics. This research used a qualitative research method. The Research was conducted at private universities in Semarang, held in the second semester of the academic year 2016/2017. The subjects were six students of the seventh semester. This research used two instruments; test to explore the concept of creative thinking and interview. This study provides findings that there are similarities in the concept of prospective teachers in mathematical creative thinking. The prospective teacher's conception of the creative thinking of mathematics leads to the emergence of new concepts or ideas in completing mathematical problems based on experience. The appearance of the new idea in question is to solve a different problem from the existing procedure and solve the problem with a different perspective that is still logical. The prospective teacher's said that it was necessary for prospective teachers to understand the concept of creative thinking in mathematics to solve mathematical problems from various perspectives based on his learning experience.

Keywords: Creative thinking conception of prospective teachers, creative thinking, mathematics.

The conception of teachers or prospective teachers on creativity in mathematics is diverse. According to Leikin & Pitta-Pantazi (2013), the teacher's conception of mathematical creativity in each country varies due to cultural differences. Emre-Akdoğan and Yazgan-Sağ (2015) explain that the concept of aspiring teachers on creativity is still limited to student activities in the classroom that tend to use the problem-solving approach, and the characteristics of creative teacher candidates are determined by cultural factors and contextual issues. Hence, based on the opinion of Leikin, Emre & Yazgan it is understandable that cultural differences in a country will influence the conception formed in the understanding of each prospective teacher in their respective countries. Problem-solving skills are influenced by the culture adopted by certain countries. However, there are things that are intrigued the researchers, even though the concept of creativity is diverse in each country, the researchers believe there will be things that might be identical and become one idea that is acceptable as a joint study of creativity.

The conception of creative thinking teachers or prospective teachers is still divergent. According to Areti & Georgia (2014), prospective teachers have not comprehensively understood the conception of creative thinking since prospective teachers do not meet the criteria of originality. According to Baker, Rudd, and Pomeroy, creative thinking is thinking diverging and generating something of a novelty. Creative thinking is defined thoroughly that creative thinking is related to originality, flexibility, fluency, and divergent thinking (Morais and Azevedo, 2011). Based on the research conducted by Panaoura, Beker & et al, and Morais & Azevedo, the concept of creative thinking of prospective teachers is varies. Panaoura views creative thinking as a necessity to fulfill originality.

Beker and others view creative thinking as a brand-new concept. While Morais & Azevedo see creative thinking as fulfilling several concepts, namely; flexibility, smoothness, and originality. But basically, those views on creative thinking are most likely identical. Researchers are aware of the diverse views regarding one's creative thinking. But in reality, it attracted the attention of researchers to learn more about what and how the conception of creative thinking? Particularly for prospective math teachers.

Creativity is one of the most important things. Four skills (4C's: Critical Thinking, Creative Thinking, Collaboration, and Communication skills) are indispensable for surviving the current globalized world (As 'ari, 2016). Learning activities should include activities that lead to the 4C's. Learning activities which enhance students' creativity should be enforced. The creative thinking of prospective teachers requires a clear conception. The apprehensible understanding of prospective teachers regarding the concept of creative thinking impacts positively on prospective teachers to prepare creative learning, and indeed, the prospective teacher will encourage students to think creatively. Yet, there are still many prospective teachers who do not take into account the concept of creative thinking. Many prospective teachers understand the concept of creative thinking but do not want to learn and explore the concept of creative thinking nevertheless. Consequently, the concept of creative thinking remains a theory and it has never been implemented in the learning process.

Based on the aforesaid explanation regarding the various views of prospective teachers or teachers on the diverse concepts of creative thinking, particularly in mathematics, it urgently requires a more in-depth study of the conception of creative thinking. There are numerous prospective teachers might not grasp the significance creative thinking concept that impacts on their thinking, and influences the prospective teachers' teaching. Creative thinking should be habituated instead of serving as a mere theory which is abstract and pretty undefinable during its implementation. Therefore, the researchers aim at conducting an in-depth investigation of the initial concept of creative thinking among prospective teacher.

METHOD

This research employed the descriptive explorative approach. This research was conducted at a private university in Semarang. The implementation of this research was carried out in the even semester of the academic year 2016/2017. The subjects of this study were seventh-semester students who met the requirements, as follows; 1) has gone through Teaching Practice (Internship), 2) is available to be interviewed and has the potential to obtain information in-depth. Hence, the initial concept of prospective teachers about creative thinking is revealed. According to Karp (2017), Mathematics education is a place to foster creative thinking, productive, mathematical thinking, problem-solving abilities. This is in line with the development of mathematics teacher thinking regarding the formation of the concept of creative thinking which has started to develop. Prospective math teachers are very relevant to explore in-depth and conceptual information about creative thinking in learning.

The subject-taking technique was employed to obtain much information from various sources. The sampling technique used in this research was a purposive sample. The researcher acquired an initial sampling of 27 prospective teachers on creative thinking in general (instrument 1). Furthermore, six selected teachers out of 27 were selected as an in-depth subject by considering the answers (instrument 1). The interview on the six selected subjects was straightforward and manageable, thus in-depth information was attainable (instrument 2). The questions on instrument 2 are as follows:

What is the meaning of creative thinking in mathematics?

What are the characteristics of a person possessing creative thinking in mathematics?

What factors influence a person to think creatively?

What is the impact of creative thinking in mathematics?

How do you form one's creative thinking/student prospective teacher) in learning mathematics?

Data collection was done both in writing and orally. Oral data were obtained from interviews of prospective teachers about the conception of creative thinking mathematics. Research using the following instruments:

Written tests in a series of collaborations that must be answered by the prospective teachers in exploring the conception of creative thinking mathematics

Interviews in this study were conducted through question and answer activities to respondents directly, through WhatsApp social media, and phone calls.

Documentation of personal notes

Audiovisual, which consist of images or sounds that researchers use to help them understand the main phenomena being studied.

The next step is to do the data analysis. To validate the accuracy of the findings, use data triangulation. The data analysis technique used in this research is qualitative data analysis. The activity in qualitative data analysis is done interactively and continuously in every stage of the research until the data until is completed and saturated. The activity in data analysis, are data reduction, display data, and conclusion drawing or verification. Next, researchers conducted a discussion by looking for links between the findings of the researchers and the findings of previous researchers. According to Fraenkel, Wallen, & Hyun (2013) Interpreting the meaning of findings by "conducting discussion", "concluding", "Interpretation". Interpretation is that researchers step back and form broader meanings about phenomena based on personal views or comparisons with the results of previous studies.

RESULT AND DISCUSSION

This research explores the prospective teacher's conception of creative thinking in mathematics. The researchers used the second instrument in the form of written questions about the conception of creative thinking. Furthermore, the researchers conducted interviews of the six prospective teachers, to examine and explore the students' answers. To confirm the answers written by the prospective teachers of the questions given in writing on the second instrument, the data was analyzed one by one and validated.

The description of the prospective teacher's answer to the question of the conception of creative thinking is presented in the following transcription as follows.

Prospective teachers answer on the question: "What is creative thinking in mathematics?"

Subject 1: Logic-based thinking with various ideas and ways that if it is applied at the time of learning, it will build new insights and discoveries in solving mathematical problems

Subject 2: A mental activity employed by an individual to build general concepts or ideas in mathematics

Subject 3: The ability of students to understand and find problem-solving in mathematics by using their own way and employing the existing approach.

Subject 4: The ability to create an original idea that in mathematics.

Subject 5: A student's efforts to bring up a new idea/experience associated with learning mathematics.

Subject 6: The way of thinking/mindset of a person in solving mathematical problems with a different perspective and remains logical

Based on the teacher's answer to the question: "What is creative thinking in mathematics?", they almost have identical conception regarding creative thinking in Mathematics. Their conception of creative thinking leads to the emergence of new ideas and the building of concepts or ideas in solving experiential math problems. However, not all prospective teachers have a conception of creative thinking that leads to originality. Based on the answers and interviews, the emergence of new ideas in question is the ideas used in solving problems that are different from existing procedures, and solve problems with different perspectives and remains logical.

Prospective teachers understand the concept of creative thinking but they have not applied it to solving mathematical problems. The answers from the prospective teachers above are in line with Areti & Georgia (2014) views that state prospective teachers have not yet comprehensively understood the conception of creative mathematical thinking. Prospective teachers are raised from the idea of simplistic and flexible ideas. Meanwhile, conceptions of creative thinking tend to be used to solve a problem.

The answers of prospective teachers on the question: "What are the characteristics of a person having creative thinking in Mathematics?"

Subject 1:

- 1) *Skillfully in solving math problems*
- 2) *Able to generate ideas on each new topic given*
- 3) *Has more than one way to solve math problems*
- 4) *Able to accept new things or new mathematical problems which they encounter and try to solve them by looking from different viewpoints from previous learning experiences*
- 5) *Having a high curiosity when encountering mathematical problems and trying to solve problems in various ways or ideas.*

Subject 2:

- 1) *Having considerably high curiosity*
- 2) *Opening to new experiences*
- 3) *Having a lot of sense*
- 4) *Having curiosity to discover and do research*
- 5) *Tending to seek a broad and satisfying answer*

- 6) *Having a flexible thinking*
 - 7) *Giving more answers*
 - 8) *Having the ability to create analysis and synthesis*
- Subject 3:
- 1) *Being able to think fluently*
 - 2) *Being able to think in detail*
 - 3) *Being able to assess wisely*
 - 4) *Being able to think flexibly*
 - 5) *Having a curiosity*
 - 6) *Being able to think critically*
- Subject 4:
- 1) *Having great curiosity*
 - 2) *Having many ideas or suggestions on a problem*
 - 3) *Being not easily influenced by others*
 - 4) *Having a strong imagination*
 - 5) *Being able to work alone*
 - 6) *Being enthusiast in trying new things*
- Subject 5:
- 1) *Having a high curiosity about math*
 - 2) *Looking for broad answers (not enough just one answer)*
 - 3) *Being open, accept suggestions from others*
- Subject 6:
- 1) *Being able to solve mathematical problems in various ways*
 - 2) *Being able to solve math problems with simply*
 - 3) *Becoming thinkers, when there is a difficult problem, continue to conduct analysis and testing.*

Based on the prospective teacher's answer to the question: "What are the characteristics of a person having creative thinking in Mathematics?", The prospective teacher mentions various characteristics of an individual who has creative thinking. In this study, the characteristics mentioned are 1) able to solve math problems in various ways, 2) Having a high curiosity, 3) Open and accept suggestions from others, 4) Not easily influenced by others, 5) having strong imagination, 6) able to work independently, 7) willing to try new things, 8) able to think fluently, 9) able to think in detail, 10) able to think flexibly, 11) capable of solving mathematical problems, 12) able to think when encountering difficult problems and continuing to do analysis and testing. This is in line with Morais & Azevedo (2011) defining that creative thinking is all that is related to fluency, flexibility, originality, and divergent thinking. There are at least three aspects in common, namely; fluency, flexibility, and divergence. Even though in the aspect of originality is not yet understood by the prospective teacher, the prospective teacher's view of creative thinking is still related to critical thinking. It means that some of the prospective teachers still cannot distinguish the conception of creative thinking and critical thinking. The prospective teacher's conception of the person's traits of creative thinking is in line with Mc William (in Cremin and Cremin, no date) that the personality of the creative teacher must include diligence, willingness to develop, acceptance of new experiences, confidence, sense of humor, curiosity, ideas, imagination, and etc. Confidence in teaching, hard work and motivation are key aspects of creative thinking. According to Irawan (in As 'ari, 2016), creative thinking is an organized abstract, courageous, disciplined, a never-ending force that arises from environmental conditions and encourages

individual to do something. The main feature of creative thinking is the creation of a new idea which has never be seen or never be thought before.

The answers of prospective teachers on the question: "What factors influence a person to think creatively?"

- Subject 1:*
- 1) *The intelligence of each individual*
 - 2) *High curiosity*
 - 3) *Learning experience*
 - 4) *Ability to analyze a problem*
 - 5) *Ability to solve problems independently*
 - 6) *Treatment or learning received by a person*
 - 7) *A person's perspective on the problem*
 - 8) *The opportunity was given to someone to express his ideas.*
- Subject 2:*
- 1) *Incubation factor (way of solving difficult problems by delaying/giving time lag and then working again)*
 - 2) *Social Factors (when other people are concerned while working, offer exposure because of their creativity or striving for rewards)*
- Subject 3:* *Cognitive ability, confidence, learning environment or social factors*
- Subject 4:* *Cognitive factors*
- Subject 5:* *Open attitude, free attitude, curiosity*
- Subject 6:*
- 1) *Willingness to solve mathematical problems*
 - 2) *The ability of brain power*
 - 3) *Abstinence to give up seeking solutions*

According to Leikin & Pitta-Pantazi (2013), the teacher's conception of mathematical creativity in each country varies due to cultural differences. Emre-Akdoğan and Yazgan-Sağ (2015) explain that the concept of aspiring teachers regarding creativity is still limited to student activities in the classroom in problem-solving, cultural factors, and contextual issues.

Based on the prospective teacher's answer to the question: "What factors influence a person to think creatively?" prospective teachers have identical perspective regarding the factors that affect creative thinking. They mention cognitive, social and learning environment factors which affect the creative thinking of a person. In addition, creative thinking is influenced by intelligence, learning experience, treatment from others, and one's perspective on the problem, problem analysis skills, curiosity, independence, confidence, abstinence, opportunity, freedom, and incubation factors.

The conception of prospective teachers on factors that influence creative thinking is cognitive factors, learning environment, learning experience, and perspective to the problem. This is in line with the view of Leikin & Pitta-Pantazi (2013); Emre-Akdoğan and Yazgan-Sağ (2015) in terms of cultural factors and problem-solving. However, the concept of prospective teachers does not lead to contextual problem factors because the problems that bring up creative thinking are not always contextual problems, it can be mathematical problems that lead to the analysis of mathematical thinking.

Answers to prospective teachers on the question: "What is the impact of creative thinking in mathematics?"

- Subject 1:*
- 1) *Increasing learning activities,*

- 2) *Adaptable to problems and solutions,*
 - 3) *Easy to understand the concept of the material*
 - 4) *Always seeking information from the learning experience*
 - 5) *More confidence in new ideas*
 - 6) *Analytical and problem-solving skills increase*
- Subject 2: *A person is able to achieve above average accomplishment compare to the most learner because the learner is able to draw up a settlement plan and be active in their own problem solving*
- Subject 3: *Someone who is not able to think creatively will feel frustrated, dissatisfied and will not be systematic in solving problems.*
- Subject 4: *Become a well-liked individual and able to strive in real life*
- Subject 5: *Having significant experiences or insights and have new concepts or ideas*
- Subject 6:
 - 1) *Able to solve math problems easily*
 - 2) *Able to solve math problems simply and logically*
 - 3) *Able to make mathematical assumption easily*

Based on the prospective teacher's answer to the question: "What is the impact of creative thinking in mathematics?", prospective teachers argue that there is numerous impact gained from creative thinking in mathematics. These impacts directly and indirectly obtained by a person from creative thinking. The direct impacts include more learning activities, more confident in proposing new ideas, frequently have new concepts or ideas and are able to solve math problems simply and logically. Indirect impacts include easy to adapt to the problem and solving, easy to understand the concept of a material, increasing the ability of analysis and problem solving, having a lot of experience/insight. There are several prospective teachers who mention the negative impact of creative thinking, namely; feeling frustrated when the student is too long in solving a problem, not systematic in solving problems or overconfident.

Answers to prospective teachers on the Question: "How is individual creative thinking (student teacher candidate) in learning mathematics?"

- Subject 1: *By using the model, methods and learning media, the problem is presented in a fun and interesting way hence individual will be more motivated in solving math problems. This way of learning provides an opportunity for someone to develop the ability to analyze, reason, solve, and represent a systematic problem.*
- Subject 2:
 - 1) *Encouraging students to find a different question in a problem faced*
 - 2) *Questioning assumptions and analyzes or assumptions of a person to encourage others to question as well*
 - 3) *Encouraging someone to give birth to concepts or ideas*
 - 4) *Encouraging to build self-esteem.*
- Subject 3:
 - 1) *One must be able to find a solution to the problem*
 - 2) *One must start thinking critically of a problem*
 - 3) *Encouraging their curiosity about a problem*
- Subject 4:
 - 1) *Not easily discouraged*
 - 2) *Improving self-quality*
 - 3) *Being a good listener*
- Subject 5:
 - 1) *Forming new ideas*

- 2) *Comparing the information from outside with the informants they have*
- Subject 6: 1) *Keep practicing by solving mathematical problems*
2) *Abstinence giving up before finding answers*

Based on the teacher's answer to the question: "How is individual creative thinking (student teacher candidate) in learning mathematics?", The prospective teachers state that several benefits are obtainable from creative thinking. First, the use of appropriate and interesting models and methods can shape students' creative thinking, thus someone is more motivated in solving math problems, able to develop the ability to analyze, reason, problem solve and represent a problem. Second, giving different questions can encourage students to think creatively, encourage concepts or ideas and find solutions to problems. Some of the views expressed by prospective teachers are relatively different.

The conception of the creative thinking of teachers and prospective teachers still has different understandings. (Baker, Rudd, & Pomeroy, n.d.; Morais & Azevedo, 2011; Areti & Georgia, 2014). The results of this study found that there is a similarity of conception about the creative thinking of prospective teachers. Their conception of creative thinking leads to the emergence of new ideas and the building of concepts or ideas in solving experiential math problems. The emergence of new ideas in question is to solve problems that are different from existing procedures and solve problems with different viewpoints logically.

Prospective teachers argue that it is necessary to understand the concept of creative thinking. Prospective teachers who have the concept of creative thinking solve the problems of mathematics from various perspectives based on learning experience. With the correct conception of creative thinking, prospective teachers are able to develop ways of thinking in solving various math problems. As Kinach said, problem-solving requires representation, such as; manipulating images, symbols, and mathematical notation, this is done to find out, students avoid memorization/procedures. (Kang & Liu, 2018). Creative teacher thinking skills are needed. By understanding the concept of creative thinking, prospective teachers will develop different ways of solving mathematical problems.

CONCLUSION

The prospective teacher's conception of creative thinking leads to the emergence of new ideas and building concepts or ideas in solving mathematical problems with different points of view based on experience. The emergence of new ideas in solving math problems is the characteristic of a person's creative thinking. Future research is expected to explore how the process of creative thinking of students or prospective teachers is raising and developing new ideas in solving mathematical problems. It is also suggested to explore how to develop learning that can improve the creative thinking of students, prospective teachers, and teachers to further clarify the conception and implementation of creative thinking in mathematics. This research is in line with the findings of Tudor (2008) which confirm that creative thinking is an attempt to bring up many new ideas and create new ways to practice and the learning process.

ACKNOWLEDGMENTS

The authors would like to express the greatest gratitude to Mr. Abdur Rahman As'ari, Edy Bambang Irawan, and LPDP DN who have contributed, supported and provided direction on the research in order to obtain meaningful findings in mathematics education as well as all the parties who helped this research.

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