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Creative Thinking in Mathematics

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Abstract

Creative thinking is important in increasing the formation and discovery of learning ideas in the 21st century. The 21st century is closely related to the era of the industrial revolution 4.0 which requires humans to have the ability to think more creatively and be able to accept rapid technological developments. Through education and learning, the ability to think creatively can be improved for the better. The ability to think creatively which is one of the cognitive abilities in learning activities needs to be developed. When the ability to think creatively develops, it will give birth to ideas, find interrelated relationships, create and carry out imaginations, and have many perspectives on things. Students who have high creative thinking skills tend to feel challenged and interested in solving various problems in learning. Interest in solving this problem also causes curiosity. A student with mathematical creative thinking has the ability to be able to solve problems he encounters in new or unusual ways. The tendency of mathematics teachers to dominate learning results in low student activity so that they do not provide opportunities to be directly involved in scientific activities. These conditions have an impact on students' limited opportunities to think creatively in finding new information or ideas from the learning process, it is necessary to increase creative thinking in learning which can be done in various ways.

Keywords: mathematical creative thinking

INTRODUCTION

The unique curriculum has been attracting attention in recent years in education. (anggraena et al., 2021) stated: “the curriculum, based on its own learning policy, has a flexible character, is competency-based, focuses on character and soft skills development, and meets the needs of the world.” (permendikbud no. 22 of 2020), p. 55). Our unique curriculum is designed to be simple and flexible. This is a clear advantage as the curriculum places more emphasis on student freedom and makes learning more meaningful. During the learning process, students are expected to be able to relate and apply what they have learned and use it to solve everyday life problems. Solving everyday problems requires creative thinking and good math skills.

Creative thinking is a very important thought process in learning activities. Creative thinking requires a high level of concentration to solve problems. (freiman & tassell, 2018) states: “the elements of mathematical creativity include reversing the train of thought, solving problems in unique and unusual ways, thinking clearly, and abstracting and generalizing mathematical content. Thinking (krutetskii, 1976; sheffield, 2003)”, i.e., mathematical creative thinking includes the ability to work with a variety of expressions and

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to adopt appropriate expressions for specific problems and situations. Creativity is a fluid and flexible (non-linear) thought process that can generate original ideas. The ability to think creatively should be developed in learning activities, especially in solving math problems. The creative thinking process helps and facilitates students' thinking when they need to be able to solve complex problems. This eliminates the need to rely on standard algorithms to solve problems.

METHODS

The method used to write this article is a literature review. A search of international and national literature was performed using the google scholar and publish or perish databases. In the initial stage of the journal article search, 47,100 articles were published with the keyword "creative thinking in mathematics" from 2014 to 2023, and the relevance of articles to be edited was examined. After sorting these articles by most recent, only about 27 articles were used and deemed relevant for this study.

DISCUSSION AND RESULTS

1. Creative thinking

Thinking is the process of human behavior that produces purposeful discoveries related to goals. Through thought activity, people are able to find understanding, solve problems, make decisions, and ultimately come to an understanding of everything they encounter in life. Thinking has two main aspects, he said, critical and creative (maulana, 2017). These two basic human abilities motivate people to critically evaluate every problem they face, to creatively find answers, and to come up with new, better and more useful answers in life. Can do.

Creative thinking is a very important thought process in the learning process. The ability to think creatively requires a high level of concentration in memorizing and solving problems. A thinking person is someone who has the ability to think continuously and to create something creative from the ideas and imaginations in their head (hanany, 2020). Creative thinking is a mental activity associated with problem-solving sensitivity, open-minded attention to additional information and unusual ideas, and making connections

when solving problems (yaniawati et al., 2020). A creative person's way of thinking is always new, unique, unusual, and different from others. Creative thinkers dare to defend their ideas and points of view and at the same time dare to risk rejection, rejection or humiliation from the social environment (erawanto & santoso, 2016). Creative thinking refers to the skills used to explore new ideas and find solutions when solving problems (suherman & vidákovich, 2022). If students have well-developed creative thinking skills, they will be able to generate ideas, make connections, develop and execute fantasies, and have many perspectives on things (dewi mardhiyan, 2015).

Creative thinking is often defined as divergent thinking. Here are her three thoughts that can dominate a creative person's thinking: lateral, divergent, and convergent-integrated (suherman & vidákovich, 2022). Divergent thinking scores relate to originality, novelty, fluency, flexibility, sophistication, and explanation. Convergent integrative thinking is a thinking skill that allows you to identify the key elements of a problem and understand how those elements fit together.

The ability to think creatively is the ability related to creativity, the way of thinking to change or develop a problem, to look at a situation or problem from another side, to accept different ideas and ideas. Can be interpreted as uncommon (meika & sujana, 2017). Creativity is the process by which a person produces an “original” and culturally “worthy” response or product in a particular field (yeh & lin, 2015). The ability to think creatively is one of the fundamental skills that students must acquire in today's rapidly evolving information technology age. Educational institutions as spaces that help position students as actors in the educational system to promote creative behavior, positive attitudes and good character (satriawati, 2017). The ability to think creatively in solving the learning problems we face must be solved with creative solutions because we cannot always solve them in the same way as before (ni, 2022). From this it can be concluded that creative thinking is a thought process in which various ideas and ideas are interconnected, give rise to imagination and realize, and provide many perspectives for solving the problems that arise l can.

2. Mathematical creative thinking

An academic background that gives students freedom can have a positive impact on their thinking and creativity. Students of different educational levels and interests may also encourage mathematical creativity. We define creativity in mathematics as both the process of finding original or novel solutions to given problems and the process of generating new problems and perspectives on existing problems (freiman & tassell, 2018). Students with mathematically creative thinking have the ability to solve the problems they encounter in new and unusual ways.

Creativity is the process of becoming more aware of what you don't know (revealing blind spots), finding ways to fill those gaps, and sharing the results with others (filling in the blanks) (freiman & tassell, 2018). Thus, we can observe the behavior of problem-solving and problem-setting students with mathematically creative thinking during the learning process. In mathematics, the ability to think creatively is specifically called mathematical creative thinking. Mathematical creative thinking is the ability to explore different creative ideas to find solutions to mathematical problems. Students with good mathematical creative thinking are said to be capable of solving encountered mathematical problems in new or unusual ways. This is because the ability to think creatively while learning mathematics is a skill that allows students to come up with different solutions and ideas to solve problems, not only for mathematics problems, but also for the creativity required in their work. (kulsum et al., 2019).

Creative thinking in mathematics is the ability to express new ideas, see a problem from a new point of view, and form new innovations from several previously mastered concepts, as well as come up with solutions with varied completions and being able to be accounted for with detailed explanations (hanany, 2020). The ability to think creatively mathematically is the ability to find various new solutions to mathematical problems that are open easily and flexibly, but the truth is acceptable (amidi & zahid, 2016). Someone with the ability to think creatively mathematically is described as someone who has the ability to find solutions in a more varied and novel way so that they can solve open-ended mathematical problems easily and flexibly, but the truth can be accepted (abdurashidovna, 2022).

Mathematical creative thinking is characterized by creating something new from results, ideas, descriptions, concepts, experiences, and knowledge related to

mathematics which includes fluency, flexibility, originality, and elaboration (suherman & vidákovich, 2022). In accordance with this statement, it was also revealed that mathematical creative thinking skills are characterized by the skill of providing ideas for solving mathematical problems based on indicators which include (1) fluency, (2) flexibility, and (3) originality (satriawati, 2017). In his book, maulana described the structure of the model that represents the basic characteristics of creative thinking. In the first opinion, the structure of the model consists of three main elements, including fluency (fluency or liquidity), flexibility (flexibility or flexibility), along with a plurality of branching product flows (divergent thinking). Provides an overview of human intelligence, which consists of elements of) and refinement (detail) guilford (hudgins et al., 1983). The second view he adopted by torrance (hudgins et al., 1983) added an originality factor (authenticity or novelty) that was part of the flexibility factor (adaptive flexibility). A third opinion comes from his evans (1991), which adds a problem sensitivity component (sensitivity to problems). From this we can conclude that a student with good mathematical creative thinking will be recognized by meeting his five criteria: (1) subject sensitivity, (2) fluency, (3) flexibility or flexibility), (4) originality (reliability), and (5) sophistication (detail or sophistication).

3. Why you should think mathematically creatively

It takes a creative thinking skills are required. It is also necessary to have an attitude of valuing the use of mathematics in life. Depending on the type of work, you can become a highly skilled worker. Through education, everyone should learn to understand mathematical concepts, use thinking skills, solve problems, and apply ideas. We not only need smart people, but we also need smart people full of ideas and innovation to support the progress of relevant institutions. The study of mathematics is not only aimed at learning algorithms, statistics and geometry, but also to practice and train students' way of thinking so that they become more logical, creative, rational and critical. There is another goal of (kulsum et al., 2019). The ability to think creatively should be developed in the learning process, especially for solving math problems. The information technology age is now developing faster because this is very helpful for

students and makes it easier to reason and solve complex problems that do not rely solely on standard formulas and algorithms (hanany, 2020). Complex mathematical problems require the ability to think creatively, leading to innovation in a variety of problem-solving (yaniawati et al., 2020).

Mathematical problems that may arise in learning activities and in everyday life require creative thinking that requires diverse and original thinking, curiosity, prediction and speculation, imagination by developing experiments, intuition, and discovery. Activities need to be expanded. This suggests the importance of developing mathematical creative thinking skills through creative activities while learning mathematics (amidi & zahid, 2016).

She needs to develop her one of her cognitive skills in learning activities: the ability to think creatively. As your creative thinking skills develop, you generate ideas, find connections, create and bring your fantasies to life, and have many perspectives on things. Students with high creative thinking skills tend to be challenged and interested in solving a variety of learning problems. Interest in solving this problem also arouses curiosity. Learning through curiosity is not just knowledge, but a quest to know and understand more of what is gained in the process of learning (dewi mardhiyan, 2015). The ability to think creatively determines the superiority of a country. Mathematics lessons must then be designed to improve students' creative thinking skills. In practice, however, creative thinking capacity is still relatively low (syafitri pudji astuti, nita delima, 2016).

Students' ability to think creatively in problem solving is very low, and the available materials do not address their needs and characteristics, leaving them stuck in fixed patterns when answering. Efforts are made to overcome the problem of students' low ability to think creatively when solving problems by increasing learning effectiveness. In this case, teachers use materials according to the needs and characteristics of the students (erawanto & santoso, 2016). The ability to think creatively and solve mathematical problems (bkpm) is a skill students need to have to face the challenges of the 21st century world of work. Problem-solving skills, critical thinking, and creativity are important elements of students' future life capital (meika & sujana, 2017). Creative thinking is critical to fostering the formation and discovery of learning ideas in the 21st

century. The 21st century is closely related to the era of industrial revolution 4.0, which requires people to be able to think more creatively and be receptive to rapid technological development. Through teaching and learning, we can enhance our ability to think creatively. Improving the quality of education affects people's ability to think (maskur et al., 2020). In line with the goals of mathematics learning to teach and encourage students to think in a systematic, logical, creative, critical, and coherent way students develop a never-give-up attitude and confidence in problem solving (satriawati, 2017).

Complex problems down to detailed topics in learning and daily life require students' creativity. Creativity plays an important role in mathematics learning, so teachers should provide appropriate learning opportunities for their students (abdurashidovna, 2022). The presence of teachers is very important to stimulate students to bring new ideas and ideas through learning and experience (ni, 2022). Given the importance of creativity and the dominance of e-learning in higher education, it is very important to be able to identify the mechanisms that underlie and contribute to students' creative learning in e-learning environments. Therefore, there is a need to develop effective learning training programs that stimulate their creativity (yeh & lin, 2015).

4. Factors influencing mathematical creative thinking

The tendency of math teachers to dominate the classroom reduces student activity and denies opportunities for direct scientific activity. These situations affect students' limited ability to think creatively and find new information and ideas from the learning process. To optimize creative thinking skills that require endurance, personal discipline, and mindfulness, we need to work around these limitations. B. Ask questions and think openly about new information and unusual ideas. Teachers need to change the paradigm of being the central figure in the class and become facilitators who can guide students to take an active role in their learning. Teachers are not the only source of learning, as students can seek and obtain learning materials from a variety of sources inside and outside the classroom (yaniawati et al., 2020).

Interest in solving this problem also arouses curiosity. Learning through curiosity is not just knowledge, but an inquiry to know and understand more of what is gained in the process of learning (mardhiyana & sejati, 2016). To improve creative thinking ability in mathematics learning, learning activities should be linked to the development of thinking skills, such as giving up on problems that cannot be solved by sticking to learned formulas alone (syafitri pudji astuti, nita delima, 2016). In learning environments where tasks provide students with opportunities to use multiple strategies to solve and formulate their own problems, students engage in broader inquiry, are more motivated, investigate, and make decisions. It can encourage people to explore, generalize, follow patterns, explore and communicate. In relationships. Discuss ideas and identify alternatives (abdurashidovna, 2022). Students with different abilities and backgrounds can answer questions according to their abilities (suherman & vidákovich, 2022).

A major factor in students' poor ability to think creatively in mathematics is influenced by the teacher's approach to learning. Creative thinking skills in students are poorly developed because the teacher gives the material and presents examples of questions without involving the student's interaction in opinion and analysis so that the student thinks according to what the teacher gives (hendriana & fadhillah, 2019). Efforts of teachers to address these issues lie in their evaluation of ideas conveyed by their students. Teachers can stimulate students' creativity during learning and teachers must respect students' questions and answers (ni, 2022). A strong knowledge base is essential for creative development. Self-regulation contributes to learner creativity (yeh & lin, 2015).

5. Development of creative thinking processes in solving mathematical problems

Creative thinking is the process of generating or potentially generating new ideas. You can combine previous ideas that you haven't had time for yet. When someone uses creative thinking to solve a problem, different thinking creates methods that can be used to solve the problem (hanany, 2020). Submitting and solving questions that test language ability and flexibility can therefore be used as a means of assessing creativity as a product of an individual's creative thinking.

Improving creative thinking in learning includes understanding problems through representations of knowledge and questions, solving problems with multiple answers (fluency), using different methods to solve problems, solving it can be achieved in a number of ways, including being able to be detailed at times. Problem (flexibility), verifying the results of the solution in different ways and creating new ways (novelty) of solving the problem (hanany, 2020). Creative thinking is exercised through attitudes that require persistence, personal discipline, and thoughtfulness. These activities include mental activities such as asking questions, thinking openly about new information and unusual ideas, connecting freely with each other, using imagination, and paying attention to intuition (yaniawati et al., 2020).

Learning mathematics using a problem-based model plays a very important role in developing creative thinking skills as students perceive problems as something that needs to be solved. Problem solving can be done by investigating, discovering, or investigating through social and environmental interactions, which can produce very useful ideas. Through investigative activities, students can also develop their creative thinking skills and curiosity (dewi mardhiyan, 2015). The use of tasks, especially tasks with multiple solutions or resolutions, usually requires creative thinking and is a potential way to enhance student creativity (abdurashidovna, 2022). Creative thinking skills also emerge and develop at higher levels of education when supported by a good learning environment. Learning activities must be student-centered and faculty are expected to function only as facilitators, motivators and dynamists. Learning strategies no longer follow traditional learning patterns but refer to and apply constructivist learning models (erawanto & santoso, 2016). Creativity and creative thinking do not come naturally and require some practice. In this case, teachers must be able to train and improve students' creative thinking skills through learning that does not cause routine, routine problems. Here are some ways to develop and improve these two skills of hers. That is, (1) applying learning models relevant to these skills; (2) by developing materials that can leverage both mathematics skills individually or together (meika & sujana, 2017). By observing, questioning, and thinking, students can enhance their knowledge and creative thinking by planning and actively learning mathematics in a fun way (satriawati, 2017). The

methods or methods used by teachers to apply habits of creative thinking to students in teaching and learning activities. After explaining the material, the teacher is expected to conduct a quiz or initiate a question-and-answer session to stimulate the student's thinking through creative activities based on the material being studied was discussed (ni, 2022). Other initiatives teachers can take to stimulate creativity in students during learning include learning through play, evaluating ideas submitted by students, developing creativity during learning, and asking and answering questions from students including responding appropriately to.

CONCLUSION

Creative thinking skills need to be developed in learning activities, especially in solving math problems. The creative thinking process helps students to rely only on standard algorithms to solve complex problems, making them easier to think about when asked to solve them. Creative thinking is a thought process in which different ideas and imaginations are interconnected, creating imagination, realizing it, and providing many perspectives to solve the problems that arise. Students with mathematically creative thinking have the ability to solve the problems they encounter in new and unusual ways. A major factor in students' poor ability to think creatively in mathematics is influenced by the teacher's approach to learning. Teachers must continue to strive to address these issues. There are several methods teachers can use to develop creative thinking processes when solving math problems. (1) designing and implementing active her learning in a playful way through observation, reasoning, and question-and-answer activities, (2) dealing with math problems, and so on. (3) use discovery and inquiry methods in learning activities; (4) provide students with opportunities to solve problems using a variety of methods; respond appropriately to questions and answers.

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