

Research Article

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Mathematics Teachers' Conceptions of Creativity in Indonesian Secondary Schools

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Abstract

Background/purpose. Mathematics teachers' conception of creativity needs to be considered because they are key to successfully enhancing student creativity in learning. This study aims to (1) determine the definition of creativity according to teachers; (2) determine the characteristics of creative students; (3) determine whether student creativity can be enhanced through mathematics learning; (4) determine the factors that influence student creativity; and (5) determine the learning characteristics that can enhance student creativity.

Materials/methods. This study uses a qualitative research approach with a phenomenological research design that aims to reveal mathematics teachers' conceptions of creativity in mathematics learning. Seven teachers from various levels of education in Indonesia were given questionnaires and interviewed to explore their views regarding the definition of creativity, characteristics of creative students, efforts to enhance creativity through mathematics learning, factors that influence it, and learning characteristics that support creativity, with data analyzed using a content analysis approach.

Results. Teachers believe that creativity is the ability to generate new ideas and different solutions in solving problems. Teachers identified the characteristics of creative students, including curiosity, flexibility of thinking, imagination, and independence. All teachers agreed that creativity can be enhanced through mathematics learning. Student-centered learning and providing space for exploration are said to be effective in fostering student creativity.

Conclusion. This study concludes that teachers realize the importance of creativity in mathematics learning and have conceptual understanding and practices that support its development, although not yet fully systematic.

1. Introduction

The development of science and technology demands that education not only focus on knowledge, but also on developing higher-order thinking skills, including creative thinking skills (Kwangmuang et al., 2021; Tanujaya et al., 2017; Yayuk et al., 2020). Dreyfus & Eisenberg (1996) suggest that the nature of mathematics is creative thinking, not just finding the right answer. Creative thinking is the ability to generate new solutions or ideas in the problem-solving process (Hadar & Tirosh, 2019). Correspondingly, in the context of education, creative thinking is a reflection of creativity, which is now one of the important indicators in the success of learning (Ritter & Mostert, 2017; Tabach & Friedlander, 2017).

Creativity is still often neglected in learning, especially in mathematics (Henriksen et al., 2017). Mathematics is seen as a rigid, procedure-based discipline that focuses on correct answers and systematic steps (Boaler, 2016; Sheffield, 2017). In fact, some experts emphasize that creativity is very important in mathematics to solve problems or generate new ideas (Hadar & Tirosh, 2019; Suherman & Vidákovich, 2022). Creative thinking skills can be realized through non-routine problem solving and exploration of various solution strategies (Kholid et al., 2024).

TIMSS (Trends in International Mathematics and Science Study) and PISA (Program for International Student Assessment) place creative thinking skills as one of the aspects in assessing students' mathematical literacy (Alotaibi & Alyahya, 2019; OECD, 2018). PISA added a new domain related to creative thinking skills because students need to prepare for the world of work and daily life full of complex challenges that do not have a single solution (Barbot & Kaufman, 2025; Foster & Schleicher, 2022). However, unfortunately, various studies show that students' mathematics learning is still directed to memorize formulas and solve problems with one specific procedure (Nilimaa, 2023; Retnawati et al., 2017; Widana, 2018). This does not provide space for students to develop their creativity. Teachers tend to assess student success from the speed and accuracy of solving problems, not from the solution strategies used.

One of the factors that determine whether or not students' creativity develops in learning is the teacher's conception of creativity itself (Harris & de Bruin, 2018; Jahnke et al., 2017; Kettler et al., 2018). Teachers' conceptions relate to how teachers define, understand, and interpret creativity in the context of their learning. This understanding becomes the foundation for pedagogical decision-making, which includes developing lesson plans, learning strategies, and assessing student learning outcomes. Research shows that teachers' understanding of creativity varies widely. Studies by Aktaş (2016) show that teachers' understanding of creativity varies widely. Teachers with a broad understanding of creativity tend to provide students with greater space to explore, ask questions, and find alternative problem-solving approaches. On the other hand, research by Mullet et al. (2016) revealed that many teachers have misperceptions related to creative students.

Teachers' conceptions of creativity can influence how they encourage creativity in the classroom (Bryant, 2014). However, there is a gap in the literature regarding teachers' conceptions of creativity enhancement. Teachers are often unaware of the key qualities of creative students, as most teachers misunderstand or have negative perceptions of them. Additionally, creativity is not usually encouraged in schools (Aljughaiman & Mowrer-Reynolds, 2005; Hondzel, 2013). Determining teachers' conceptions can be a first step in determining how to foster creativity in schools (Beghetto & Plucker, 2006). It is also a prerequisite for any policy that will be developed on creativity in education (Cachia & Ferrari, 2010). Furthermore, determining whether teachers have misconceptions about creativity and introducing what is needed to eliminate these weaknesses provides a basis for better implementation to develop creativity in the classroom (Newton & Newton, 2009).

Teachers' conceptions of creativity reflect cultural values (Hong & Kang, 2010), and differences in education systems across countries are reflected in teachers' conceptions (Leikin et al., 2013). Although there have been several studies on teachers' conceptions of creativity around the world (Ayele, 2016; Kettler et al., 2018; Leikin et al., 2013; Levenson, 2022), research specifically examining mathematics teachers' conceptions of creativity is still limited, especially in local contexts such as Indonesia. Therefore, the findings may not fully reflect the social, cultural, and learning practices that occur in Indonesian schools. Therefore, research is needed to gain insights in the Indonesian context. The findings obtained from this study are expected to contribute to revealing mathematics teachers' conceptions of creativity in the Indonesian context. In addition, the researchers believe that this study will contribute to the literature for similar studies on creativity.

Understanding how teachers interpret creativity is very important. Given that teachers are a key factor in the implementation of learning in the classroom, the exploration of mathematics teachers' conceptions of creativity is very relevant. This study aims to explore how mathematics teachers in Indonesia understand creativity in the context of mathematics learning. To that end, this study was designed to answer the following questions:

- a. What is the definition of creativity according to teachers?
- b. What are the characteristics of creative students?
- c. Can creativity be enhanced through mathematics learning?
- d. What are the factors that influence students' creativity?
- e. What are the characteristics of learning that can enhance students' creativity?

2. Literature Review

Creativity is seen as an important aspect of individual and societal development, as well as a universal ability that supports progress in various fields of science, including mathematics (Richardson & Mishra, 2018; Ulger, 2018). In the context of mathematics, creativity refers to the ability to generate original, valuable, and contextually appropriate mathematical ideas or solutions, which can be viewed from the perspective of individuals, ways of thinking, environments, and products (Joklitschke et al., 2022; Rhodes, 1961). Creativity is the ability to generate ideas, especially those related to divergent thinking (Kim et al., 2016). According to Silver (1997), mathematical creativity involves various abilities, such as thinking flexibly, having curiosity, strong imagination, interest in finding solutions, the ability to make parables, and thinking that is directed and purposeful. Mathematical creativity is not only repeating methods that have been taught, but also includes the ability to find new solutions that are relevant and useful (Haylock, 1987; Schoevers et al., 2019). In line with that, Bishara (2016) states that mathematical creativity involves the ability to reformulate simple problems in a new way, explore various alternative solutions, and create original methods to solve unusual problems.

Several factors hinder the development of creativity in mathematics learning, namely the pressure on one correct answer taught by the teacher, the prohibition of making mistakes, ignoring students' ideas, and time constraints due to curriculum pressures (Aguilera & Ortiz-Revilla, 2021; Lince, 2016). This results in teachers tending to emphasize memorization rather than encouraging creative thinking (Ayele, 2016). In supporting creativity, teachers are advised to act as facilitators who can create learning environments based on open-divergent questions, motivational questions, and activities (Kandemir et al., 2019; Mrayyan, 2016). Research also shows that the use of open-ended questions, modeling approaches, and multi-answer tasks encourages student creativity, especially in context-based learning, problem solving, and problem posing (Ayllon et al., 2016; Purba et al., 2017; Sitorus & Masrayati, 2016). Active interaction and cooperation between students strengthen the

emergence of original ideas, so learning strategies based on collaboration, reflection, and constructive evaluation are indispensable in developing student creativity in mathematics.

3. Methodology

This study uses a qualitative research approach with a phenomenological research design. The main focus of this study was mathematics teachers' conceptions of creativity. The participants consisted of seven mathematics teachers who teach at junior high schools (SMP), senior high schools (SMA), and vocational high schools (SMK) in several regions in Indonesia. The selection of participants reflects the diversity of formal education in Indonesia, both in terms of educational levels and professional backgrounds. In this study, the criteria for selecting participants included teaching experience, level of education where they teach, and status of educator certificate ownership. Demographic characteristics of teachers were coded with T1-T7 which are presented in Table 1.

Table 1. Demographic qualities of research participants

Teacher code	Teaching institution	Teaching experience	Educator certificate
T1	SMA	5 years	No
T2	SMA	5 years	No
T3	SMK	10 years	Yes
T4	SMP	10 years	Yes
T5	SMP	3 years	No
T6	SMP	8 years	Yes
T7	SMP	10 years	Yes

Data were collected using questionnaires and interviews. Questionnaires and interviews were used to determine teachers' conceptions of creativity in mathematics learning. Teachers were asked to express their opinions regarding: 1) the definition of creativity, 2) the characteristics of creative students, 3) whether creativity can be enhanced through mathematics learning, 4) factors that affect student creativity, 5) learning characteristics that can enhance student creativity. Data analysis was conducted using content analysis. The data obtained were coded, and then similar codes were grouped into several main topics. The results of the analysis are presented descriptively and reinforced by the teacher's opinion during the interview.

4. Results

4.1. Definition of Creativity According to Mathematics Teachers

Based on the results of questionnaires and interviews with seven mathematics teachers, it was found that the teachers had quite diverse views in defining creativity. The resulting model of the teachers' definition of creativity is presented in Figure 1 below.

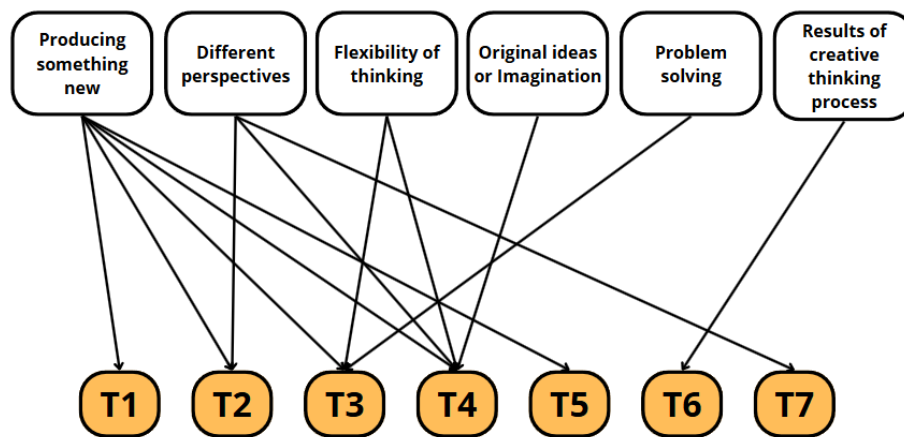


Figure 1. Definition of creativity according to mathematics teachers

The majority of teachers (T1, T2, T3, T4, and T5) defined creativity as the ability to produce something new. This novelty refers not only to the creation of ideas, but also to solving problems in a way that differs from the usual approach. In addition, most teachers emphasized that creativity is seeing from a different perspective (T2, T4, T7). Creativity is not only about producing something that has never existed, but it is also about looking at and understanding a problem in an unconventional way. Teacher T4 mentioned in more detail that creativity involves flexibility of thinking, imagination, openness to new possibilities, and the courage to think outside the boundaries. Teacher T3 linked creativity to the ability to solve problems through various solutions. Meanwhile, teacher T6 argued that creativity is the result of creative thinking itself, thus emphasizing more on the cognitive aspects that underlie the emergence of new ideas.

4.2. Characteristics of Creative Students

Based on the results of questionnaires and interviews with seven mathematics teachers, five main points describe the characteristics of creative students. The model generated from teachers' opinions related to the characteristics of creative students is presented in Figure 2 below.

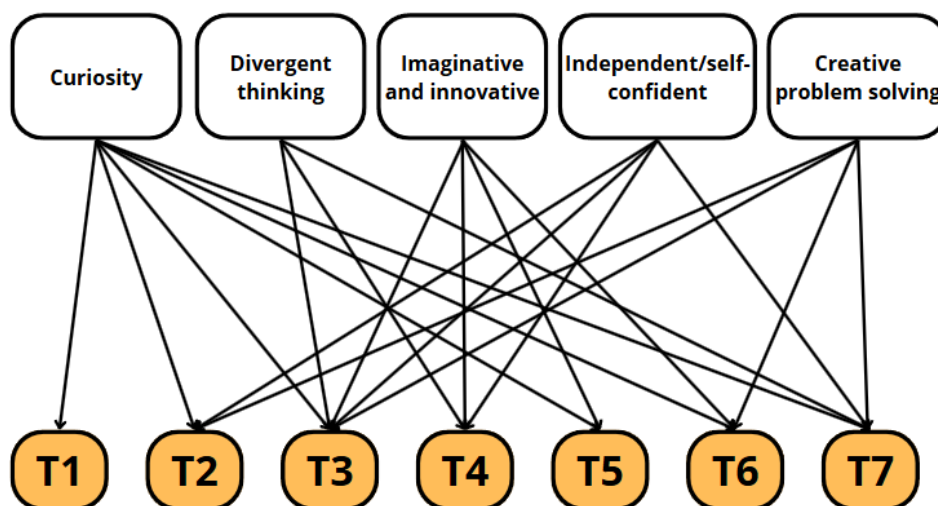


Figure 2. Characteristics of creative students

The first point mentioned by teachers is high curiosity. Six mathematics teachers (T1, T2, T3, T5, T6, T7) revealed that creative students usually show strong curiosity about the subject matter, often ask questions, and want to understand something more deeply. Furthermore, some teachers (T3, T4, T7) emphasized the importance of flexible ability and divergent thinking. Creative students do not just stick to one way of thinking or one answer, but have several other points of view. Creative students are also described as imaginative and innovative individuals. Teachers (T3, T4, T5, T6)

mentioned that creative students often have a broad imagination, are able to imagine new concepts, enjoy creating, and dare to develop something unique. Another characteristic that emerged was independence and initiative in thinking and acting expressed by teachers T2, T3, T4, and T7. There are also characteristics in the form of the ability to solve problems creatively. Teachers T2, T3, T6, and T7 said that creative students are able to design alternative solutions and are able to connect prior knowledge with new contexts.

4.3. Can Creativity be Enhanced Through Mathematics Learning

Based on the results of questionnaires and interviews with seven mathematics teachers, it was found that all teachers stated that students' creativity can be improved through learning mathematics. Some teachers (T1, T2, T5, T6) expressed their opinion briefly that creativity can be enhanced through learning mathematics. Meanwhile, other teachers gave more in-depth descriptions. Teacher T3 suggested that creativity can be enhanced through project-based learning models, giving open-ended type problems, and using math games that challenge students' logic and imagination. Teacher T4 also expressed the same view with an open-ended problem-solving context approach. Teacher T7 added that creativity in mathematics learning can be enhanced through critical thinking skills, especially in finding various problem-solving strategies.

4.4. Factors Affecting Student Creativity

Based on the results of questionnaires and interviews with seven mathematics teachers, it was found that student creativity is influenced by various factors categorized into internal factors and external factors. The model generated from the teachers' opinions on factors influencing students' creativity is presented in Figure 3 below.

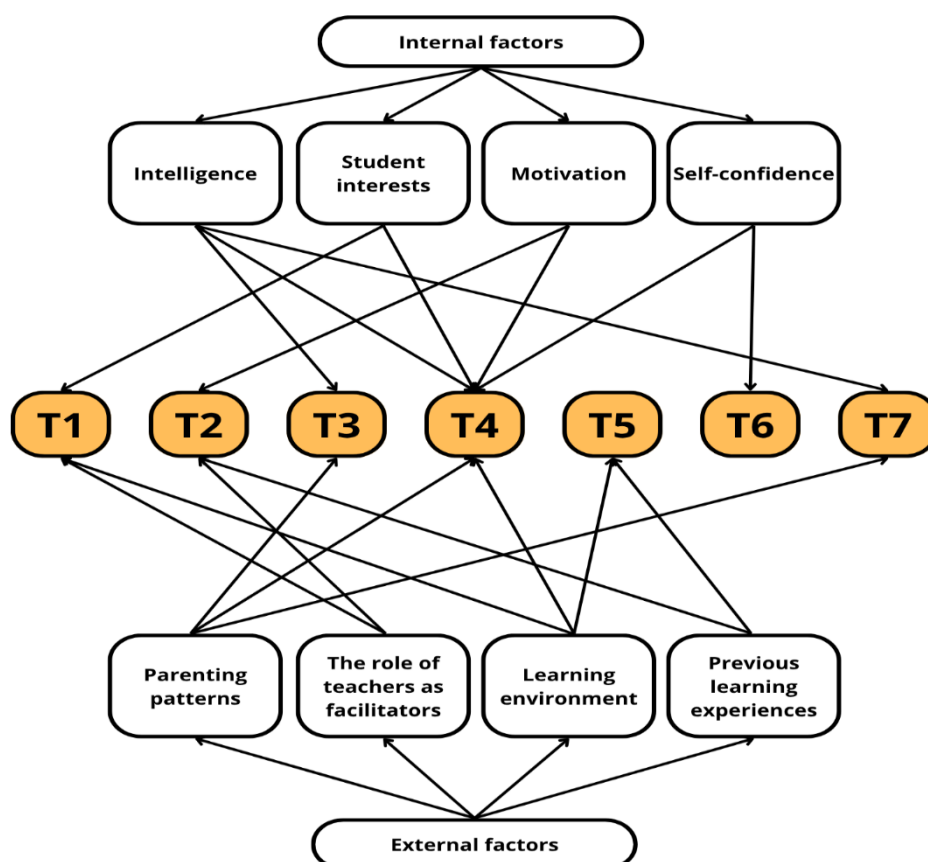


Figure 3. Factors that influence student creativity

Internal factors that influence students' creativity include intelligence, interest in learning, motivation, and self-belief. Some teachers (T3, T4, T7) suggested that creativity is closely related to students' intelligence level. Teacher T3 explained that creativity is a cognitive ability that students possess and develop when supported by the right environment. Teachers T1 and T4 added that students' interest and motivation to learn are the beginning of creative ideas in solving problems. Meanwhile, T4 and T6 emphasized the importance of self-confidence in expressing ideas.

External factors include family upbringing, the role of teachers, the learning environment and previous learning experiences. Teachers T3 and T7 explained that parenting provides space for expression and decision-making. Teachers T2 and T5 suggested that a conducive learning environment and adequate facilities are important in enhancing students' creativity. Teachers T1 and T2 suggested that teachers have an important role in managing the classroom atmosphere and packaging challenging learning. In addition, teacher T5 added that learning experiences come from what students read, hear and see.

4.5. Characteristics of learning that can enhance students' creativity

The results of questionnaires and interviews with seven mathematics teachers revealed various perceptions and views regarding the characteristics of learning that can enhance students' creativity. The model generated from the teachers' opinions is presented in Figure 4 below.

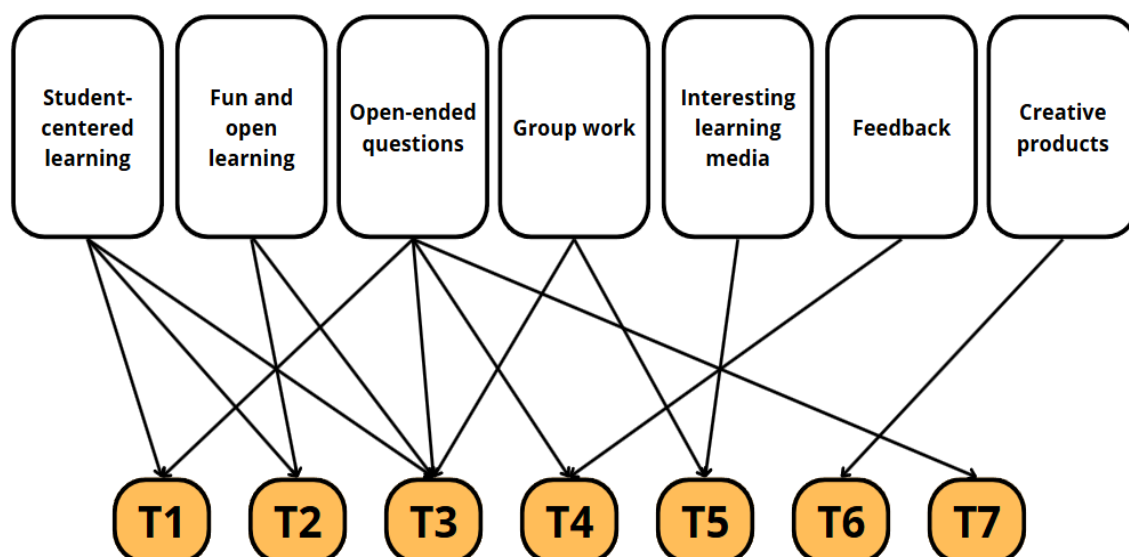


Figure 4. Characteristics of learning that can enhance students' creativity

Most teachers (T1, T2, T3) stated that students' creativity develops when learning is student-centered. Learning should provide space for students to explore ideas and be active in learning. T1 highlighted the significance of problem and project-based learning, whereas T2 stressed the importance of interaction and engaging learning. T3 underlined that students should be free to express their opinions. Teachers T3 and T4 highlighted the importance of learning that arouses curiosity and freedom of thought. Teachers (T1, T3, T4, T7) suggested that giving open-ended problems that allow more than one way of solving plays an important role in developing creativity. T3 suggested that essay questions are a form of questioning that can trigger creative thinking and T4 added that project-based learning encourages students to explore diverse solutions. T3 and T5 emphasized that creativity also emerges in group work situations. In addition, according to teacher T5, creativity will develop if students are given interesting stimulus, such as videos, educational games, or other interactive media. Teacher T4 also emphasized the importance of providing supportive and constructive feedback. Teacher T6 stated that the variety of students' creative work can be an indicator that the learning is effective in facilitating students' creativity.

5. Discussion

The majority of teachers defined creativity as the ability to produce something new and different in solving mathematics problems. Most teachers also emphasized the importance of seeing from different perspectives as a characteristic of creativity. This reflects that creativity is not only about having ideas, but also thinking freely, seeing opportunities from simple things, and daring to try new things (Arán Filippetti & Krumm, 2020; Chi, 1997). Teacher T4 explicitly mentioned four important elements of creativity: flexibility, imagination, openness to new possibilities, and thinking outside the box. This is in line with the opinion of Dow (2022) which states that creativity consists of fluency, flexibility, originality, and elaboration. However, although some teachers have shown a deep understanding of the definition of creativity, not all of them mentioned the divergent thinking aspect, which, according to de Vries & Lubart (2019), is the main component of creativity in mathematics.

Most teachers mentioned the characteristics of creative students are curiosity, flexibility of thinking, imagination and initiative. Rahayuningsih et al. (2021) suggested that creative students are able to think flexibly when solving open-ended problems. Beaty et al. (2018) stated that creative students are able to combine various ways of thinking such as divergent thinking, focus on important things, and organize strategies at the same time. Some teachers also mentioned the ability to solve problems creatively and connect old knowledge with new.

All teachers stated that creativity can be enhanced through learning mathematics. This can be designed with an open-ended approach, project-based learning, or through games in learning. This finding is supported by Beghetto's (2017), which emphasizes the importance of presenting non-routine problems to enhance students' creativity. In addition, project-based learning allows students to explore more than one way of solving. Some research findings reveal that project-based learning can enhance students' creativity (Chen et al., 2022; Hanif et al., 2019; Ummah et al., 2019).

Several factors influence student creativity. Internal factors that influence such as intelligence, interest, motivation, and student confidence. External factors that influence, such as parenting, learning environment, and the role of teachers, are identified as facilitators in improving student creativity. Teachers T4 and T6 emphasized the importance of self-confidence, and in line with research by Nufus et al. (2018), which shows that students with high self-confidence tend to have high creativity as well. The findings also reinforce the opinion that teachers and environment are the main factors that support students' creativity (Barbot & Kaufman, 2025; Fredagsvik, 2023; Mullet et al., 2016).

Most of the teachers stated that student-centered, open, interactive, and fun learning can encourage students' creativity. This aligns with the opinion of Selkrig & Keamy (2017), who state that the teacher acts as a facilitator providing exploration space for students to find creative ideas. Giving open-ended questions and project-based learning, explained by the teacher, is an effective means to improve students' creativity. This is supported by Osakwe et al. (2023) who stated that mathematical creativity requires freedom to find new solutions. Teachers also mentioned the importance of using interactive learning media and group discussions. This is in accordance with the research results of Hidayati et al. (2024) which states that the use of interactive learning media and group discussions can increase student creativity in mathematics.

6. Conclusion

This study shows that mathematics teachers have a fairly diverse understanding of the concept of creativity, where most define it as the ability to produce new and original solutions in solving problems and see problems from various perspectives. Teachers also identified the characteristics of creative students, including high curiosity, divergent thinking ability, strong imagination, independence, and the ability to design alternative solutions creatively, which includes the cognitive

and affective aspects of students. All teachers agreed that creativity can be developed through learning mathematics. Teachers recognize that both internal factors (such as students' motivation, interest, and confidence) and external factors (such as family upbringing, teachers' role, and learning environment) impact the development of creativity. Therefore, teachers consider that effective learning in improving creativity is student-centered, provides space for exploration, encourages open discussion, and uses interesting learning stimuli, so as to create a learning atmosphere that supports the growth of students' creativity optimally.

7. Suggestion

Based on the research findings, it is suggested that teachers' conceptions of student creativity in mathematics learning be strengthened continuously through training and professional development. The development of learning tools that support creativity, such as open-ended questions and project-based tasks, needs to be prioritized. In addition, further research is recommended using a classroom observation approach to examine real practices as well as comparative studies between levels or regions. Empowering teachers as facilitators of creativity should be a major concern in education policy, allowing them autonomy in designing learning that suits student characteristics. Because the research was conducted using a qualitative research approach, the findings cannot be generalized. Therefore, further research conducted with a larger population using a qualitative research approach or mixed methods could provide an opportunity to examine the topic from a different and broader perspective.

Declarations

Author Contributions. All authors have read and approved the published on the final version of the article.

Conflicts of Interest. The authors declare no conflict of interest.

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Data Availability Statement. The data that supports the findings of this study are available from the corresponding author upon reasonable request.

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References

- Aguilera, D., & Ortiz-Revilla, J. (2021). STEM vs. STEAM education and student creativity: A systematic literature review. *Education Sciences*, 11(7), 1–13. <https://doi.org/10.3390/educsci11070331>
- Aktaş, M. A. (2016). Turkish high school teachers' conceptions of creativity in mathematics. *Journal of Education and Training Studies*, 4(2), 42–52.
- Aljughaiman, A., & Mowrer-Reynolds, E. (2005). Teachers' conceptions of creativity and creative students. *Journal of Creative Behavior*, 39(1), 17–34.
- Alotaibi, A., & Alyahya, D. (2019). Computational thinking skills and its impact on TIMSS achievement: An Instructional Design Approach. *Issues and Trends in Educational Technology*, 7(1), 3–19. https://doi.org/10.2458/azu_itet_v7i1_alyahya
- Arán Filippetti, V., & Krumm, G. (2020). A hierarchical model of cognitive flexibility in children:

- Extending the relationship between flexibility, creativity and academic achievement. *Child Neuropsychology*, 26(6), 770–800. <https://doi.org/10.1080/09297049.2019.1711034>
- Ayele, M. A. (2016). Mathematics teachers' perceptions on enhancing students' creativity in mathematics. *Mathematics Education*, 11(10), 3521–3537.
- Ayllon, M. E., Gomez, I. A., & Claver, J. B. (2016). Mathematical thinking and creativity through mathematical problem posing and solving. *Propósitos y Representaciones*, 4(1), 169–218. <https://eric.ed.gov/?id=EJ1126306>
- Barbot, B., & Kaufman, J. C. (2025). PISA 2022 Creative Thinking Assessment: Opportunities, Challenges, and Cautions. *The Journal of Creative Behavior*, 59(1), 1-11.
- Beaty, R. E., Kenett, Y. N., Christensen, A. P., Rosenberg, M. D., Benedek, M., Chen, Q., Fink, A., Qiu, J., Kwapil, T. R., Kane, M. J., & Silvia, P. J. (2018). Robust prediction of individual creative ability from brain functional connectivity. *Proceedings of the National Academy of Sciences of the United States of America*, 115(5), 1087–1092. <https://doi.org/10.1073/pnas.1713532115>
- Beghetto, R. A., & Plucker, J. A. (2006). The Relationship Among Schooling, Learning, and Creativity: "All Roads Lead to Creativity" or "You Can't Get There from Here"? In J. C. Kaufman, & J. Baer, *Creativity and Reason in Cognitive Development* (pp. 316-332). Cambridge: Cambridge University Press.
- Beghetto, R. A. (2017). Lesson unplanning: toward transforming routine tasks into non-routine problems. *ZDM - Mathematics Education*, 49(7), 987–993. <https://doi.org/10.1007/s11858-017-0885-1>
- Bishara, S. (2016). Creativity in unique problem-solving in mathematics and its influence on motivation for learning. *Cogent Education*, 3(1), 1–14. <https://doi.org/10.1080/2331186X.2016.1202604>
- Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. Jossey-Bass.
- Bryant, S. L. (2014). *Queensland Teachers' Conceptions of Creativity: A Phenomenographic Investigation*. Brisbane: Queensland University of Technology. Retrieved from https://eprints.qut.edu.au/70237/1/Sandra_Bryant_Thesis.pdf
- Cachia, R., & Ferrari, A. (2010). *Creativity in Schools: A Survey of Teachers in Europe*. Luxembourg: Publications Office of the European Union. Retrieved from <https://publications.jrc.ec.europa.eu/repository/handle/JRC59232>
- Chen, S. Y., Lai, C. F., Lai, Y. H., & Su, Y. S. (2022). Effect of project-based learning on development of students' creative thinking. *International Journal of Electrical Engineering and Education*, 59(3), 232–250. <https://doi.org/10.1177/0020720919846808>
- Chi, M. T. H. (1997). Creativity: Shifting across ontological categories flexibly. In An investigation of conceptual structures and processes (pp. 209–234). American Psychological Association. <https://doi.org/10.1037/10227-009>
- de Vries, H. B., & Lubart, T. I. (2019). Scientific Creativity: Divergent and Convergent Thinking and the Impact of Culture. *Journal of Creative Behavior*, 53(2), 145–155. <https://doi.org/10.1002/jocb.184>
- Dow, G. T. (2022). Defining creativity. In *In Creativity and Innovation* (pp. 5–21). Routledge.
- Dreyfus, T., & Eisenberg, T. (1996). On different facets of mathematical thinking. In *The nature of mathematical thinking* (pp. 253–284). Lawrence Erlbaum.

- Foster, N., & Schleicher, A. (2022). Assessing Creative Skills. *Creative Education*, 13(01), 1–29. <https://doi.org/10.4236/ce.2022.131001>
- Fredagsvik, M. S. (2023). The challenge of supporting creativity in problem-solving projects in science: a study of teachers' conversational practices with students. *Research in Science and Technological Education*, 41(1), 289–305. <https://doi.org/10.1080/02635143.2021.1898359>
- Hadar, L. L., & Tirosh, M. (2019). Creative thinking in mathematics curriculum: An analytic framework. *Thinking Skills and Creativity*, 33(September 2018), 1–13. <https://doi.org/10.1016/j.tsc.2019.100585>
- Hanif, S., Wijaya, A. F. C., & Winarno, N. (2019). Enhancing students' creativity through STEM project-based learning. *Journal of Science Learning*, 2(2), 50–57. <https://doi.org/10.17509/jsl.v2i2.13271>
- Harris, A., & de Bruin, L. R. (2018). Secondary school creativity, teacher practice and STEAM education: An international study. *Journal of Educational Change*, 19(2), 153–179. <https://doi.org/10.1007/s10833-017-9311-2>
- Haylock, D. W. (1987). A framework for assessing mathematical creativity in school children. *Educational Studies in Mathematics*, 18(1), 59–74. <https://doi.org/10.1007/BF00367914>
- Henriksen, D., Richardson, C., & Mehta, R. (2017). Design thinking: A creative approach to educational problems of practice. *Thinking Skills and Creativity*, 26(March), 140–153. <https://doi.org/10.1016/j.tsc.2017.10.001>
- Hidayati, W. S., Dian, J., Iffah, N., Trisanti, L. B., & Nabilah, A. (2024). Digital assessment model to identify student creativity in constructing mathematics instructional media. *Journal of Hunan University*, 51(9), 60–77.
- Hondzel, C. D. (2013). *Fostering Creativity: Ontario Teachers' Perceptions, Strategies, and Experiences*. London: The University of Western Ontario. Retrieved from <https://ir.lib.uwo.ca/cgi/viewcontent.cgi?article=2533&context=etd>
- Hong, M., & Kang, N. H. (2010). South Korean and the US secondary school science teachers' conceptions of creativity and teaching for creativity. *International Journal of Science and Mathematics Education*, 8(5), 821–843.
- Jahnke, I., Haertel, T., & Wildt, J. (2017). Teachers' conceptions of student creativity in higher education. *Innovations in Education and Teaching International*, 54(1), 87–95. <https://doi.org/10.1080/14703297.2015.1088396>
- Joklitschke, J., Rott, B., & Schindler, M. (2022). Notions of creativity in mathematics education research: A systematic literature review. *International Journal of Science and Mathematics Education*, 20(6), 1161–1181. <https://doi.org/10.1007/s10763-021-10192-z>
- Kandemir, M. A., Tezci, E., Shelley, M., & Demirli, C. (2019). Measurement of creative teaching in mathematics class. *Creativity Research Journal*, 1–12. <https://doi.org/10.1080/10400419.2019.1641677>
- Kettler, T., Lamb, K. N., Willerson, A., & Mullet, D. R. (2018). Teachers' perceptions of creativity in the classroom. *Creativity Research Journal*, 30(2), 164–171. <https://doi.org/10.1080/10400419.2018.1446503>
- Kholid, M. N., Mahmudah, M. H., Ishartono, N., Putra, F. G., & Forthmann, B. (2024). Classification of students' creative thinking for non-routine mathematical problems. *Cogent Education*, 11(1), 1–16. <https://doi.org/10.1080/2331186X.2024.2394738>

- Kim, M. K., Roh, I. S., & Cho, M. K. (2016). Creativity of gifted students in an integrated math-science instruction. *Thinking Skills and Creativity*, 19, 38–48. <https://doi.org/10.1016/j.tsc.2015.07.004>
- Kwangmuang, P., Jarutkamolpong, S., Sangboonraung, W., & Daungtod, S. (2021). The development of learning innovation to enhance higher-order thinking skills for students in Thailand's junior high schools. *Heliyon*, 7(6), 1–13. <https://doi.org/10.1016/j.heliyon.2021.e07309>
- Leikin, R., Subotnik, R., Pitta-Pantazi, D., Singer, F. M., & Pelczer, I. (2013). Teachers' views on creativity in mathematics education: an international survey. *ZDM – Mathematics Education*, 45(2), 309–324.
- Levenson, E. S. (2022). Exploring the relationship between teachers' values and their choice of tasks: the case of occasioning mathematical creativity. *Educational Studies in Mathematics*, 109(3), 469–489. <https://doi.org/10.1007/s10649-021-10101-9>
- Lince, R. (2016). Enhancing junior high school students' mathematical abilities through creative thinking by applying the Numbered Heads Together model. *Journal of Education and Practice*, 7(6), 206–212.
- Mrayyan, S. (2016). Investigating mathematics teachers' role to improve students' creative thinking. *American Journal of Educational Research*, 4(1), 82–90. <https://doi.org/10.12691/education-4-1-13>
- Mullet, D. R., Willerson, A., N. Lamb, K., & Kettler, T. (2016). Examining teacher perceptions of creativity: A systematic review of the literature. *Thinking Skills and Creativity*, 21, 9–30. <https://doi.org/10.1016/j.tsc.2016.05.001>
- Newton, D. P., & Newton, L. D. (2009). Some student teachers' conceptions of creativity in school science. *Research in Science & Technological Education*, 27(1), 45–60.
- Nilimaa, J. (2023). New examination approach for real-world creativity and problem-solving skills in mathematics. *Trends in Higher Education*, 2(3), 477–495. <https://doi.org/10.3390/higheredu2030028>
- Nufus, H., Duskri, M., & Bahrin, B. (2018). Mathematical creative thinking and student self-confidence in the challenge-based learning approach. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, 3(2), 57–68. <https://doi.org/10.23917/jramathedu.v3i2.6367>
- OECD. (2018). *PISA 2021 mathematics framework*. OECD Publisher.
- Osakwe, I. J., Egara, F. O., Nzeadibe, A. C., Okeke, A. M., Agugoesi, O. J., Odo, I. O., Chinweike, J. N., Owolawi, O., Emeji, I. E., Ogbu, S., Inweregbuh, O. C., Emefo, C. N., Umakalu, C. P., Kwalat, K. S., Danbong, C. P., Afufu, J. E., Abugu, G. N., Orga, C. A., Zinkat, O. A., ... B., D. (2023). Multiple solution tasks: An approach for enhancing secondary school students' mathematical creativity. *Multicultural Education*, 9(1), 10–18. <https://mc-caddogap.com/wp-content/uploads/galleyproof-2-mc-9-2.pdf>
- Purba, E. P., Sinaga, B., Mukhtar, M., & Surya, E. (2017). Analysis of the difficulties of the mathematical creative thinking process in the application of problem based learning model. 2nd Annual International Seminar on Transformative Education and Educational Leadership, 104(Aisteel), 265–268. <https://doi.org/10.2991/aisteel-17.2017.55>
- Rahayuningsih, S., Sirajuddin, S., & Ikram, M. (2021). Using open-ended problem-solving tests to identify students' mathematical creative thinking ability. *Participatory Educational Research*, 8(3), 285–299. <https://doi.org/10.17275/per.21.66.8.3>

- Retnawati, H., Arlinwibowo, J., & Sulistyaningsih, E. (2017). The students face difficulties in completing geometry items on the national examination. *International Journal on New Trends in Education and Their Implications*, 8(4), 28–41.
- Rhodes, M. (1961). An analysis of creativity. *The Phi Delta Kappan*, 42(7), 305–310.
- Richardson, C., & Mishra, P. (2018). Learning environments that support student creativity: Developing the SCALE. *Thinking Skills and Creativity*, 27, 45–54. <https://doi.org/10.1016/j.tsc.2017.11.004>
- Ritter, S. M., & Mostert, N. (2017). Enhancement of creative thinking skills using a cognitive-based creativity training. *Journal of Cognitive Enhancement*, 1(3), 243–253. <https://doi.org/10.1007/s41465-016-0002-3>
- Schoevers, E. M., Leseman, P. P. M., Slot, E. M., Bakker, A., Keijzer, R., & Kroesbergen, E. H. (2019). Promoting pupils' creative thinking in primary school mathematics: A case study. *Thinking Skills and Creativity*, 31(February), 323–334. <https://doi.org/10.1016/j.tsc.2019.02.003>
- Selkrig, M., & Keamy, R. (2017). Creative pedagogy: A case for teachers' creative learning being at the centre. *Teaching Education*, 28(3), 317–332. <https://doi.org/10.1080/10476210.2017.1296829>
- Sheffield, L. J. (2017). Dangerous myths about “gifted” mathematics students. *ZDM - Mathematics Education*, 49(1), 13–23. <https://doi.org/10.1007/s11858-016-0814-8>
- Silver, E. A. (1997). Fostering creativity through instruction rich in mathematical problem solving and problem posing. *Zentralblatt Für Didaktik Der Mathematik*, 29(3), 75–80. <https://doi.org/10.1007/s11858-997-0003-x>
- Sitorus, J., & Masrayati. (2016). Students' creative thinking process stages: Implementation of realistic mathematics education. *Thinking Skills and Creativity*, 22, 111–120. <https://doi.org/10.1016/j.tsc.2016.09.007>
- Suherman, S., & Vidákovich, T. (2022). Assessment of mathematical creative thinking: A systematic review. *Thinking Skills and Creativity*, 44(March), 1–13. <https://doi.org/10.1016/j.tsc.2022.101019>
- Tabach, M., & Friedlander, A. (2017). Algebraic procedures and creative thinking. *ZDM - Mathematics Education*, 49(1), 53–63. <https://doi.org/10.1007/s11858-016-0803-y>
- Tanujaya, B., Mumu, J., & Margono, G. (2017). The relationship between higher-order thinking skills and academic performance of students in mathematics instruction. *International Education Studies*, 10(11), 78–85. <https://doi.org/10.5539/ies.v10n11p78>
- Ulger, K. (2018). The effect of problem-based learning on the creative thinking and critical thinking disposition of students in visual arts education. *Interdisciplinary Journal of Problem-Based Learning*, 12(1), 3–6. <https://doi.org/10.7771/1541-5015.1649>
- Ummah, S. K., Inam, A., & Azmi, R. D. (2019). Creating manipulatives: Improving students' creativity through project-based learning. *Journal on Mathematics Education*, 10(1), 93–102. <https://doi.org/10.22342/jme.10.1.5093.93-102>
- Widana, I. W. (2018). Assessment of higher-order thinking skills in relation to critical thinking in mathematics lessons. *International Journal of Social Sciences and Humanities (IJSSH)*, 2(1), 24–32. <https://doi.org/10.29332/ijssh.v2n1.74>
- Yayuk, E., Purwanto, As'Ari, A. R., & Subanji. (2020). Primary school students' creative thinking skills in mathematics problem solving. *European Journal of Educational Research*, 9(3), 1281–1295. <https://doi.org/10.12973/eu-jer.9.3.1281>

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