Differentiated Mathematics Learning: How Do Primary School Students Think Creatively in It?

Novy Trisnani[1]*, Asih Utami[2], Atika Dwi Evitasari[3], Desi Hermawati[4], Sri Budyartati[5]

[1,3]IKIP PGRI Wates, Yogyakarta 55653, Indonesia
[2]Palangka Raya University, Central Kalimantan 73111, Indonesia
[4]Universitas Widya Gama Mahakam Samarinda, East Kalimantan, 75243, Indonesia
[5]Universitas PGRI Madiun, East Java, 63117, Indonesia
*novytrisnani@ipw.ac.id

Abstract. Increasing creative thinking in mathematics learning has become a major focus in primary education. The objective of this research is to discover the portrayal of students' creative thinking in the application of differentiated mathematics learning in primary schools. This study used qualitative research methods involving 6 students in primary schools drawn from students with the category of high cognitive ability and the category of moderate cognitive ability. The results showed that primary school students can think creatively in learning differentiated mathematics. Of the four indicators of creative thinking, differences are seen in the aspect of fluency and aspects of originality. The fluency aspect in students from the category of high cognitive ability students appears in the process of think, while in moderate-group students has not been seen. In the aspect of originality, students from the category of moderate cognitive ability can bring out the results of originality of creative thinking even though it is still basic. Unlike students from the category of high cognitive ability, originality appears in their ability to give rise to forms of calculation other than integers.

Keywords: Differentiated Mathematics Learning, Primary School, Creative Thinking.

1 Introduction

Effective application of DI is a demanding aspect of mathematics teaching at all levels of education (1). In mathematics learning, NCTM promotes DI to facilitate differences in student learning styles as well as differences in aptitude, interests, and confidence (2). Mathematical differentiation is a form of differentiation of mathematical instruction by referring to a collection of techniques, strategies, and adaptations that can be used by teachers to reach a heterogeneous group of learners and make mathematics accessible to every student. In addition, differentiation means that in differentiated learning, teachers serve various students, various competencies, various times,

M. Salimi et al. (eds.), *Proceedings of the 7th International Conference on Learning Innovation and Quality Education (ICLIQE 2023)*, Advances in Social Science, Education and Humanities Research 873,
https://doi.org/10.2991/978-2-38476-301-6_57

various tools, various resources, various facilities, various objectives, various methods, various tasks, various results, and various values, in the same class (3).

Differentiated learning, also known as Differentiated Instruction (DI), involves teaching that takes into account each student's readiness, interests, and learning profile. Differentiation can involve adjusting the content, processes, products, or learning environments to suit the needs of students (4,5). Differentiated learning (DI) is included in Indonesia's education program through the independent learning curriculum which began to be implemented in 2022. The emphasis and goals of the curriculum's development revolve around ensuring equal opportunities and accessibility for all students, along with instructional materials that prioritize the self-development of students (6). Differentiated learning in the independent curriculum is the Indonesian government's answer to the learning loss, learning gap, and demands for 21st-century competencies.

The framework for 21st-century learning emphasizes that students need to acquire a combination of content knowledge, specific skills, expertise, and literacy to thrive in both their careers and personal lives (7). Creative thinking is one of the most sought-after life and work skills of the 21st century (8), is the foundation of science (9), has significance in solving problems of everyday life (10), and how to successfully adapt to change (11). Creative thinking refers to the cognitive capacity to recognize and propose solutions to a problem and generate new ideas and combine new ideas with previous ideas (12). Creative thinking in mathematics is apparent when individuals come up with innovative approaches to representing or conceptualizing a mathematical problem, or devising an original path towards its resolution (13). Many experts proposed indicators of creative thinking in mathematics. However, it is worth noting that not all of these indicators can be effectively measured among primary school students, given their cognitive development is still limited to the concrete operational stage (14). Indicators of creative thinking among primary school students encompass fluency, flexibility, originality, and elaboration (14,15).

In the last few years, there has been recognition and more and more recognition that creativity and creative thinking must be nurtured as a valuable outcome of schooling, both as a learning skill and a 21st-century skill(16–18). To foster the development of student's unique creative thinking abilities, it is essential to create learning environments that incorporate experiential learning (19). Teachers play a crucial role in integrating creative thinking into the learning process, thus they have the responsibility to cultivate and enhance students' creative thinking skills (20).

Al Azhar primary School is one of the primary schools that has implemented differentiated mathematics learning. The application of differentiated mathematics learning, which is still relatively new, certainly raises a question of how students' creative thinking skills through differentiated learning. Every child or student can be assumed to be creative and can think creatively, but the degree of creativity is different for each person. These differences will affect the teaching process for each child. The purpose of this study is to describe the creative thinking ability of primary school students in differentiated mathematics learning. This needs to be done to further be able to make mathematics learning tailored to the level of creative thinking of students.

2 Method

In this study, a qualitative research design is utilized. To determine the location of the study, researchers looked for some data and information from schools that had implemented or implemented differentiated learning, by visiting several primary schools that entered driving schools because they were suspected of having implemented differentiated learning, searching school databases from official online sources, and asking for some information from colleagues and friends of teachers. Based on the search results, SD Al Azhar 38 Yogyakarta was chosen as the research location because it has carried out differentiated learning on mathematical content. The subjects of the study were conducted by purposive sampling. The categories of research subjects taken are in Table 1.

Table 1. Categories of research subjects

Nama	Number of mathematics	Category
A1	60	Moderat
A2	60	Moderat
A3	65	Moderat
B1	75	High
B2	90	High
B3	92	High

At the data collection stage, it was carried out by giving mathematical creative thinking test questions on square and rectangular flat building material which was then followed by an in-depth interview. The results of the student process of doing test questions and interview results are then used for data analysis. Data is analyzed in 3 stages: (1) data reduction, (2) data presentation, and (3) conclusion drawing or verification.

3 Result

3.1 Differentiated Mathematics Learning

Differentiated learning can be carried out in several ways, including content, process, and product (21–23). The implementation of differentiated learning is carried out by providing process differentiation. The first step in the differentiated learning process is to carry out an initial diagnostic to understand the needs and abilities of each student in understanding the solid shape material. For this reason, the teacher conducts an initial assessment or observation so that the teacher can identify students who need additional assistance or higher challenges.

Fig. 1. High Cognitive Ability Group Learning Process

Fig. 2. Moderate Conitive Ability Group Learning Process

The initial diagnostics carried out by the teacher are used to group students into two groups, the category of high cognitive ability group and the category of moderate cognitive ability. The diagnostic results obtained there were 30 students, with the categorization of 13 students classified in the moderate cognitive ability category, and 17 students in the high category. Based on the needs analysis, the teacher chooses an appropriate learning strategy. For groups of students in the category of moderate cognitive ability, the teacher uses a concrete approach with manipulatives or pictures that help visualize. Meanwhile, for groups of students in the high category of cognitive ability, the teacher gives more complex questions or invites them to find patterns in flat shapes.

3.2 Students' Creative Thinking

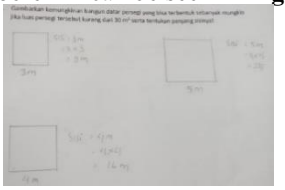
The evaluation of students' mathematical creative thinking ability is aligned with indicators such as the capacity to generate numerous ideas (fluency), the ability to produce diverse ideas (flexibility), the aptitude for generating novel ideas (originality), and the proficiency in elaboration. Students' creative thinking indicators can be seen as follows:

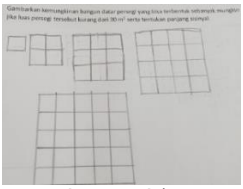
Table 2. Achievement of students' creative thinking indicators

Subject	Question 1				Question 2			
	Fle	Flu	Ori	Ela	Fle	Flu	Ori	Ela
A1	√	-	√	√	√	-	√	√
A2	√	-	-	√	√	-	-	√
A3	√	-	-	√	√	-	-	√
B1	√	-	-	√	√	-	-	√
B2	√	√	-	√	√	√	-	√
B3	√	√	√	√	√	√	√	√

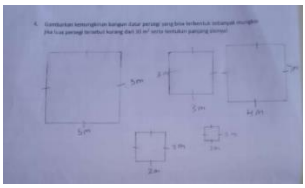
Moderate Cognitive Ability Students' Creative Thinking Process

Students with moderate cognitive ability in solving mathematical problems related to square area material for problem 1 can be seen in **Fig. 3.**





Answer A1



Answer A2 Answer A3

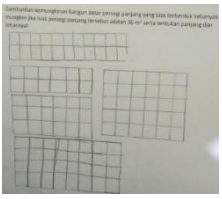
Fig. 3. Answers question 1 from the group of students with moderate cognitive abilities

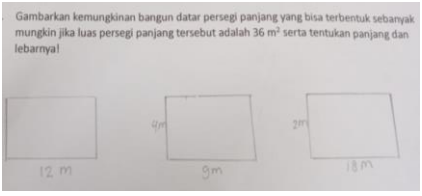
Based on the results of the answers in **Fig. 3**, it can be seen that for the three students both A1, A2, and A3 have met the fluency indicator, which can make at least two different answers correctly. In the flexibility indicator, it has not been seen in the three students, the method used by A1, A2, and A3 to find the area of a square is the same as all, namely by taking any number and then multiplying the number by itself according to the square area formula. Originality indicators are not yet visible for A2 and A3 but are starting to appear for A1 students. A1 students have a different way and a different answer from their classmates, namely by using unit boxes to find the area. Although the A1 method is the basic concept of obtaining the area of a square, this concept is correct so originality has been seen because it has a different answer from his classmates. A2 and A3 students have similar answers and answers. Here are the results of interviews with A3 students.

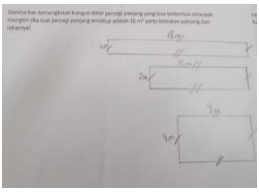
P : How do I get this answer?
A3 : The area is under 30 so I look for the numbers 1x1, 2x2, 3x3, 4x4 and 5x5
P : Why the number is multiplied?
A3 : Because the square area is side times side Ma'am

Based on the results of the interview, it can explain how students get these various answers. The way students relate broad concepts to find their systems so that they can disguise them in visual form is a form of elaboration. Other elaborations appear also in the concept of students relating concepts less than or more than to understand a given problem.

The results of interviews with A1 students illustrate how to do the area using unit boxes to easily calculate the area. The elaboration indicator of A1 students can be seen from the detailedness of the concept of the square area. The math problem for question 2 is almost the same as question number 1. Here are the moderate cognitive ability group's answers to question 2.







Answer A1 Answer A2 Answer A3

Fig. 4. Answers question 2 from the group of students with moderate cognitive abilities

Based on **Fig. 4.**, it can be analyzed that the answers of student A2 and student A3 are

similar. Student A1 has different answers, out of the 5 answers he wrote there is no correct answer. Thus, for A2 and A3 students meet the fluency indicator while for A1 it has not met if only seen with the answer results. For this reason, it is necessary to conduct in-depth interviews with A1.

The interview results showed that actually, A1 students were able to show fluency. The flexibility indicator was not yet visible for the three students because all answers used the same method. The originality indicator was not yet visible for A2 and A3 students but appeared for A1 from the interview results because the answers given were different from other friends. For the elaboration indicator, based on the interview results of A1 students connect the answer with the area concept using a unit box and connect it with the rectangular area formula. For A2 and A3 students, the concept of elaboration appears in the detail worthiness of the answer by writing the length and width of the rectangle which shows the relationship with the concept of rectangular area. The detailedness of the concept of square definition is also seen in A3 students, namely by marking two sides of equal length.

High-Cognitive Ability Students' Creative Thinking Process

Students in the category of high cognitive ability, in solving mathematical problems about the square area can be seen in Figure 7.

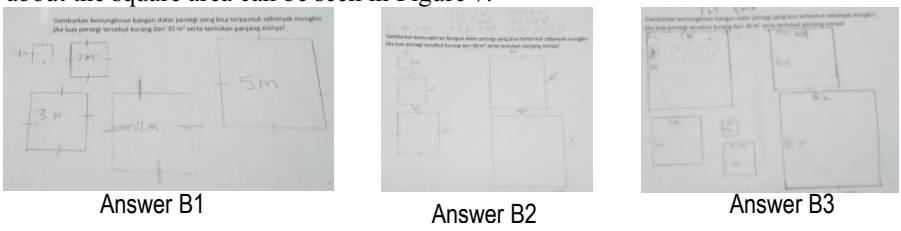


Fig. 5. Answers question 1 from the group of students with high cognitive abilities

Based on **Fig. 5.**, fluency indicators for students B1, B2, and B3 are already visible with students giving many diverse answers correctly. The flexibility indicator was not yet visible for all three students because the same method was used to obtain all answers. Originality is also not apparent for B1 and B2 students. For B3 students, the results of written answers do not appear the originality of the answers but seeing that there are scribbles on the answer sheet, there is a different mindset from others. From the results of the interview, it turned out that the following answers emerged.

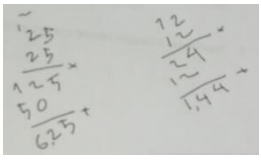


Fig. 6. The result of the multiplication of decimal numbers by B3

Based on the results of the interview, B3 students were able to show indicators of originality. The question asked by the researcher to B3 students related to the side of the square that can be in the form of decimal numbers was inspired by the scribbles of

B3 students in the paper used to answer the question no. 2. Elaboration indicators have been seen for students B1, B2 and B3 from the results of written answers. The three students had already associated the concept of a square having equal sides by marking their drawings. The three students also related to the concept of the square area formula even though only student B2 wrote in written answers but from the interview results all three understood the square formula.

The results of the category high cognitive ability group's answer to question no. 2 showed that there was a high creative thinking process. This can be seen from the answer of the following high cognitive ability group.

Fig. 7. Answers Question 2 from the Group of Students with High Cognitive Abilities

Fig. 7. shows that the three students of both B1, B2, and B3 were able to vary the answers correctly. This concluded that all three students in the high cognitive ability group had met the fluency indicator. Flexibility indicators have also appeared for the three students. B1 and B2 students have the same flexibility process, namely how to draw a rectangle that looks different, namely, there are pictures whose long sides are made horizontal and some whose long sides are made vertical. For B3 students, flexibility can be seen in how to get an answer, which is to find the side of the rectangle by dividing the area by the number even though there are decimal results. Indicators of originality have not been seen in B1 and B2 students but have been seen in B3 students. The following are the results of B3 students' scribbles on the answer sheet to find various answers to question 2.

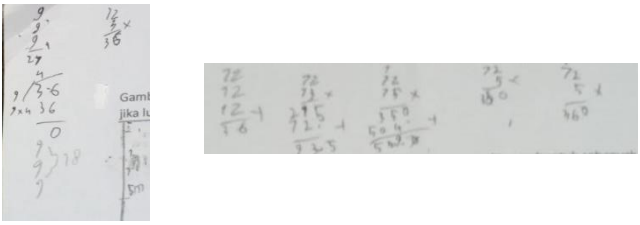


Fig. 8. Scribble how to count B3 students

Based on **Fig. 8.**, it can be seen the various ways that B3 students use to convince the answers they bolt. Using stacked division is then strengthened by multiplying stacked and reinforced again by repeated addition (multiplication concept). For the elaboration indicator, it can be seen that both groups of students, both students with high and low cognitive ability categories, have fulfilled this indicator. This can be seen from the detailed answers on the answer sheets which are also reinforced by the results of the interviews.

4 Disscussion

The creative thinking ability of primary school students can be seen from the level of their cognitive development. Primary school students are in an age range that is important for cognitive development, including the development of their creativity. At the stage of early cognitive development, such as at primary school age, children are usually at the stage of concrete operations according to Jean Piaget's theory of cognitive development. They begin to understand abstract concepts in a limited way and focus more on concrete and tangible things. Therefore, the ability to think creatively at this stage may still be limited and simpler. However, it is important to remember that every child has a different level of development. The provision of instruction with the use of different media, namely semi-concrete for the high cognitive ability group and concrete for the moderate cognitive ability group can help students understand and solve the given mathematical problems. The utilization of tangible resources enables students to grasp the learning process more effortlessly, as it offers them authentic experiences and stimulates the generation of inquiries or ideas (24).

Based on the findings, students in the high cognitive ability group were able to understand math questions well. They can generate a lot of ideas smoothly. They can also provide solutions to given math problems in about 35 minutes, this is much faster than moderate cognitive ability group students, and their answers are correct (flexibility). Students in the moderate cognitive ability group, have more difficulty compared to students who have high cognitive ability. Understand the problem, they still find it difficult, in the answers delivered have not seen the emergence of flexibility. In the aspect of fluency and elaboration of the two groups of students, it can bring up both aspects.

In the aspect of originality, the moderate cognitive ability group can bring out the results of originality of creative thinking even though it is still basic. Unlike the high cognitive ability group, originality appears in their ability to give rise to forms of calculation other than integers. Individuals possessing creative thinking abilities undoubtedly require a sense of sensitivity when comprehending the challenges they encounter. They meticulously evaluate the given information, establish connections between various relevant concepts, formulate a set of strategies to address the problem, and utilize their imagination to generate innovative ideas. Creative thinking plays a crucial role in effectively, methodically, and comprehensively resolving mathematical problems, enabling students to devise accurate and exceptional solutions that align with their capacities. Extraordinary outcomes, which deviate from established patterns, are commonly referred to as exceptional results (25).

Some studies show relationships between creativity and academic achievement are consistent with each other. The findings from previous studies regarding the correlation between creativity and academic achievement have been inconclusive. However, certain research indicates a positive link between creativity and academic performance (26,27). Teachers and parents can help improve the creative thinking skills of primary school students by providing an environment that supports creativity, encourages imagination, and provides opportunities for exploration and experimentation. Some previous research has shown that differentiated learning has an important role

in the development of student's creative thinking (28–30). In the context of differentiated learning, teachers can provide learning experiences specifically designed to stimulate students' imagination and creativity. They can provide different and varied challenges, facilitate collaboration, and encourage students to find unique and original solutions.

Research conducted by (31) shows that differentiated learning approaches can affect students' creative thinking abilities. In their research, they found that when students are given space to explore their ideas and given opportunities to create, they can generate more creative and original ideas. In addition, according to Hébert, differentiated learning allows students to explore different types of materials and learning methods that can stimulate their creative thinking. By facilitating diverse learning experiences, teachers can encourage students to think divergently, look at problems from different points of view, and generate innovative ideas. Thus, differentiated learning opens doors for students to develop their creative potential. It creates an environment that supports students' exploration, imagination, and creativity. In this context, students have the opportunity to transcend limitations and create innovative solutions to the problems they encounter.

5 Conclusions

Students with the category of moderate cognitive ability and high cognitive ability have different creative processes. Moderate cognitive ability group students were only able to show fluency indicators and elaboration of all four indicators of creative thinking. There was one student out of 3 moderate cognitive ability group students who were able to show originality in the answer even though it was still a basic concept and this had indeed been taught by the teacher during the introduction of the broad concept of a flat building using unit boxes. High cognitive ability group students were able to show indicators of fluency, flexibility, and elaboration. There was one student out of 3 high cognitive ability group students who was able to show indicators of originality with a complex way of thinking.

References

1. Russo J, Bobis J, Sullivan P. Differentiating instruction in mathematics. Mathematics Teacher Education and Development. 2021;23(3):1–5.
2. NCTM. Principles & standards for school mathematics (PSSM) Est: 2000. http://www.nctm.org/; 2000.
3. Subban PK. Differentiated instruction: a research basis. International Education Journal. 2006;7(7):935–47.
4. ASCD. Key Elements of Differentiated Instruction. ASCD. ASCD; 2011. p. 1–7.
5. Tomlinson CA. Differentiation of Instruction in the Elementary Grades. ERIC Digest. 2000 Aug;1–7.
6. Indarta Y, Jalinus N, Waskito W, Samala AD, Riyanda AR, Adi NH. Relevansi kurikulum merdeka belajar dengan model pembelajaran abad 21 dalam perkembangan era society 5.0. Edukatif: Jurnal Ilmu Pendidikan. 2022 Mar 28;4(2):3011–24.

7. Schmoker M. Focus : elevating the essentials to radically improve student learning. 1st ed. 1703 N. Beauregard St. • Alexandria, VA 22311 1714 USA: ASCD; 2011. 1–251 p.
8. Ritter SM, Gu X, Crijns M, Biekens P. Fostering students' creative thinking skills by means of a one-year creativity training program. PLoS One. 2020 Mar 20;15(3):e0229773.
9. Hadzigeorgiou Y, Fokialis P, Kabouropoulou M. Thinking about creativity in science education. Creat Educ. 2012;03(05):603–11.
10. Carvalho C, Fiuza E, Conboy J, Fonseca J, Santos JPB dos, Gama P, et al. Critical thinking, real life problems and feedback in the sciences classroom. Journal of Turkish Science Education. 2015;12(2):21–31.
11. Reiter-Palmon R, Mumford MD, Threlfall KV. Solving everyday problems creatively: The role of problem construction and personality type. Creat Res J. 1998;11(3):187–97.
12. Jankowska DM, Gajda A, Karwowski M. How children's creative visual imagination and creative thinking relate to their representation of space. Int J Sci Educ. 2019 May 24;41(8):1096–117.
13. Newton D, Wang Y (Linda), Newton L. 'Allowing them to dream': Fostering creativity in mathematics undergraduates. J Furth High Educ. 2022 Nov 26;46(10):1334–46.
14. Putri SU, Sumiati T, Larasati I. Improving creative thinking skill through project-based-learning in science for primary school. J Phys Conf Ser. 2019 Feb;1157:022052.
15. Nugroho AA, Nizaruddin N, Dwijayanti I, Tristianti A. Exploring students' creative thinking in the use of representations in solving mathematical problems based on cognitive style. JRAMathEdu (Journal of Research and Advances in Mathematics Education). 2020 Jun 28;5(2):202–17.
16. Griffin P, Care E. Assessment and Teaching of 21st Century Skills: Methods and Approach. New York: Springer Science+Business Media; 2014.
17. Kereluik K, Mishra P, Fahnoe C, Terry L. What knowledge is of most worth. Journal of Digital Learning in Teacher Education. 2013 Jun;29(4):127–40.
18. Ramalingam D, Anderson P, Duckworth D, Scoular C, Heard J. Creative thinking: Definition and structure. Camberwell VIC: The Australian Council for Educational Research Ltd; 2020.
19. Yusnaeni, Corebima AD, Susilo H, Zubaidah S. Creative thinking of low academic student undergoing search solve create and share learning integrated with metacognitive strategy. International Journal of Instruction. 2017 Apr;10(2):245–62.
20. Wheeler S, Waite SJ, Bromfield C. Promoting creative thinking through the use of ICT. J Comput Assist Learn. 2002 Sep;18(3):367–78.
21. Lindner KT, Schwab S. Differentiation and individualisation in inclusive education: a systematic review and narrative synthesis. International Journal of Inclusive Education. 2020 Sep 16;1–21.
22. Taylor BK. Content, process, and product: Modeling differentiated instruction. Kappa Delta Pi Record. 2015 Jan 2;51(1):13–7.
23. Ismajli H, Imami-Morina I. Differentiated Instruction: Understanding and Applying Interactive Strategies to Meet the Needs of all the Students. International Journal of Instruction. 2018 Jul 25;11(3):207–18.
24. Widiana IW, Tegeh IM, Lanang Agung Parwata IG, . H. Improving student's factual knowledge with concrete media through observing activities in scientific approaches in elementary schools. J Educ Elearn Res. 2020;7(3):293–9.
25. Kaufman JC, Beghetto RA. Beyond big and little: The four C model of creativity. Review of General Psychology. 2009 Mar 1;13(1):1–12.

26. Anwar MN, Anees M, Khizar A, Naseer M, Muhammad G. Relationship of creative thinking with the academic achievements of secondary school students. International Interdisciplinary Journal of Education . 2020;1(3):44–7.
27. Yang J, Zhao X. The effect of creative thinking on academic performance: Mechanisms, heterogeneity, and implication. Think Skills Creat. 2021 Jun;40:100831.
28. Anggareni P, Hidayat AF. Students creative thinking skills on differentiated instruction. International Journal of Trends in Mathematics Education Research. 2022 Dec 30;5(4):365–73.
29. Cenberci S. The investigation of the creative thinking tendency of prospective mathematics teachers in terms of different variables. J Educ Train Stud. 2018 Jul 10;6(9):78.
30. Prast EJ, Van de Weijer-Bergsma E, Kroesbergen EH, Van Luit JEH. Differentiated instruction in primary mathematics: Effects of teacher professional development on student achievement. Learn Instr. 2018 Apr;54:22–34.
31. Beghetto RA, Kaufman JC. Toward a broader conception of creativity: A case for "mini-c" creativity. Psychol Aesthet Creat Arts. 2007 May;1(2):73–9.