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Enhancing Students' Mathematical Creative Thinking through Ethnomathematics - Based Differentiated Learning

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Abstract: This study focused on the impact of differentiated learning based on ethnomathematics on students' mathematical creative thinking skills, with particular attention to the influence of differences in their readiness and initial abilities. The aim of this study is to analyses the efficacy of ethnomathematics-based differentiated learning in enhancing students' mathematical creative thinking abilities. The study was conducted with 47 students enrolled in the elementary school teacher education program at Yogyakarta State University. The data were collected using a pretest and posttest, employing a descriptive quantitative approach. The findings revealed a notable enhancement in mathematical creative thinking proficiency, with an initial mean score of 68.55 on the pretest, which increased to 86.10 on the posttest following the implementation of an ethnomathematics-based differentiated learning approach. The Shapiro-Wilk normality test, conducted on SPSS 25, indicates that the data are not normally distributed, as the significance value (Sig) is less than α. The Wilcoxon nonparametric test yielded an Asymp. Sig (2-tailed) value of 0.001. The results demonstrate that ethnomathematics-based differentiated learning notably impacts students' mathematical creative thinking abilities. This approach integrates local culture into mathematics learning, improving concept understanding and encouraging students' active involvement in discussions and presentations. Developing an approach that combines differentiated strategies with elements of ethnomathematics makes a practical and theoretical contribution to mathematics education. This study confirms that the integration of local culture is relevant in mathematics learning and is essential for shaping future teachers who can create inclusive, adaptive, and meaningful learning environments.

Keywords: differentiated learning, ethnomatematics, mathematics creative thinking (MCT).

▪ INTRODUCTION

Improving education quality and effectiveness is crucial for a nation's progress. Educators significantly influence the learning process, and students with access to high-caliber educators often do better (Bernard et al., 2019). The Ministry of Education, Culture, Research and Technology of the Republic of Indonesia has introduced a new policy on learning process norms and assessment to ensure continuous improvement in the quality of education. This policy is articulated in Permendikbudristek Number 53 of 2023, Article 11, Paragraph 1, which regulates several essential aspects of the implementation of learning in higher education. According to the regulations, the learning process standard serves as a minimum guideline, ensuring that the educational process attains the anticipated level of competence among graduates. The learning process encompasses three principal stages: planning, implementation, and assessment (Kasman & Lubis, 2022).

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This new policy is aligned with the significance of an engaging and enjoyable learning process, which meets students' needs to promote active involvement. Furthermore, meticulous learning planning and implementing an appropriate model or approach have been demonstrated to enhance the efficacy of the learning process. This illustrates that students are heterogeneous individual learners, exhibiting diverse learning preferences and styles (Sholihah et al., 2021; Rusalam et al., 2019; Mardiono et al., 2020; Hanafiah et al., 2023).

A study published in an educational journal demonstrated that learners frequently exhibit multiple learning styles that can be applied in diverse contexts (Kasman & Lubis, 2022; Bhuiyan et al., 2021). Consequently, rather than being constrained to a singular category of learning styles, it is more advantageous for learners to cultivate and enhance their diverse learning styles. This approach will improve student engagement and equip them to overcome challenges in the real world.

Misconceptions about differentiated learning frequently emerge when educators categorize students based on a narrow classification of learning styles, including visual, auditory, and kinesthetic groupings. This perspective needs to capture the nuances of the actual learning process. Differentiated learning should prioritize individual needs, abilities, and learning environments (Tomlinson et al., 2003). Research demonstrates that holistic strategies tailored to the distinct attributes of each learner can significantly enhance learning outcomes.

Carol Ann Tomlinson, an author, and educator known for her pioneering work in differentiated learning, defines it as a pedagogical strategy that accommodates students' individual needs (Smale-Jacobse et al., 2019). Tomlinson identifies four key principles underpinning differentiated learning: The four main pillars are content, process, product, and learning environment (Magableh & Abdullah, 2020; Smale-Jacobse et al., 2019). The term "differentiated learning" describes an educational approach whereby educators utilize various teaching strategies to meet the specific needs of each student. These needs may include prior knowledge, preferred learning modalities, interests, and understanding of the subject matter. Differentiated learning allows educators to engage with students at a level commensurate with their existing expertise, matching their learning preferences.

Differentiated learning aims to ensure educational equality for all students and reduce the achievement gap between high- and low-achieving students (Ardiansyah et al., 2021). The pedagogical approach of differentiated learning is designed to engage students by presenting challenging material (Smale-Jacobse et al., 2019; Scalise, 2007). Furthermore, it is crucial to ensure that learning activities are aligned with the materials and models used. Educators should employ innovative approaches, strategies, and learning aids tailored to students' specific demands and learning styles (Ardiansyah et al., 2021; Ulfiana et al., 2019).

Differentiated Learning is an instructional strategy that customizes teaching approaches to meet learners' specific needs (Ouyang & Ye, 2023; Iqbal et al., 2020). This educational initiative in mathematics, specifically for elementary teacher education students at Universitas Negeri Yogyakarta, seeks to bridge the gap in various skills and academic backgrounds, thus promoting a more inclusive and effective learning environment. This study examines the impact of ethnomathematics-based Differentiated Learning on students' mathematical creative thinking skills, considering variations in their readiness and basic abilities.

Differences in educational backgrounds, including students from science, social studies, language, or vocational majors, often result in variations in preparedness and basic understanding of fundamental mathematical ideas. Pre-research findings indicated a need for mathematical creative thinking among Elementary School Teacher Education students at Yogyakarta State University related to basic geometry concepts, as only 3 out of 44 students successfully answered higher-order thinking skills (HOTS) questions about basic measurement concepts. This indicates the need for more flexible strategies to overcome this difficulty, considering each student's initial ability and learning readiness (Ardiansyah et al., 2021). Inadequate understanding of basic mathematical ideas inhibits students' active engagement in Learning. Presentation actions were delivered textually based on the content of the slides.

In addition, answering mathematical questions became difficult due to the lack of mastery of basic mathematical materials or principles that should be an essential foundation for prospective teachers. However, many students today struggle with a lack of creativity in their mathematical thinking, which can adversely impact their learning outcomes (Sahliawati & Nurlaelah, 2020). Students usually view math as a curricular requirement and lack the motivation to learn independently outside of school, which limits their mathematical creativity. (Ardiansyah et al., 2021) Found that students can improve their math creativity and independence.

These background variations indicate the diversity of students' initial knowledge of basic mathematics concepts, mathematical creative thinking skills, and learning approaches, thus emphasizing the necessity of differentiated learning strategies to accommodate these differences. One relevant approach is the use of ethnomathematics, which is the integration of local culture into mathematics learning, especially in geometry. The integration of ethnomathematics-based learning strategies in geometry education holds great promise for improving students' creative thinking skills and fostering a deeper appreciation for the role of local culture in mathematics (Sunzuma & Maharaj, 2020; Fajriah & Suryaningsih, 2021; Araiku et al., 2020).

Ubiratan D'Ambrosio defines ethnomathematics as the mathematical practices and knowledge systems embedded within various cultural groups (Faiziyah et al., 2020). By grounding geometry instruction in the cultural experiences and traditions of the local community, students can develop a more meaningful and engaged understanding of mathematical concepts. (Budiarto et al., 2019; Danoebroto et al., 2020; Safrida et al., 2020). Integrating mathematics with local culture, which is familiar to students, contextualizes learning and enhances its appeal. This approach fosters the development of mathematical creativity by encouraging students to identify patterns, relationships, and solutions from their cultural perspectives (Suharta et al., 2021; Sunzuma & Maharaj, 2020). Consequently, this approach not only improves conceptual understanding but also cultivates creative thinking skills that are essential in basic education.

The National Council of Teachers of Mathematics (NCTM, 2000), an organization of mathematics educators in the United States, defines mathematical power as problem-solving, reasoning and proof, mathematical communication, mathematical connections, and mathematical representation (Monteleone et al., 2023). Furthermore, Ulfiana et al. (2019) said that mathematical creative thinking skills are essential for effective problem-solving. Therefore, students must be able to think creatively to design new solutions and actively address current challenges by demonstrating various competencies (Ulfiana et al., 2019; Ardiansyah et al., 2021).

Torrance et al. (1969) proposed that the attributes of an individual's creative thinking capacity can be assessed through three indicators: fluency, which is shown by the number of ideas generated in response to a prompt; flexibility, which is demonstrated by the variety of approaches when handling a prompt; and originality, which is reflected in the uniqueness of ideas generated in response to a prompt. Meanwhile, Kusuma et al. (2021) and Suherman et al. (2021) identified four dimensions of creative thinking ability. The first is fluency, which relates to the ease of solving problems and generating multiple solutions. The flexibility component includes the capacity to use various problem-solving solutions the element of originality, which consists of the ability to use new, different, or unconventional tactics. The elaboration component consists of the ability to explain a particular mathematical technique, solution, or scenario in a detailed and cohesive manner.

Emphasizing creative thinking is a crucial skill for everyone, as it involves consistently and continuously generating new and original ideas (Albab et al., 2021; Sirajudin et al., 2021; Prasetyo et al., 2021). This capacity is vital in mathematics learning, where students must solve problems, identify diverse perspectives, and develop innovative solutions. (Sahliawati & Nurlaelah, 2020). According to Munandar, four key indicators measure students' creative thinking abilities in mathematics: fluency, flexibility, originality, and elaboration (Sahliawati & Nurlaelah, 2020). Fluency refers to the ability to produce a wide range of answers and solutions, while flexibility is the capacity to approach problems from different angles and employ varied methods. Originality encompasses the skill to devise unique and unconventional responses, and elaboration involves expanding and refining ideas in detail (Isyrofinnisak et al., 2020).

Creative thinking skills can be improved by incorporating local cultural perspectives or ethnomathematics (Sya'roni et al., 2020). This approach, which links mathematical principles with everyday experiences, can significantly impact students' understanding of fundamental mathematical ideas and problem-solving abilities in real-life scenarios (Ardiansyah et al., 2021; Faiziyah et al., 2020). Therefore, it is essential to analyze the elements that influence students' mathematical creative thinking ability to improve the quality of mathematics education in the future. In this context, ethnomathematics is a powerful method to enhance the significance and understanding of mathematics by linking mathematical concepts with local culture. Maths education is intrinsically connected to everyday life. Mathematics is a prevalent way of reasoning and a means of human survival (Hanim et al., 2019; Fajriah & Suryaningsih, 2021). Incorporating local cultural examples, such as traditional arts, can increase student engagement in learning and facilitate understanding of mathematical concepts, such as spatial reasoning, by providing a more accurate and relatable context (Faiziyah et al., 2020).

Using diverse learning strategies rooted in ethnomathematics in geometry education can improve mathematical creative thinking skills and encourage recognition of the importance of local culture in mathematics education (Faiziyah et al., 2020). By linking measurement materials with local culture and customs, students understand mathematical principles and recognize the importance of their own culture. This is expected to encourage students to engage more actively in learning and increase their involvement in class discussions. Consequently, researchers are interested in investigating the impact of ethnomathematics-based differentiated learning on Primary Teacher Education students' mathematical creative thinking ability.

▪ METHOD

The research utilized is pre-experimental, employing a one-group pretest-posttest design. In this model, a group is administered a treatment, after which the process and its subsequent outcomes are meticulously observed. This research does not require a control group for differentiation; pre-experimental designs emphasize the class receiving the therapy (Alshahrni & Al-Kawafeha, 2019). This study used a One-Group Pretest-Posttest Design, using one group: the experimental class that received intervention through differentiated learning strategies.

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This study involved 47 first-semester students enrolled in the Elementary School Teacher Education (PGSD) program at Yogyakarta State University (UNY). The students were chosen through purposive sampling due to their varied educational backgrounds before attending the program. This variance highlights disparities in fundamental skills across students in the same class, rendering them appropriate for a research on differentiated learning. Most participants (about 45%) have a science background, whereas 30% originated from social studies. Other educational disciplines, including Accounting, Broadcasting, Religion, and Language, constituted less than 10% each. This emphasizes that not all students in a single class possess identical foundational abilities. Consequently, differentiated learning grounded on ethnomathematics is pertinent to enhancing students' mathematical creative thinking abilities in fundamental mathematical concepts (Nurasiah et al., 2020; Isyrofinnisak et al., 2020).

This study utilized a pre-experimental using a one-group pretest-posttest design. The research was carried out from August 29, 2024, until November 7, 2024. At the outset of the intervention, a pretest was conducted to evaluate the students' first mathematical creative thinking skills, emphasizing fluency, flexibility, originality, and elaboration. The experimental group thereafter underwent teaching utilizing ethnomathematics-based differentiated learning approach, particularly formulated to augment students' creative thinking in fundamental geometric ideas base on local culture. Upon conclusion of the session, a posttest was conducted to assess alterations in mathematical creative thinking abilities. Data were systematically monitored and documented during the investigation to guarantee precise result analysis.

The study employed a non-objective descriptive test to evaluate mathematical creative thinking skills. The assessment concentrated on ethnomathematics-oriented geometry and included 12 descriptive questions aimed at evaluating fluency, flexibility, creativity, and elaboration. Fluency denotes the capacity to generate numerous solutions or answers, flexibility signifies the capability to tackle problems through various methods or viewpoints, originality pertains to the ability to create distinctive and unconventional responses, and elaboration refers to the skill of offering comprehensive and well-developed solutions. The test instrument was created by the researcher utilizing geometric materials and an ethnomathematics method, focusing on the content of traditional dwellings, musical instruments, and cuisine of Yogyakarta. The instrument's validity and reliability were confirmed by expert evaluation and pilot testing, resulting in an acceptable reliability coefficient. This paper summarizes the outcomes of validity and reliability assessments on 12 items, executed using SPSS with Pearson correlation analysis. The p-value (sig.) determined less then 0.05, so signifying that the query is deemed legitimate and credible.

The data analysis was performed in many phases. Mathematical creative thinking skills were evaluated using a five-point scale, divided into five categories: "Very Low" (0-20), "Low" (21-40), "Medium" (41-60), "High" (61-80), and "Very High" (81-100). Initially, the normalized gain (N-Gain) was computed to assess the intervention's efficacy, with N-Gain scores classified as Low Improvement (< 0.3), Moderate Improvement (0.3 – 0.7), and High Improvement (> 0.7). The Shapiro-Wilk test was conducted using SPSS 25 to evaluate the normality of the data distribution. If the significance (Sig) value above 0.05, the data were deemed regularly distributed. furthermore, non-parametric tests were employed owing to the non-normal distribution of the data. The Mann-Whitney U test assessed the disparities between pretest and posttest results. The decision criteria relied on significance (Sig) values: if Sig < 0.05, the alternative hypothesis (Ha) was accepted, signifying a significant difference; conversely, if Sig > 0.05, the null hypothesis (H0) was accepted, showing no significant difference. subsequently, Cohen's d, adjusted with Hedges' g adjustment, was computed to assess the intervention's impact size, with a significance value (2-tailed) of < 0.05 denoting a statistically significant difference between pretest and posttest scores. The thorough analyses enabled a rigorous assessment of the intervention's effect on improving mathematical creative thinking skills.

▪ RESULT AND DISSCUSSION

This study utilized descriptive statistics. The instruments employed were pretest-posttest inquiries. A pretest-posttest evaluation was utilized to evaluate students' mathematical creative thinking abilities following the implementation of ethnomathematics-based differentiated learning activities,. This research encompassed 47 students from the elementary school teacher education program (PGSD) at Yogyakarta State University, who were designated as the sample population. Prior to getting instruction, pupils were administered pretest questions. Subsequently, pupils underwent intervention via a customized learning approach grounded in ethnomathematics. Following the lesson, students were administered post-test questions to evaluate their mathematical creative thinking abilities.

The classification of pretest and posttest results is presented according to their frequency and percentage distribution. In the pretest, no participants achieved scores in the "Very Low" (0–20) or "High" (61–80) categories, but the majority (70%, or 33 individuals) fell into the "Low" range (21–40). Furthermore, 30% of participants (14 people) attained a "Medium" score (41–60), while none obtained the "Very High" category (81–100). The posttest findings indicate a substantial enhancement, with no subjects achieving scores in the "Very Low" or "Low" categories. Merely 2% (1 individual) attained the "Medium" category, whereas 68% (32 individuals) secured "High" marks, and 30% (14 individuals) obtained the "Very High" level. The data demonstrate a distinct transition to elevated score categories from pretest to posttest, signifying enhanced performance.

The examination of the pretest and post-test data indicated a significant enhancement in pupils' performance. The average score of the pretest was 68.55, but the average score of the post-test rose to 81.10. This signifies a general enhancement, since the post-test mean value exceeds the pretest mean. This enhancement is further evidenced by the dispersion of student results across several areas of mathematical creative thinking abilities. The results are illustrated in the images below for a visual comparison of the students' pretest and post-test performance.

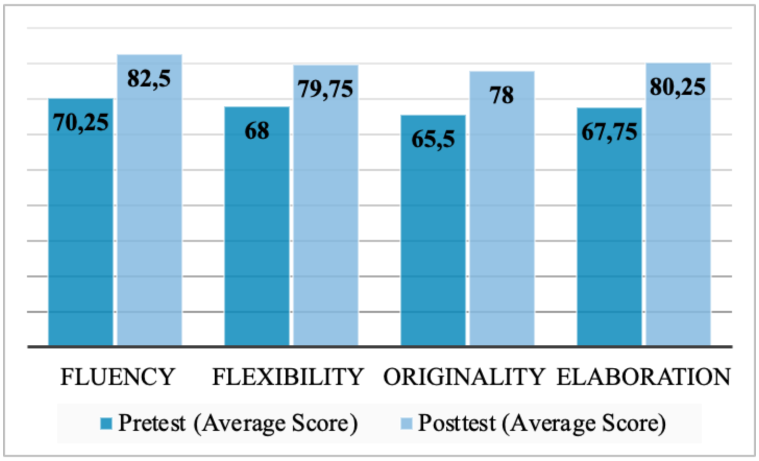

Figure 1. Category of N-Gain test score of matematics creative thinking outcomes of students before (pretest) and after treatment (posttest)

The Shapiro-Wilk test for data normality is applicable for small sample sizes, namely those less than 50. If the significance of the results is below 0.05, it indicates a departure from normal distribution. The data evaluated for normalcy comprised the pretest and post-test findings. The normality test outcomes for the pretest and post-test data of Elementary School Teacher Education students at Yogyakarta State University. The normality test indicated that the significance value for the pretest data was 0.003, and for the post-test data, it was also 0.003, both of which are below 0.05. This study suggests that the pretest and post-test data from students in the Elementary School Teacher Education Programme at Yogyakarta State University do not exhibit a normal distribution. Consequently, the results of this inquiry demonstrate that the data does not satisfy the assumption of normalcy, thereby necessitating the application of a non-parametric technique for further data examination.

Therefore, the hypothesis was tested using non-parametric methods. The non-parametric test used is the Wilcoxon test. The data analysis method was used to test the difference between pretest learning outcomes before intervention and post-test learning outcomes after intervention. The results of the Wilcoxon test can be seen from the significance level. If Asymp.sig < 0.05 (α), then the alternative hypothesis (Ha) is accepted; conversely, if Asymp.sig > 0.05 (α), then the null hypothesis (H0) is rejected. The results of the Wilcoxon test are presented in the following table:

Table 1. Wilcoxon sign rank test

		N	Mean Rank	Sum of Ranks
Pretest-Posttest	Negative Ranks	0[a]	.00	.00
	Positive Ranks	47[b]	24.00	1128.00
	Ties	0[c]		
	Total	47		

a. Posttest < Pretest
b. Posttest > Pretest
c. Posttest = Pretest

Table 1 concludes that Negative Ranks represent the distance between the pretest and post-test variables, which shows a negative value of 0, signifying that no students have shown a decrease in mathematical creative thinking ability. Positive ranks, the difference between the pretest and post-test variables, showed 47 positive data (N), indicating that students had improved their mathematical creative thinking ability. There is a relationship, the equality of pretest and post-test results, with a tie value of 0. It can be concluded that there is no equality between pretest and post-test scores.

Table 2. Paired samples effect sizes - cohen's d test result

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Pretest - Posttest	Cohen's d	5.71344	-3.072	-3.750	-2.388
	Hedges' correction	5.80668	-3.023	-3.689	-2.350

[a]. The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

The Cohen's d value for the comparison between pretest and posttest is -3.072, with a 95% confidence interval that falls within the range of -3.750 to -2.388. This range does not include zero, indicating that the change from pretest to posttest is statistically significant. This value is notably large, exceeding the threshold for a large effect size ($d > 0.80$) established by Cohen, thereby indicating a substantial impact of ethnomathematics-based learning on student learning outcomes. Utilizing Hedges' g correction, a method employed to mitigate bias in small sample sizes, the effect size value is -3.023, with a 95% confidence interval of -3.689 to -2.350. This range of intervals also does not include zero, thus corroborating the significance of the results. The value of Hedges' g being very close to Cohen's d confirms the consistency of the results, showing that ethnomathematics-based learning significantly improves student learning outcomes.

The negative effect sizes in Cohen's d and Hedges' g indicate a significant improvement in learning outcomes from pretest to posttest. This is due to the calculation of d using the difference between pretest and posttest scores as the basis, where the posttest score is higher than the pretest, thus giving a negative value. In the context of this study, a negative value does not signify an unfavorable outcome; instead, it demonstrates the efficacy of ethnomathematics-based learning interventions in enhancing student learning outcomes. The substantial effect sizes ($d > 2.0$) indicate the overwhelming strength of the impact, signaling that the intervention provided highly significant benefits in practical terms and was statistically significant.

The Wilcoxon test results further support this conclusion. The test yielded a Z-value of -5.995 and an Asymp. Sig. (2-tailed) value of less than 0.001. Since the significance value is below the threshold of $\alpha = 0.05$, the alternative hypothesis (Ha) is accepted. This finding confirms that there is a significant difference between the pretest and posttest scores of mathematical creative thinking skills, reinforcing the positive impact of the ethnomathematics-based differentiated learning approach on the students' abilities.

The analysis findings on each dimension of mathematical creativity demonstrated that the ethnomathematics-based learning intervention substantially enhanced students' competencies across all dimensions. The originality dimension exhibited the most significant increase, suggesting that the ethnomathematics-based approach could motivate students to generate creative and distinctive solutions to mathematical problems. The enhancement in the fluency and flexibility dimensions indicated that students developed a more advanced aptitude for formulating diverse concepts and methodologies for problem-solving. Furthermore, the enhancement observed in the elaboration dimension suggests an augmentation in students' capacity to develop their ideas with more incredible intricacy and depth. These results align with the findings of previous studies (Sya'roni et al., 2020; Ardiansyah et al., 2021; Faiziyah et al., 2020), which emphasize that local culture-based approaches can enhance mathematical creativity through understanding students' contexts and experiences of local culture.

This study comprehensively analyzes ethnomathematics-based differentiated teaching on mathematical creative thinking skills. Descriptive data showed that primary education students with diverse backgrounds had different initial competencies in understanding basic mathematical concepts. Consequently, a uniform grouping of students substantially increased active engagement during debates and presentations. Differentiated learning allows students to learn based on their needs and abilities, thus promoting higher order thinking skills, including creativity (Hodges, 2018; Feldman & Denti, 2017). A sense of security and congruence of learning styles among students in a group fuel this.

Differentiated learning based on ethnomathematics is particularly relevant as it aligns the educational experience with local culture, often experienced in everyday life. Learning based on ethnomathematics enhances students' contextual understanding of mathematical topics while improving confidence and problem-solving skills (Peni & Baba, 2019; Supiyati & Halqi, 2020; Zuhra et al., 2021). Incorporating local culture into mathematics education fosters a deep connection between students and the material, thus enhancing creativity and originality in mathematical reasoning (Kleden & Geradus, 2018; Buan et al., 2021). This aligns with research results that highlight the potential of Differentiated Learning to improve students' creative thinking skills in elementary Maths. Strategic grouping according to individual needs and abilities and incorporating cultural backgrounds in education is an excellent method to promote meaningful and enduring learning.

This study shows that ethnomathematics-based differentiated learning significantly improves students' creative thinking skills in mathematics. The increase in the mean pre-test score from 68.55 to 81.10 in the post-test reflects the effectiveness of this approach. This result is supported by the findings of Faiziyah et al. (2020), who reported a 17.45%

increase in creativity through culture-based learning using scientific approaches such as observing, questioning, associating, and communicating. As emphasized by Nur et al. (2020), integrating local cultural elements allows students with different levels of thinking to improve their mathematical problem-solving skills, especially students with formal levels of thinking who show better results than transitional or concrete levels.

Research indicates that integrating ethnomathematics into mathematics education can enhance students' creative thinking and problem-solving abilities. Contextual learning with ethnomathematics has been shown to improve problem-solving skills based on students' thinking levels (Andi Saparuddin Nur et al., 2020). Studies have demonstrated that culture-based learning using ethnomathematics can significantly increase students' creativity (Nuqthy Faiziyah et al., 2020). The ethnomathematical approach improves mathematical understanding and connects mathematics to local culture, increasing student motivation and satisfaction (Deah Uji Wulandari et al., 2024). Furthermore, ethnomathematics-based learning has been found to enhance students' learning outcomes and problem-solving abilities while simultaneously increasing their cultural awareness (Neda Permana, 2023). These findings suggest that incorporating ethnomathematics into mathematics curricula and learning materials can lead to more engaging, relevant, and practical mathematics education, fostering academic achievement and cultural appreciation.

Research data from 47 students at the Elementary School Teacher Education program at Yogyakarta State University showed an increase in mathematical creative thinking ability, as evidenced by the average scores of the pre-test and post-test after participating in ethnomathematics-based differentiated learning. The pre-test was distributed using Google Forms one day before the learning session. The pre-test results showed the student's average score of 68.55; after the intervention, the post-test average score increased to 81.10. Students' mathematical creative thinking skills after receiving the assistance showed substantial differences. The considerable increase in mean scores from pre-test to post-test in this study further corroborates the assertion that a learning process tailored to individual students' needs enables them to maximize their potential, particularly in creative thinking (Harahap et al., 2022; Stockard et al., 2018). Local culture-based learning indicated as ethnomathematics, enhances the connection between students and subject matter, thus fostering more profound knowledge and higher cognitive abilities (Faiziyah et al., 2020; Chao et al., 2019).

Differentiated Learning can replicate the knowledge gained through an ethnomathematics-based approach for geometric content to ensure that there is a difference before implementing the intervention that uses ethnomathematics-based differentiated learning strategies. This study's findings align with previous research showing the efficacy of ethnomathematics-based differentiated learning in improving mathematical creative thinking skills. Ethnomathematics-based learning enhances students' understanding of complex mathematical ideas by integrating cultural settings relevant to everyday life, thus increasing interest and motivation to learn (Faiziyah et al., 2020; Nur et al., 2020; Peni & Baba, 2019). In addition, knowing that emphasizes creative approaches, such as differentiation, can encourage broader and more imaginative thinking among students in tackling mathematical problems (Utemov & Masalimova, 2017; Ritonga et al., 2018; Park & Jeon, 2022). Students' limited engagement in mathematics is driven by a lack of understanding of mathematical ideas, as not all students have the same educational background. Students have different initial competencies. The absence of mathematical creative thinking skills hindered students' ability to solve some mathematical problems. Students improved their mathematical creative thinking ability significantly after a differentiated learning intervention based on ethnomathematics. This method overcame the barriers posed by diverse students' educational backgrounds while facilitating increased exploration of creative thinking skills.

One of the previous studies conducted by Purwaningrum indicated that problem-based learning, discovery Learning, and open-ended models may significantly improve students' creative thinking in mathematics. Furthermore, research conducted by Subanji and Nusantara demonstrates that critical thinking might underpin the development of students' creative competencies in mathematics (Riadi et al., 2021; Zakeri et al., 2022). In conclusion, fostering creative thinking abilities is essential for kids' success in mathematics education. Educators must implement pedagogical strategies that promote fluency, flexibility, originality, and elaboration, thereby enabling students to become innovative problem-solvers and creative thinkers in mathematics (Isyrofinnisak et al., 2020; Tanjung et al., 2020; Sahliawati & Nurlaelah, 2020).

Implementing ethnomathematics-based differentiated learning is a multifaceted endeavor that requires a comprehensive strategy, which includes selecting ethnomathematics materials that are relevant and aligned with the subject matter. The results of this study offer insights into improving learning effectiveness by incorporating local culture into mathematics education. As a culture-centered approach, ethnomathematics can enhance the mathematics learning experience by making the content more relevant and significant to students (Nur et al., 2020; Peni & Baba, 2019; Budiarto et al., 2019). Culture-based mathematics teaching fosters a more individualized relationship between students and topics, thereby increasing their engagement and understanding (Saqdiah et al., 2018; Afifah, 2019; Nasrulloh et al., 2021; Naresh & Kasmer, 2018; Saputra et al., 2021). The dimensions of mathematical creative thinking ability and learning experiences related to culture-based ethnomathematics show low average scores, indicating that students need a comprehensive understanding of ethnomathematics-based differentiated learning and mathematical creative thinking ability. The results of the low average mathematical creative thinking ability and students' learning experience underscore the need for more comprehensive and contextualized education. Creative thinking skills require systematic improvement through relevant and demanding activities (Nurhamidah et al., 2018; Zhanqiang, 2023; Yang & Zhao, 2021).

Creative thinking skills can be developed through varied materials and approaches that allow students to investigate ideas thoroughly (Nurhamidah et al., 2018; Kallanxhi et al., 2020; Rosen et al., 2020; Gardiner, 2020; Park et al., 2021). The success of these tactics significantly relies on personalizing relevant learning approaches. The results of this study underline the importance of mathematical creative thinking skills for students who aspire to become educators. Personalized and contextualized learning can enhance students' critical and creative thinking skills. Mathematical creative thinking skills are essential for improving instructional techniques to increase student engagement and foster more relevant and meaningful learning experiences. Creative thinking skills are necessary for aspiring educators, as these skills will influence the design and implementation of new instructional practices in the classroom.

▪ CONCLUSION

This research shows that the implementation of ethnomathematics-based differentiated learning has significant potential in improving students' mathematical creative thinking skills, especially in geometry. The approach integrates local cultural elements into differentiated learning, designed to address the challenges of heterogeneity in students' educational backgrounds. The results of this study not only proved the effectiveness of the strategy through a significant increase in the mean scores of the pretest and posttest but also showed that grouping students based on initial ability can encourage active involvement and confidence in the learning process. In particular, the integration of local culture not only provides a more meaningful learning experience for students but also prepares them to become educators who are able to create an inclusive and adaptive learning environment. Thus, this research offers a new contribution to the field of mathematics education, combining the uniqueness of local culture with modern pedagogical needs through differentiated learning. The effectiveness of the ethnomathematics-based differentiated learning approach is also essential, as it provides in-depth insights into how this strategy can be customised to meet individual needs and improve the overall quality of education. Future research could investigate the integration of digital technologies, including augmented reality and e-learning applications, within ethnomathematics-based education to increase engagement and success in learning.

▪ REFERENCES

Afifah, W. (2019). Developing culture-based English instructional materials for grade VII of junior high school students. English Language Teaching Educational Journal, 1(2), 76–84. Ahmad Dahlan University. https://doi.org/10.12928/eltej.v1i2.390

Albab, U., Budiyono, B., & Indriati, D. (2021). Creative thinking process on high order thinking skills for junior high school students with cognitive style field independent. Advances in Social Science, Education and Humanities Research/Advances in social science, education and humanities research. https://doi.org/10.2991/assehr.k.211122.037

Alshahrni, M. M., & Al-Kawafeha, N. M. (2019). Effectiveness of the strategy of thinking aloud in developing the ability to solve mathematical problems among gifted students. The International Journal for Talent Development, 10(2), 23. https://doi.org/10.20428/ijtd.v10i2.1578

Ardiansyah, A. S., Mulyono, M., Mashuri, Fiyanti, R. A., & Hamidah, F. S. (2021). CB-BL model (challenge-based on blended learning) for mathematical creativity. Journal of Physics: Conference Series, 1918(4), 042065. https://doi.org/10.1088/1742-6596/1918/4/042065

Bernard, R., Borokhovski, E., Schmid, R. F., Waddington, D. I., & Pickup, D. (2019). Twenty-first century adaptive teaching and individualized learning operationalized as specific blends of student-centered instructional events: A systematic review and meta-analysis. Campbell Systematic Reviews, 15(1). https://doi.org/10.1002/cl2.1017

Bhuiyan, B. A., Molla, M. S., & Alam, M. (2021). Managing innovation in technical education: Revisiting the developmental strategies of Politeknik Brunei. SSRN Electronic Journal. RELX Group. https://doi.org/10.2139/ssrn.3956515

Buan, A. T., Ali, A. Z. M., & Gomez, R. G. (2021). Development and validation of contextualized lesson in mathematics. Journal of Physics Conference Series, 1835(1), 12100. https://doi.org/10.1088/1742-6596/1835/1/012100

Budiarto, M. T., Artiono, R., & Setianingsih, R. (2019). Ethnomathematics: Formal mathematics milestones for primary education. Journal of Physics Conference Series, 1387(1), 12139. https://doi.org/10.1088/1742-6596/1387/1/012139

Chao, J., Jiang, T.-W., Yeh, Y.-H., Liu, C., & Lin, C. (2019). Integration of ARCS motivational model and IT to enhance students learning in the context of Atayal culture. Eurasia Journal of Mathematics Science and Technology Education, 15(11). https://doi.org/10.29333/ejmste/109608

Faiziyah, N., Sutama, S., Sholihah, I., Wulandari, S., & Yudha, D. A. (2020). Enhancing creativity through ethnomathematics. Universal Journal of Educational Research, 8(8), 3704. https://doi.org/10.13189/ujer.2020.080850

Fajriah, N., & Suryaningsih, Y. (2021). Ethnomathematics of the Jami Mosque Jingah River as a source mathematics learning. Journal of Physics Conference Series, 1760(1), 12025. https://doi.org/10.1088/1742-6596/1760/1/012025

Feldman, K., & Denti, L. (2017). High-access instruction: Practical strategies to increase active learning in diverse classrooms. Focus on Exceptional Children, 36(7). https://doi.org/10.17161/foec.v36i7.6805

Gardiner, P. (2020). Learning to think together: Creativity, interdisciplinary collaboration and epistemic control. Thinking Skills and Creativity, 38, 100749. https://doi.org/10.1016/j.tsc.2020.100749

Hafizi, M. H. M., & Kamarudin, N. (2020). Creativity in mathematics: Malaysian perspective. Universal Journal of Educational Research, 8(3), 77. https://doi.org/10.13189/ujer.2020.081609

Hanafiah, Firman, M., & Gunawan, U. (2023). Leadership of school principle in developing education management standards at MTS Yaspida Sukabumi. Indonesian Journal of Educational Development (IJED), 4(2), 259. https://doi.org/10.59672/ijed.v4i2.2973

Hanim, M., Makur, A. P., Raga, P., & Pantaleon, K. V. (2019). Mathematical learning by utilizing loce, Manggarian traditional mats. Journal of Physics Conference Series, 1315(1), 12035. https://doi.org/10.1088/1742-6596/1315/1/012035

Harahap, R., Ahmad, N. Q., & Fiteri, R. (2022). Peningkatan kemampuan kreativitas matematis mahasiswa melalui pendekatan STEM (Science, Technology, Engineering, and Mathematics) berbasis Project-Based Learning (PjBL). Edukatif Jurnal Ilmu Pendidikan, 4(3), 3479. https://doi.org/10.31004/edukatif.v4i3.2621

Herawaty, D., Widada, W., Adhitya, A., Sari, R. D. W., Novianita, L., & Anggoro, A. F. D. (2020). Students’ ability to simplify the concept of function through realistic mathematics learning with the ethnomathematics approach. Journal of Physics: Conference Series, 1470(1), 012031. https://doi.org/10.1088/1742-6596/1470/1/012031

Hodges, L. C. (2018). Contemporary issues in group learning in undergraduate science classrooms: A perspective from student engagement. CBE—Life Sciences Education, 17(2). https://doi.org/10.1187/cbe.17-11-0239

Iqbal, J., Khan, A. M., & Nisar, M. (2020). Impact of differentiated instruction on student learning: Perception of students and teachers. Global Regional Review, 364. https://doi.org/10.31703/grr.2020(v-i).40

Isyrofinnisak, F., Kusmayadi, T. A., & Fitriana, L. (2020). Mathematics creativity skill of student in junior high school based on students' thinking style. Journal of Physics: Conference Series, 1538(1), 012068. https://doi.org/10.1088/1742-6596/1538/1/012068

Kallanxhi, B., Çinaj, V., & Meçe, M. (2020). Management of pre-university education schools in the new century - The case of Albania. European Journal of Education, 3. https://ideas.repec.org/a/eur/ejedjr/89.html

Kasman, K., & Lubis, S. K. (2022). Teachers' performance evaluation instrument designs in the implementation of the new learning paradigm of the Merdeka Curriculum. Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran, dan Pembelajaran, 8(3), 760. https://doi.org/10.33394/jk.v8i3.5674

Kleden, M. A., & Geradus, U. (2018). Enhancement of mathematical communication competency upon students of junior high school through contextual learning based on coastal culture. Education Quarterly Reviews, 1(1), 9–16. https://doi.org/10.31014/aior.1993.01.01.3

Kusuma, D., Zaenuri, Z., & Wardono. (2021). Mathematic creative thinking ability based on student metacognition in blended learning model with e-module. Journal of Physics Conference Series, 1918(4), 042103. https://doi.org/10.1088/1742-6596/1918/4/042103

Magableh, I. S. I., & Abdullah, A. (2020). The effect of differentiated instruction on EFL learners: Teachers' perspective. International Journal of Academic Research in Business and Social Sciences, 10(5). https://doi.org/10.6007/ijarbss/v10-i5/7235

Mardiono, I., Marwan, M., & Abror, A. (2020). Strategy to improve the quality of education in Semen Padang. Proceedings of the 4th Padang International Conference on Education, Economics, Business and Accounting (PICEEBA-2 2019). https://doi.org/10.2991/aebmr.k.200305.105

Monteleone, C., Miller, J., & Warren, E. (2023). Conceptualising critical mathematical thinking in young students. Mathematics Education Research Journal, 35(2), 339–355. https://doi.org/10.1007/s13394-023-00445-1

Munahefi, D. N., Mulyono, M., Zahid, M. Z., Syaharani, E. A., & Fariz, R. (2021). Analysis of mathematical creative thinking test instruments on open-ended problems with ethnomatematic nuances. Journal of Physics Conference Series, 1918(4), 042060. https://doi.org/10.1088/1742-6596/1918/4/042060

Naresh, N., & Kasmer, L. (2018). Using ethnomathematics perspective to widen the vision of mathematics teacher education curriculum. In Research in mathematics education (p. 309). https://doi.org/10.1007/978-3-319-92907-1_18

Nasrulloh, I., Rahadian, D., Hamdani, N. A., Imania, K. A. N., & Rikaldi, P. B. R. (2021). A comparative study: Multimedia interactive use on contextual and cooperative approaches in increasing mathematical understanding. Journal of Physics Conference Series, 1987(1), 12015. https://doi.org/10.1088/1742-6596/1987/1/012015

Nur, A. S., Waluya, S. B., Rochmad, R., & Wardono, W. (2020). Contextual learning with ethnomathematics in enhancing the problem solving based on thinking levels. JRAMathEdu (Journal of Research and Advances in Mathematics Education), 5(3), 331–341. https://doi.org/10.23917/jramathedu.v5i3.11679

Nurasiah, L., Priatna, B. A., & Priatna, N. (2020). The effect of differentiated instruction on student mathematical communication ability. Journal of Physics Conference Series, 1469(1), 012160. https://doi.org/10.1088/1742-6596/1469/1/012160

Nurhamidah, D., Masykuri, M., & Dwiastuti, S. (2018). Profile of senior high school students' creative thinking skills on biology material in low, medium, and high academic perspective. Journal of Physics Conference Series, 1006, 12035. https://doi.org/10.1088/1742-6596/1006/1/012035

Ouyang, J., & Ye, N. (2023). Differentiated instruction: Meeting the needs of all learners. Curriculum and Teaching Methodology, 6(11). https://doi.org/10.23977/curtm.2023.061111

Park, H., & Jeon, Y. J. (2022). A design and application of software liberal arts course based on ct-cps model for developing creative problem-solving ability and learning motivation of non-software majors. JOIV International Journal on Informatics Visualization, 6(2), 317. https://doi.org/10.30630/joiv.6.2.996

Park, J. H., Niu, W., Li, C., & Allen, H. (2021). Fostering creativity and critical thinking in college: a cross-cultural investigation. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.760351

Peni, N. R. N., & Baba, T. (2019). Consideration of curriculum approaches of employing ethnomathematics in mathematics classroom. Journal of Physics Conference Series, 1321(3), 32125. https://doi.org/10.1088/1742-6596/1321/3/032125

Plass, J. L., & Pawar, S. (2020). Toward a taxonomy of adaptivity for learning. Journal of Research on Technology in Education, 52(3), 275–287. https://doi.org/10.1080/15391523.2020.1719943

Prasetyo, T., M.S, Z., & Fahrurrozi, F. (2021). *Analisis berpikir kreatif mahasiswa dalam pembelajaran daring bahasa Indonesia.* Edukatif Jurnal Ilmu Pendidikan (Vol. 3, Issue 6, p. 3617). Universitas Pahlawan Tuanku Tambusai. https://doi.org/10.31004/edukatif.v3i6.669

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. Proceedings of the 3rd Annual International Seminar on Transformative Education and Educational Leadership (AISTEEL 2017). https://doi.org/10.2991/aisteel-17.2017.55

Riadi, R., Sinaga, B., & Syahputra, E. (2021). Analysis of the difficulty of understanding concepts and creative thinking of students in mathematics through problem-based learning in students of sma angkasa lanud soewondo. Budapest International Research and Critics in Linguistics and Education (BirLE) Journal (Vol. 4, Issue 1, p. 77). https://doi.org/10.33258/birle.v4i1.1557

Ritonga, H. D., Mulyono, M., & Minarni, A. (2018). The effect of integrated Batak-Angkola culture on open-ended approach to mathematical creative thinking skills of middle secondary school students. American Journal of Educational Research, 6(10), 1407–1413. https://doi.org/10.12691/education-6-10-11

Rosen, Y., Stoeffler, K., & Simmering, V. R. (2020). Imagine: design for creative thinking, learning, and assessment in schools. Journal of Intelligence, 8(2), 16. https://doi.org/10.3390/jintelligence8020016

Rusalam, N. R., Munawar, W., & Hardikusumah, I. (2019). Development of authentic assessment in TVET. Proceedings of the 5th UPI International Conference on Technical and Vocational Education and Training (ICTVET 2018). https://doi.org/10.2991/ictvet-18.2019.78

Sahliawati, M., & Nurlaelah, E. (2020). Mathematical creative thinking ability in middle school students'. Journal of Physics Conference Series (Vol. 1469, Issue 1, p. 12145). IOP Publishing. https://doi.org/10.1088/1742-6596/1469/1/012145

Saputra, E., & Zulmaulida, R. (2021). Implementation of reflective thinking process approach to students' mathematical critical thinking. Journal of Physics Conference Series, 2123(1), 012033. https://doi.org/10.1088/1742-6596/2123/1/012033

Saputra, W. B., Utami, N. W., & Kusuma, I. A. (2021). Developing culture-based mathematics learning media with adobe flash for jhs students. Journal of Physics Conference Series, 1823(1), 12114. https://doi.org/10.1088/1742-6596/1823/1/012114

Saqdiah, A., Armiati, A., & Yerizon, Y. (2018). Handout development on contextual based-approach to improve the problem solving ability of grade vii student. Proceedings of the International Conferences on Educational, Social Sciences and Technology - ICESST 2018, 401. https://doi.org/10.29210/2018158

Scalise, K. (2007). Differentiated e-learning: Five approaches through instructional technology. International Journal of Learning Technology, 3(2), 169–182. https://doi.org/10.1504/ijlt.2007.014843

Sholihah, M., Permatasari, Y. D., Zionis, R. M., Budianto, N., & Fadlillah, F. (2021). Teacher quality gap in elementary and primary schools. IOP Conference Series Earth and Environmental Science, 747(1), 012051. https://doi.org/10.1088/1755-1315/747/1/012051

Sirajudin, N., Suratno, J., & Pamuti, P. (2021). Developing creativity through STEM education. Journal of Physics Conference Series (Vol. 1806, Issue 1, p. 12211). IOP Publishing. https://doi.org/10.1088/1742-6596/1806/1/012211

Smale-Jacobse, A., Meijer, A., Helms-Lorenz, M., & Maulana, R. (2019). Differentiated instruction in secondary education: A systematic review of research evidence. Frontiers in Psychology, 10, 2366. https://doi.org/10.3389/fpsyg.2019.02366

Stockard, J., Wood, T. W., Coughlin, C., & Khoury, C. R. (2018). The effectiveness of direct instruction curricula: a meta-analysis of a half century of research. Review of Educational Research, 88(4), 479. https://doi.org/10.3102/0034654317751919

Suherman, S., Komarudin, K., & Supriadi, N. (2021). Mathematical creative thinking ability in online learning during the COVID-19 pandemic: A systematic review. Online Learning in Educational Research (OLER), 1(2), 75–89. https://doi.org/10.58524/oler.v1i2.49

Sun, Y., & Xiao, L. (2021). Research trends and hotspots of differentiated instruction over the past two decades (2000–2020): A bibliometric analysis. Educational Studies, 50(2), 186–201. https://doi.org/10.1080/03055698.2021.1937945

Supiyati, S., & Halqi, M. (2020). Ethnomathematic Of Sasaknese As A Mathematic Learning Source. Journal of Physics Conference Series, 1539(1), 12076. https://doi.org/10.1088/1742-6596/1539/1/012076

Sya'roni, A. R., Inawati, P. A., Guswanto, E., Susanto, S., & Hobri, H. (2020). Students' creative thinking skill in the flipped classroom-blended learning of mathematics based on lesson study for learning community. Journal of Physics Conference Series, 1563(1), 012046. https://doi.org/10.1088/1742-6596/1563/1/012046

Tanjung, D. F., Syahputra, E., & Irvan, I. (2020). Problem Based Learning, Discovery Learning, and Open Ended Models: An experiment On Mathematical Problem Solving Ability. JTAM (Jurnal Teori dan Aplikasi Matematika) (Vol. 4, Issue 1, p. 9). https://doi.org/10.31764/jtam.v4i1.1736

Tomlinson, C. A., Brighton, C. M., Hertberg, H. L., Callahan, C. M., Moon, T. R., Brimijoin, K., Conover, L. A., & Reynolds, T. D. (2003). Differentiating instruction in response to student readiness, interest, and learning profile in academically diverse classrooms: A review of literature. Journal for the Education of the Gifted, 27(2), 119–145. https://doi.org/10.1177/016235320302700203

Ulfiana, E., Usodo, B., & Triyanto, T. (2019). The students' mathematical critical thinking skill ability in solving mathematical problems. Journal of Physics Conference Series, 1180, 012015. https://doi.org/10.1088/1742-6596/1180/1/012015

Utemov, V. V., & Masalimova, A. R. (2017). Differentiation of Creative Mathematical Problems for Primary School Students. Eurasia Journal of Mathematics Science and Technology Education, 13(8). https://doi.org/10.12973/eurasia.2017.00931a

Yang, J., & Zhao, X. (2021). The effect of creative thinking on academic performance: Mechanisms, heterogeneity, and implication. Thinking Skills and Creativity, 40, 100831. Elsevier BV. https://doi.org/10.1016/j.tsc.2021.100831

Zakeri, N. N. binti, Hidayat, R., Sabri, N. A. binti M., Yaakub, N. F. binti, Balachandran, K. S., & Azizan, N. I. binti. (2022). Creative methods in STEM for secondary school students: Systematic literature review. Contemporary Mathematics and Science Education (Vol. 4, Issue 1). https://doi.org/10.30935/conmaths/12601

Zhanqiang, M. (2023). Strategies for Cultivating Creative Thinking Ability of Students Majoring in Educational Technology. Frontiers in Educational Research, 6(19). https://doi.org/10.25236/fer.2023.061911

Zuhra, M., Anwar, A., & Mailizar, M. (2021). The development of ethnomathematics-based mathematics students worksheet for junior high schools using contextual approach. AIP Conference Proceedings, 2331, 20025. American Institute of Physics. https://doi.org/10.1063/5.0045499