



THE ROLE OF DEPORTER LEARNING STYLES in OPTIMIZING PROSPECTIVE TEACHERS' MATHEMATICAL CREATIVE THINKING THROUGH CASE-BASED E-MODULES

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Abstrak

Penelitian ini bertujuan untuk menganalisis pengaruh gaya belajar DePorter dan penggunaan e-modul teori grup berbasis metode kasus terhadap kemampuan berpikir kreatif matematis calon guru. Kajian yang mengintegrasikan kerangka gaya belajar DePorter dengan e-modul berbasis metode kasus pada pembelajaran teori grup di pendidikan tinggi matematika Indonesia masih relatif terbatas. Penelitian ini menggunakan pendekatan kuantitatif dengan desain quasi experiment nonequivalent control group. Partisipan penelitian terdiri atas 52 mahasiswa Program Studi Pendidikan Matematika STKIP Gotong Royong Masohi yang terbagi ke dalam kelompok eksperimen (30 mahasiswa) dan kelompok kontrol (22 mahasiswa). Instrumen penelitian meliputi angket gaya belajar DePorter, tes kemampuan berpikir kreatif matematis (Content Validity Index/CVI = 0,89; Cronbach's α = 0,84), dan lembar observasi (Cohen's κ = 0,78). Data dianalisis menggunakan uji Shapiro-Wilk, uji Levene, normalized gain (N-gain), dan ANOVA dua arah. Hasil penelitian menunjukkan bahwa kelompok eksperimen memperoleh peningkatan kemampuan berpikir kreatif matematis yang lebih tinggi (N-gain = 0,72; kategori tinggi) dibandingkan kelompok kontrol (N-gain = 0,48; kategori sedang). Hasil ANOVA menunjukkan bahwa gaya belajar ($F(2,46)=5,87$; $p=0,004$; $\eta^2p=0,20$), jenis e-modul ($F(1,46)=8,21$; $p=0,001$; $\eta^2p=0,29$), dan interaksi keduanya ($F(2,46)=4,65$; $p=0,013$; $\eta^2p=0,17$) berpengaruh signifikan terhadap kemampuan berpikir kreatif matematis. Mahasiswa yang diklasifikasikan sebagai pembelajar kinestetik menunjukkan skor rata-rata tertinggi. Temuan ini mengindikasikan bahwa e-modul berbasis metode kasus yang dirancang secara diferensiatif berpotensi mendukung pengembangan kemampuan berpikir kreatif matematis calon guru.

Kata kunci: Gaya Belajar Deporter; Berpikir Kreatif Matematis; E-Modul; Case Method; Teori Grup.

Abstract

This study aimed to examine the effects of DePorter learning styles and a case method-based group theory e-module on preservice teachers' mathematical creative thinking ability. Research integrating the DePorter learning style framework with case method-based e-modules in group theory learning within Indonesian higher mathematics education remains limited. This study employed a quantitative approach using a quasi-experimental nonequivalent



control group design. The participants were 52 students of the Mathematics Education Program at STKIP Gotong Royong Masohi, consisting of 30 students in the experimental group and 22 students in the control group. The research instruments included a DePorter learning style questionnaire, a mathematical creative thinking test (Content Validity Index/CVI = 0,89; Cronbach's α = 0,84), and an observation sheet (Cohen's κ = 0,78). Data were analyzed using the Shapiro–Wilk test, Levene's test, normalized gain (N-gain), and two-way ANOVA. The results indicated that the experimental group achieved a higher improvement in mathematical creative thinking ability (N-gain = 0.72; high category) than the control group (N-gain = 0,48; moderate category). Two-way ANOVA revealed significant effects of learning style ($F(2,46)=5,87$; $p=0,004$; $\eta^2p=0,20$), e-module type ($F(1,46)=8,21$; $p=0,001$; $\eta^2p=0,29$), and their interaction ($F(2,46)=4,65$; $p=0,013$; $\eta^2p=0,17$) on mathematical creative thinking ability. Students classified as kinesthetic learners obtained the highest mean scores. These findings suggest that a differentiated case method-based e-module has the potential to support the development of preservice teachers' mathematical creative thinking ability.

Keywords: Deporter Learning Style; Mathematical Creative Thinking; E-Module; Case Method; Group Theory.

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INTRODUCTION

The development of mathematical creative thinking has become a major concern in mathematics education because it enables learners to generate multiple solution strategies, establish novel mathematical connections, and construct original mathematical arguments when solving complex problems (Silver, 1997; Leikin & Lev, 2013; Yuniarti et al., 2017; Sumarni & Kadarwati, 2020). In the context of teacher education, mathematical creative thinking is particularly important because prospective teachers are expected not only to solve mathematical problems creatively but also to design learning environments that foster creativity among future students. Consequently, higher education institutions responsible for teacher preparation must provide learning experiences that support the development of creative mathematical thinking.

This need is increasingly relevant in Indonesia following the implementation of the Merdeka Curriculum, which emphasizes higher-order thinking skills,



creativity, and learner-centered pedagogy (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2022). The successful implementation of these educational reforms depends largely on the readiness of future teachers to facilitate creative and meaningful learning experiences. Therefore, strengthening mathematical creative thinking among prospective teachers has become an important objective in mathematics teacher education programs.

Third-semester students in the Mathematics Education Study Program at STKIP Gotong Royong Masohi represent an important stage in intellectual development. According to Perry's model, university students gradually progress from dualistic thinking toward more relativistic and reflective reasoning (Perry, 1970; Pascarella & Terenzini, 2005). At this stage, students begin to recognize that mathematical problems may have multiple valid approaches and interpretations. Such cognitive development is closely related to mathematical creativity because it encourages learners to generate alternative solutions, evaluate different perspectives, and construct original mathematical arguments.

Despite these developmental opportunities, preliminary findings indicate that prospective teachers' mathematical creative thinking remains relatively low (Nufus et al., 2024; Kumandaş-Öztürk & Ulu-Kalın, 2025; Ismunandar et al., 2020). A diagnostic assessment administered to 52 third-semester students enrolled in the Group Theory course during the 2023/2024 academic year produced an average score of 58.13 out of 100. Lower achievement was particularly evident in flexibility and originality indicators, suggesting that many students experienced difficulties generating diverse solution strategies and novel mathematical ideas. Classroom observations further revealed a tendency to rely on procedural approaches and limited exploration of alternative solutions. These findings indicate the need for instructional interventions that can effectively support the development of mathematical creative thinking.

One factor that may influence students' engagement in learning is individual learning characteristics. DePorter classifies learning styles into visual, auditory, and



kinesthetic modalities (DePorter, 2019). Visual learners tend to process information through images and representations, auditory learners through listening and discussion, whereas kinesthetic learners learn through active engagement and direct experience. The visual–auditory–kinesthetic (VAK) framework provides a useful perspective for designing varied learning experiences that accommodate learner preferences. Nevertheless, contemporary studies have reported inconsistent evidence regarding the effectiveness of matching instructional methods to learning styles (Rogowsky et al., 2020; Fallace, 2023; Malvigie et al., 2023). Accordingly, learning styles in this study are not treated as deterministic predictors of achievement but as learner characteristics that may interact with instructional approaches in supporting mathematical creative thinking.

Among various instructional approaches, the case method has attracted increasing attention because it promotes higher-order thinking through the analysis of authentic or realistic situations. Unlike traditional lecture-based instruction, the case method encourages learners to evaluate evidence, consider multiple perspectives, justify decisions, and construct reasoned solutions (Rahmat et al., 2023; Dewi et al., 2024; Tsekhmister, 2023; Xiang et al., 2025; Kim & Choi, 2021). Such activities are closely aligned with the processes involved in mathematical creative thinking. When integrated into digital learning resources, the case method can provide structured opportunities for exploration, reflection, and independent learning (Turnip et al., 2021; Rofikoh et al., 2024).

In this study, the case method was implemented through a Group Theory e-module containing contextualized cases designed to stimulate mathematical creative thinking. Group Theory was selected because its abstract and axiomatic nature requires students to verify mathematical structures, examine multiple possibilities, evaluate logical consistency, and construct valid arguments (Veith et al., 2022a, 2022b; Subroto et al., 2023; Subedi, 2020). These characteristics make it a suitable context for investigating the development of mathematical creativity through innovative instructional interventions.



Although studies examining learning styles, mathematical creativity, and technology-enhanced learning have increased in recent years, several important gaps remain. First, previous studies have generally investigated learning styles and mathematical creative thinking separately rather than examining their interaction within a differentiated learning environment. Second, research integrating the DePorter learning style framework into case method-based e-modules is still limited. Third, empirical evidence regarding such integration in higher mathematics education, particularly in abstract domains such as Group Theory, remains scarce. Consequently, there is a need for research that examines how learner characteristics and case method-based digital learning resources jointly contribute to the development of mathematical creative thinking among prospective teachers.

Therefore, this study aims to analyze the effects of DePorter learning styles and a case method-based Group Theory e-module on prospective teachers' mathematical creative thinking. Specifically, the study investigates the effects of learning styles, the use of a case method-based e-module, and the interaction between these variables. The findings are expected to contribute to the development of differentiated instructional strategies and technology-enhanced learning environments that support mathematical creativity in teacher education.

METHOD

This study employed a quantitative approach using a quasi-experimental design, specifically the nonequivalent control group design (Sohilait, 2020). The design was selected because students had been assigned to intact classes before the study commenced, making random assignment impractical. Nevertheless, the equivalence of the experimental and control groups was examined through pretest scores and prerequisite mathematics achievement to support valid group comparisons (Creswell & Creswell, 2017). To reduce potential threats to internal validity, such as selection bias, maturation, and testing effects, both groups were taught by the same lecturer, received the same course content, followed the same learning schedule, and completed identical pretest and posttest instruments.



Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experimental	O ₁	X ₁	O ₂
Control	O ₁	X ₀	O ₂

Notes:

- X₁ : Learning using a case method-based group theory e-module integrated with DePorter learning style characteristics.
- X₀ : Learning using a conventional e-module without learning style differentiation.
- O₁ : Mathematical creative thinking pretest.
- O₂ : Mathematical creative thinking posttest.

The population consisted of 84 third-semester students enrolled in the Group Theory course in the Mathematics Education Program at STKIP Gotong Royong Masohi during the 2023/2024 academic year. The sample comprised 52 students selected through purposive sampling based on two criteria: (1) comparable pretest performance and prerequisite mathematics achievement, and (2) willingness to participate in technology-mediated learning activities. The experimental group consisted of 30 students, while the control group consisted of 22 students. An independent-samples t-test confirmed no significant difference in initial mathematical ability between the two groups ($t = 0.28$, $p = 0.78$), indicating baseline equivalence.

The study involved two independent factors. The first factor was DePorter learning style, categorized as visual, auditory, and kinesthetic. The second factor was e-module type, consisting of a case method-based e-module and a conventional e-module. The dependent variable was mathematical creative thinking ability.

Learning styles were identified using a DePorter learning style questionnaire adapted from Quantum Learning theory (DePorter, 2019). The questionnaire consisted of 30 items using a five-point Likert scale and measured visual, auditory, and kinesthetic tendencies. Students were classified according to the highest score obtained among the three dimensions.

Mathematical creative thinking ability was measured using a five-item essay test developed based on five indicators: sensitivity, fluency, flexibility, originality, and elaboration (5K). Each indicator was assessed using an analytic



rubric ranging from 0 to 4, where higher scores represented stronger creative thinking performance. The maximum total score was 100. Example tasks required students to analyze algebraic structures, determine group properties, construct proofs, and generate alternative solutions in group theory contexts.

Content validity was evaluated by three experts consisting of two mathematics education professors and one educational measurement specialist. The instrument achieved a Scale Content Validity Index (S-CVI/Ave) of 0.89, indicating high content validity. Reliability analysis yielded Cronbach's alpha coefficients of 0.84 for the mathematical creative thinking test and 0.81 for the learning style questionnaire, demonstrating satisfactory internal consistency. In addition, student responses were scored independently by two raters, resulting in an inter-rater reliability coefficient (Cohen's κ) of 0.78, indicating substantial agreement.

Classroom observations were conducted throughout the intervention using a structured observation sheet covering student engagement, participation in case discussions, collaborative interaction, and creative responses during learning activities. These observations were used to support the interpretation of quantitative findings.

The intervention was implemented over eight meetings. Students in the experimental group learned through a case method-based e-module containing authentic group theory cases, guided investigations, collaborative discussions, reflective activities, and differentiated learning supports aligned with visual, auditory, and kinesthetic characteristics. Meanwhile, the control group used a conventional e-module containing the same content without differentiated learning supports.

Data analysis was conducted in several stages. First, assumption testing was performed using the Shapiro–Wilk test for normality and Levene's test for homogeneity of variance. Second, improvement in mathematical creative thinking ability was calculated using normalized gain (N-gain) and interpreted according to



Hake's criteria. Third, a two-way ANOVA was employed to examine the main effects of learning style and e-module type, as well as their interaction on mathematical creative thinking ability. When significant differences were detected, post hoc comparisons were conducted using Tukey–Kramer procedures to accommodate unequal group sizes. All statistical analyses were performed using IBM SPSS Statistics version 26 with a significance level of 0.05.

RESULT AND DISCUSSION

Prior to hypothesis testing, assumption tests were conducted to ensure that the data met the requirements for parametric analysis. Normality was examined using the Shapiro–Wilk test, while homogeneity of variance was assessed using Levene's test. The results of the Shapiro–Wilk test indicated that both pretest and posttest scores in the experimental and control groups were normally distributed ($p > 0.05$). Furthermore, Levene's test yielded a significance value of 0.267 ($p > 0.05$), indicating homogeneity of variance across groups. Therefore, the data satisfied the assumptions required for two-way ANOVA.

The improvement in mathematical creative thinking ability was measured using normalized gain (N-gain). Table 2 presents the descriptive statistics.

Table 2. Mean Pretest, Posttest, and N-Gain Scores

Group	Pretest	Posttest	N-Gain	Category
Experimental	58.40	85.60	0.72	High
Control	57.90	74.30	0.48	Moderate

The results indicate that both groups experienced improvement after the intervention. However, the experimental group achieved a higher increase in mathematical creative thinking ability than the control group. Based on Hake's classification, the experimental group reached the high category, whereas the control group remained in the moderate category.



To examine the effects of learning style, e-module type, and their interaction on mathematical creative thinking ability, a two-way ANOVA was performed.

Table 2. Two-Way ANOVA Results

Source of Variation	df	SS	MS	F	p	η^2p
Learning Style	2	186.42	93.21	5.87	0.004	0.20
E-Module Type	1	130.37	130.37	8.21	0.001	0.29
Interaction	2	147.62	73.81	4.65	0.013	0.17
Error	46	730.15	15.87	—	—	—
Total	51	1194.56	—	—	—	—

The analysis revealed significant main effects of learning style ($F(2,46)=5.87$, $p=0.004$, $\eta^2p=0.20$) and e-module type ($F(1,46)=8.21$, $p=0.001$, $\eta^2p=0.29$). In addition, a significant interaction effect was observed between learning style and e-module type ($F(2,46)=4.65$, $p=0.013$, $\eta^2p=0.17$). According to Cohen's criteria, these effect sizes can be interpreted as moderate to large, indicating that both factors contributed meaningfully to variations in mathematical creative thinking ability.

Post hoc comparisons using the Tukey–Kramer procedure were conducted to identify differences among learning style groups.

Table 4. Mean Scores by Learning Style

Learning Style	Mean
Kinesthetic	83.75
Visual	78.20
Auditory	74.65

Table 5. Tukey–Kramer Post Hoc Comparisons

Comparison	MD	SE	95% CI	p
Kinesthetic vs. Auditory	9.10	2.84	[3.35, 14.85]	0.007*
Kinesthetic vs. Visual	5.55	2.76	[-0.03, 11.13]	0.122
Visual vs. Auditory	3.55	2.91	[-2.34, 9.44]	0.437

Only the comparison between kinesthetic and auditory learners reached statistical significance. Although students classified as kinesthetic learners obtained the highest mean score, no significant difference was found between kinesthetic and visual learners.



The findings indicate that students who learned through the case method-based e-module demonstrated greater improvement in mathematical creative thinking ability than those who used the conventional e-module. This result suggests that learning activities involving authentic cases, guided investigations, collaborative discussions, and reflective problem solving may provide richer opportunities for students to generate, evaluate, and refine mathematical ideas.

The significant effect of e-module type supports previous studies reporting that case-based and technology-supported learning environments can facilitate higher-order thinking skills and creativity (Tsekhmister, 2023; Turnip et al., 2021). Through authentic group theory cases, students were encouraged to analyze mathematical structures, construct arguments, explore alternative solutions, and justify their reasoning. These activities are closely related to the dimensions of fluency, flexibility, originality, and elaboration that characterize mathematical creative thinking.

The significant effect of learning style should be interpreted cautiously. The findings do not imply that learning style directly determines learning success. Rather, they indicate that students classified according to the DePorter framework responded differently to the learning environment provided in this study. This interpretation is consistent with contemporary perspectives that view learning styles as learning preferences rather than fixed determinants of achievement. Rogowsky et al. (2020) argued that empirical evidence supporting strict learning-style matching remains inconclusive. Therefore, the present findings are better understood as evidence that different learner characteristics may interact with instructional design in shaping learning outcomes.

The significant interaction effect between learning style and e-module type further suggests that the effectiveness of instructional interventions may vary across learner groups. Students classified as kinesthetic learners obtained the highest mean scores, particularly when engaged in activities requiring active exploration, manipulation of mathematical ideas, and investigation of group theory



cases. Nevertheless, post hoc analysis revealed a significant difference only between kinesthetic and auditory learners, while differences involving visual learners were not statistically significant. Consequently, claims regarding the superiority of one learning style over another should be avoided.

From a theoretical perspective, the findings support constructivist learning theory, which emphasizes that knowledge is actively constructed through meaningful experiences and social interaction (Çibukçiu, 2025). The case method-based e-module provided opportunities for students to engage in exploration, discussion, reflection, and verification, all of which are important processes in developing mathematical creativity. The findings are also consistent with multimedia learning principles suggesting that learning resources integrating multiple forms of representation can facilitate deeper cognitive processing.

Practically, the results suggest that e-module developers and mathematics educators should design learning environments that provide diverse forms of engagement, including visual representations, discussion opportunities, and active problem-solving experiences. Such differentiated learning supports may help accommodate diverse learner characteristics while promoting mathematical creative thinking among preservice teachers (Am et al., 2023; Insorio, 2024a, 2024b).

Several limitations should be acknowledged when interpreting the findings of this study. First, the sample size was relatively small and drawn from a single Mathematics Education Program at STKIP Gotong Royong Masohi. Consequently, the generalizability of the findings to other institutions, disciplines, or educational contexts should be approached with caution.

Second, the study employed a quasi-experimental nonequivalent control group design, which did not allow for random assignment of participants. Although baseline equivalence was established through pretest scores and several procedures were implemented to minimize threats to internal validity, the possibility of



uncontrolled confounding variables cannot be completely eliminated. Therefore, causal interpretations should be made carefully.

Third, learning style classification was based on a self-report questionnaire adapted from the DePorter framework. While the instrument demonstrated satisfactory validity and reliability, self-reported measures may not fully capture the complexity and dynamic nature of individual learning preferences. Moreover, contemporary research has questioned the extent to which learning style classifications alone can explain differences in learning outcomes.

Fourth, the intervention was conducted within the context of a single course, namely Group Theory, over a limited instructional period. Therefore, the effectiveness of the case method-based e-module may vary when implemented in different mathematical domains, educational levels, or learning environments.

Future studies are recommended to involve larger and more diverse samples, include multiple higher education institutions, employ more rigorous experimental designs, and examine additional learner characteristics that may interact with instructional interventions. Such efforts would provide stronger evidence regarding the effectiveness of differentiated case method-based e-modules in enhancing mathematical creative thinking ability.

CONCLUSION

This study investigated the effects of DePorter learning styles and a case method-based group theory e-module on preservice teachers' mathematical creative thinking ability. The findings indicate that students who learned through the case method-based e-module demonstrated greater improvement in mathematical creative thinking ability than those who used a conventional e-module. Furthermore, significant effects were identified for learning style, e-module type, and the interaction between these factors. Students classified as kinesthetic learners obtained the highest mean scores, although statistically significant differences were observed only between the kinesthetic and auditory groups.



The findings suggest that the effectiveness of instructional interventions may be influenced by the interaction between learner characteristics and learning environments. However, the results should not be interpreted as evidence that learning styles directly determine learning success. Rather, the study highlights the potential value of designing learning experiences that accommodate diverse learner characteristics through authentic, collaborative, and problem-centered activities.

From a theoretical perspective, this study contributes to the growing body of research on mathematical creative thinking by demonstrating how differentiated learning supports embedded within a case method-based e-module can facilitate creative mathematical engagement. From a practical perspective, the findings provide implications for mathematics educators and instructional designers in developing digital learning resources that encourage exploration, discussion, reflection, and multiple problem-solving approaches.

Considering the limitations of the present study, future research is recommended to involve larger and more diverse samples, include multiple institutions, employ more rigorous experimental designs, and investigate additional learner characteristics that may interact with innovative instructional interventions. Such studies may provide stronger evidence regarding the role of differentiated digital learning environments in supporting the development of mathematical creative thinking among preservice teachers.

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