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The relationship between independent learning and mathematical creative thinking ability in vocational high school students

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Abstract

This study contributes to mathematics education by clarifying how independent learning supports students' creative thinking processes, particularly in vocational contexts where autonomy and problem-solving skills are crucial. This study focuses on students' learning independence and creative thinking skills with the aim of determining whether there is a relationship between learning independence and creative thinking skills among vocational high school students. This study uses a quantitative descriptive approach with a correlational method conducted at one of the vocational high schools in Tangerang City, Banten Province. The sample in this study consisted of 30 students from the 10th-grade Multimedia class. Data collection techniques included observation, a 24-item questionnaire, and a written test with 5 questions. The instruments were validated by experts and declared suitable for use, ensuring content validity and reliability. Based on the results of the study conducted in the Multimedia class, it can be concluded that the level of learning independence and creative thinking ability of students is above average, with 13 students (43.33%) scoring below average and 17 students (56.66%) scoring above average, and further analysis shows a strong positive correlation ($r = 0.970$, $p < 0.01$) between the two variables. Based on the hypothesis test, there is a significant relationship between learning independence and students' creative thinking ability.

Keywords: independence; creative mathematical thinking; vocational high school

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I. Introduction

Education plays an important role in life. In the world of education, it is necessary to apply methods or steps to improve the quality of education, especially in Indonesia. Various efforts by the Indonesian government, such as curriculum reforms and the establishment of National Education Standards, have been made to improve learning quality (Barlia, Solekah & Rahayu, 2022). However, despite these efforts, international assessments such as PISA continue to show that Indonesian students' mathematical literacy and problem-solving remain below the OECD average (OECD, 2019; Schleicher, 2019). This indicates that teaching has not yet reached a higher level of quality, and expected

competencies in areas such as problem-solving and mathematical creative thinking have not been fully achieved (Nurfatimah, Hasna & Rostika, 2022; Razzaq & Nurnaifah, 2022; Safitri, Yunianti & Rostika, 2022; Maulansyah, Febrianty & Asbari, 2023). Therefore, there is a need to improve the quality of education to achieve better learning objectives. Strengthening students' independent learning and mathematical creative thinking is essential in vocational education, as these abilities determine their readiness to solve practical, industry-related problems. Therefore, identifying how independent learning influences creative thinking is crucial for improving mathematics instruction in vocational schools.

Achieving learning objectives must be balanced with advances in information technology that create effective, efficient educational tools for success in education. Technology-based learning can help students learn independently. Independent learning is the process of acquiring knowledge to achieve specific goals (Maskar & Wulantina, 2019; Pertiwi, Nurfatimah & Hasna, 2022). Independent learning has been identified as a critical factor that fosters students' capacity to engage actively with mathematics. Recent studies highlight that students with higher levels of self-regulation and independent learning strategies demonstrate stronger persistence and problem-solving outcomes (Panadero, 2017; OECD, 2021). In the Indonesian context, however, research still shows relatively low levels of learning independence, which hampers students' mathematical creativity (Gustina, Melisa & Delyana, 2021; Afifah & Harahap, 2023; Lovez & Sayu, 2023), as the lack of learning independence results in inadequate mathematical strategic abilities in the process of solving relatively unstructured problems, as well as not knowing how to carry out the problem-solving process (Ratnasari, Dwiyanti, Febriana, Nasrullah & Caesarani, 2023). Thus, learning independence is one of the keys to success in achieving good learning outcomes.

Students' mathematics learning outcomes have a direct positive influence on their learning independence. The aspect of independence in mathematics is important because, in learning mathematics, students are required to practice more independently in order to develop their mathematical competence (Nurhafsari & Sabandar, 2018). Independence means that students do not depend on others. Students will be able to learn in their own way and through their own efforts, allowing them to determine the learning methods they find most effective. The independence referred to here is not merely learning without a teacher's guidance, but rather students training themselves to take the initiative to learn and to seek out what they do not yet know from various sources with confidence.

Several indicators can be used to measure the achievement of success in independent learning. According to Rita, Dewi, Sumarno & Prasetiyo (2010), the indicators of independent learning are setting learning goals, diagnosing learning needs, monitoring and managing learning time, viewing difficulties as challenges, and self-efficacy (Kurnia, Mulyani, Rohaeti & Fitrianna, 2018). According to Mujiman (2006), indicators of independence include self-confidence, active participation in learning, discipline in learning, and responsibility in learning (Handayani & Ariyanti, 2020). Additionally, according to Darmawanti (2020), indicators of independence in understanding mathematical concepts include students being able to present learning materials, classify learning materials, solve problems related to the materials, and provide solutions to problems (Widodo, Prayitno & Widyasari, 2021). The indicators of learning independence used in this study are: initiative to learn, responsibility in learning, self-confidence, and motivation to learn. In vocational high schools, however, these indicators are often underdeveloped; students tend to rely on peers, show low confidence in tackling mathematical tasks, and have limited motivation to explore alternative solutions. This lack of independence is closely linked to their limited creative mathematical thinking, as observed in previous studies of vocational

students (Hikmah, Khairunnisa, & Nuriadin, 2020).

Independent learning triggers creative thinking in students. According to Dilla, Hidayat, and Rohaeti (2018), creative thinking is a cognitive ability that supports students' learning success (Astuti, Bintang, Utami, & Akbar, 2020). However, it is unfortunate that creative thinking skills are still lacking in mathematics education, even though in mathematics education, creative thinking can help students tackle mathematical problems and solve them using their own abilities (Febrianingsih, 2022). Creative thinking is an important aspect of social life, as it can contribute positively to greater openness and easier adaptation to any problems encountered in life. Meanwhile, those who lack a challenging environment and/or are not adequately conditioned will not develop their creative potential to the fullest.

Teaching and learning activities in education are a form of creativity. Students' creativity can emerge suddenly, with or without coercion, and in any place (Astuti et al., 2020). Therefore, it is necessary to train them so that their creativity can find the right ideas and timing. These creative ideas must be present at the right time when facing various mathematical problems. Additionally, creative thinking can motivate students in their learning, especially for those with lower levels of creative thinking who will strive to improve, while those with higher levels of creativity will serve as motivators for others.

Students' creative thinking skills have improved through the Treffinger learning model. The results obtained from the six selected students showed that four students were able to measure creative thinking indicators. Students' independence in solving problems through the Treffinger learning model showed that almost all students met the criteria for learning independence (Afnan, Ikhsan, & Duskri, 2020). The mathematical creative thinking ability of high school students is positively influenced by mathematical learning independence by 87.5%, while 12.5% is influenced by factors other than mathematical learning independence (Akhdiyat & Hidayat, 2018). Students' independence and creativity have both been shown to significantly contribute to academic achievement (Sari, Hidayah, & Najibufahmi, 2021). While these studies confirm that independence and creativity are closely related, they were generally conducted in the context of general high school or university students. Few studies have specifically examined how learning independence relates to creative mathematical thinking among vocational high school students, who face unique challenges in connecting mathematics to applied fields. This indicates a gap in the literature that this study aims to address. Therefore, the novelty of this research lies in exploring the relationship between learning independence and mathematical creative thinking, specifically within the vocational school context, and in providing evidence that has not been sufficiently discussed in prior studies. This study aims to examine the relationship between learning independence and mathematical creative thinking among vocational high school students. Theoretically, it fills a gap in literature by focusing on the vocational mathematics context, and it provides insights for teachers to design strategies that foster both independence and creativity.

II. Research Method

This study aims to determine the relationship between learning independence and creative thinking abilities among vocational high school students. Therefore, the appropriate approach for this study is a quantitative descriptive design with a correlational method. According to Azwar (2010), correlational research aims to investigate the extent to which variations in one variable are related to variations in one or more other variables (Wigunawati, 2017). This study was conducted in the 10th grade of a vocational high school located in one of the schools in Tangerang City, Banten Province. The participants in this study were 30 vocational high school students (n = 30) from the Multimedia Department. The sampling technique used in this

study was purposive sampling. Purposive sampling is a technique for determining samples based on specific considerations (Sugiyono, 2019). The researcher used purposive sampling to obtain samples that reflected the study's objectives and met the criteria for providing information.

The data collection techniques used in this study were observation, questionnaires, and tests. There was one independent variable and one dependent variable in this study. The independent variable in this study was learning independence (X), and the dependent variable was creative thinking ability (Y). To determine the extent of students' learning independence and creative thinking abilities, indicators are needed to assess progress toward these goals. The indicators of learning independence used in this study are initiative to learn, responsibility in learning, self-confidence, and motivation to learn independently. The indicators of creative thinking ability used in this study are fluency, which is the ability to generate many ideas that are relevant to fluent thinking; flexibility, which is the ability to generate different thoughts and be able to change methods; originality, which is the originality of writing that focuses on the ability of students to generate answers; and elaboration, which is the ability to develop diverse ideas and solve problems in diverse ways.

The instruments used were observation guidelines, questionnaires, and written tests. The observation was used to document students' behaviors related to initiative, independence, and persistence during mathematics activities. The purpose of the observation was to triangulate the questionnaire and test data and provide additional qualitative insights to support the interpretation of the findings. The questionnaire used in this study was a summated rating scale (Likert scale) used to measure the extent of students' learning independence in mathematics lessons. In this study, a checklist questionnaire with 12 positive questions and 12 negative questions was used. Students chose only one answer from the 5 categories provided.

Table 1. Independence learning guidelines

Variable	Indicator	Items Number	
		Positive	Negative
Independent Learning	Taking the initiative to learn	1, 2, 4	3, 5, 6
	Taking responsibility for learning	7, 9, 10	8, 11, 12
	Having self-confidence	13, 15, 17	14, 16, 18
	Having the motivation to learn	19, 20, 21	22, 23, 24

The written test consisted of 5 essay questions on trigonometry, designed to measure students' mathematical creative thinking ability. The content coverage included determining trigonometric ratios in right-angled triangles, applying the cosine rule, and solving contextual problems involving heights, distances, and triangle areas. Accordingly, student responses to each item were evaluated using a rubric that assessed fluency, flexibility, originality, and elaboration, as presented below.

Table 2. Rubric's creative thinking assessment

Indicator	Aspects assessed	Score
Fluency	Not answering or giving ideas that are not relevant to the problem.	0
	Giving ideas that are not relevant to solving the problem.	1
	Giving a relevant idea, but the answer is wrong.	2
	Giving more than one relevant idea, but the answer is wrong.	3
	Giving more than one relevant idea, and the solution is correct and clear.	4
Flexibility	Did not answer or give one or more answers, but all were incorrect.	0
	Gave one answer, but it was incorrect.	1
	Gave one answer, and the calculation process and result were correct.	2

	Gave more than one answer (various), but some of the results were incorrect due to errors in the calculation process.	3
	Gave more than one answer (various), and the calculation process and results were correct.	4
Originality	Did not answer or give the wrong answer.	0
	Gave an answer in their own way, but it was incomprehensible.	1
	Gave an answer in their own way, the calculation process was on track but was not completed.	2
	Gave an answer in their own way, but there was an error in the calculation process, resulting in the wrong answer.	3
	Gave an answer in their own way, the calculation process and answer were correct.	4
Elaboration	Did not answer or gave the wrong answer.	0
	There were errors in the answers, and no details were provided.	1
	There were errors in the answers, but the details provided were insufficient.	2
	There were errors in the answers, but the details provided were sufficient.	3
	Gave correct and detailed answers.	4

Source: Moma, 2015

The validity of the tests and questionnaires was determined through expert assessment provided by two lecturers from the mathematics education study program. The instrument validation process involved presenting the instruments to assessors using the validation sheet as a guide. After expert validation, the instruments were deemed suitable for use, subject to revision in accordance with the experts' recommendations.

Data analysis techniques in this study began with descriptive statistics to provide an overview of students' learning independence and creative thinking abilities. Inferential statistics were then applied to test the research hypotheses. Specifically, a Pearson product-moment correlation test was used to examine the relationship between learning independence and mathematical creative thinking. Furthermore, a simple linear regression analysis was conducted to determine the extent to which learning independence could predict students' creative thinking ability. The hypotheses tested were: (H_0) there is no significant relationship between learning independence and mathematical creative thinking ability of vocational high school students; (H_1) there is a significant positive relationship between the two variables."

This study used standard deviation and variance as measures of data distribution. In this study, calculations were performed using SPSS 25. Subsequently, prerequisite tests for analysis were conducted. The normality test is a prerequisite for determining the type of statistics to be used in further analysis. Data normality was tested using the Kolmogorov-Smirnov (K-S) test as part of the statistical test analysis in this study. A good correlation equation is one in which the independent and dependent variables are normally distributed or close to normal for all variables. Data is normally distributed if it has a significant value > 5% (asymp. sig. (2-tailed) > 0.05), and data is declared not normally distributed if the significance value is < 5% (asymp. sig. (2-tailed) < 0.05). After conducting the prerequisite test, the researcher conducted a regression linearity test and a Product-Moment correlation test to determine the degree of closeness of the relationship between the variables, as expressed by the correlation coefficient.

Data analysis was conducted using the following procedures: (1) descriptive statistics to summarize students' independent learning and creative thinking scores, (2) linearity testing to determine whether the relationship between variables met parametric assumptions, and (3) Pearson correlation analysis to examine the

relationship between independent learning and mathematical creative thinking. All analyses were performed at the standard significance level (α = .05).

III. Results and Discussion

This study refers to initial observations made by researchers in class X MM, which indicate that students' independence in learning mathematics remains low. This can be seen when many students do not do their homework assigned by the teacher in the previous meeting, indicating that students' motivation to learn independently is low. This is in line with the research conducted by Rismalasari and Afrilianto (2021) on the lack of independence in learning, as seen from the learning outcomes of students who scored below the minimum passing grade, which showed that almost half of the students were below the minimum passing grade. In addition, when the teacher gave assignments in class, many students still relied on their friends to complete the assignments given by the teacher. This is also in line with the research by Simamora, Khairullah, and Suryanti (2022), which found that two participants in their study relied on their friends when completing mathematics assignments due to a lack of confidence in their abilities. In mathematics learning, students only rely on the formulas listed in the student worksheet.

Students always complete assignments using the formulas provided in the worksheets, without utilizing other formulas related to the task. However, in mathematics education, creative thinking skills are essential for solving mathematical problems.

The researcher conducted the study in a Grade 10 Multimedia class consisting of 30 students (n = 30). The results of the data analysis in this study are as follows:

Data Description

The following data description contains information on the mean, median, mode, standard deviation, and variance of each research variable.

1. Student Learning Independence

The student learning independence instrument consists of 24 items with 5 alternative answers. The scores given are SS, S, N, TS, and STS. This means that the lowest score is 24 and the highest score is 120.

Based on the data obtained from the respondents in this study, the lowest score was 50 and the highest score was 72. From statistical calculations in SPSS 25, the mean was 62.57, the median was 63.00, the mode was 63, the standard deviation was 5.211, and the variance was 27.151.

Table 3. Frequency distribution of student learning independence

Interval	f	f (%)	cf	cf (%)
50-53	1	3.33	1	3.33
54-57	4	13.33	5	16.67
58-61	6	20	11	36.67
62-65	11	36.67	22	73.33
66-69	4	13.33	26	86.67
70-73	4	13.33	30	100

Based on Table 3, the highest-frequency interval is 62-65, with 11 students. It was also found that 13 students (43.33%) had scores below average, and 17 students (56.66%) had scores above the average. It can be concluded that student learning independence is above the average score.

2. Creative Thinking Ability

The number of items in the creative thinking ability tests consists of 5 items. The scores given are 0, 1, 2, 3, 4. This means that the lowest score is 0 and the highest score is 20. With the highest value being 100 and the lowest value being 0.

Based on the data obtained from the respondents in this study, the lowest score was 20 and the highest score was 90. From statistical calculations using SPSS 25, the mean was 59.67, the median was 62.50, the mode was 90, the standard deviation was 21.930, and the variance was 480.920.

Table 4. Frequency distribution of creative thinking ability

Interval	f	f (%)	cf	cf (%)
20-31	5	16,67	5	16,67
32-43	2	6,67	7	23,33
44-55	7	23,33	14	46,67
56-67	5	16,67	19	63,33
68-79	5	16,67	24	80
80-91	6	20	30	100

Based on Table 4, the 44-55 interval class has the highest frequency, with 7 students. It was also found that 13 students (43.33%) had scores below average, and 17 students (56.66%) had scores above average. It can be concluded that the students' creative thinking ability is above average.

Prerequisite Analysis Testing

1. Normality Test

The normality test determines whether the distribution of research data is normal. The normality test in this study uses SPSS 25.

Table 5. Normality test of student learning independence

	Kolmogrov-Smirnov			Shapiro-Wilk		
Learning Independence	Statistic	df	Sig	Statistic	df	Sig
	0.100	30	0.200	0.980	30	0.818

Based on Table 5, the p-value of 0.818 (> 0.05) indicates that the data are normally distributed.

Table 6. Normality test of creative thinking ability

	Kolmogrov-Smirnov			Shapiro-Wilk		
Creative thinking ability	Statistic	df	Sig	Statistic	df	Sig
	0.0996	30	0.200	0.941	30	0.96

Based on Table 6, the p-value of 0.200 (> 0.05) indicates that the data are normally distributed.

2. Linearity Test

The linearity test aims to determine whether the distribution of the research data is linear. The test used for this linearity test is the F-test. Using SPSS 25, the linearity of the relationship between the independent variable (learning independence) and the dependent variable (creative thinking ability) can be assessed using the deviation from linearity. According to the calculation results, the deviation from linearity between learning independence and students' creative thinking ability is 0.067. According to the criteria, if the deviation from the linearity value is greater than the significance level taken (5%), it means that there is a linear relationship.

Table 7. Summary of linearity test

Variable	Deviation from Linearity	Significance Level	Conclusion
Learning independence and students' creative thinking abilities	0.067	0.05	Linear

Based on Table 7, there is a linear relationship between learning independence and students' creative thinking abilities.

Hypothesis Testing

Hypothesis testing is used to determine the relationship between variables. The hypothesis to be tested is the relationship between learning independence and students' creative thinking ability. Hypothesis testing was conducted using SPSS 25, and the results are presented in Table 8.

Table 8. Correlation test

		Learning Independence	Creative Thinking Ability
Learning Independence	Pearson Correlation	1	.970**
	Sig. (2-tailed)		.000
	N	30	30
Creative Thinking Ability	Pearson Correlation	.970**	1
	Sig. (2-tailed)	.000	
	N	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

Based on Table 8, the significance value is 0.000. It can be concluded that the significance value (0.000) < α (0.005), meaning that there is a significant relationship between learning independence and students' creative thinking ability (n = 30).

The maximum score of 20 from the mathematical creative thinking rubric was converted into a 0–100 scale to facilitate clearer interpretation and comparison of performance levels. The results presented in this section are based on data from 30 vocational students (n = 30) who participated completely in the questionnaire, observation, and creative thinking test. Although the correlation value obtained in this study was very strong (r = .970), this strength may partly be influenced by the sample's relative homogeneity and the characteristics of the instruments used. Therefore, interpreting the correlation coefficient should be done with caution. Future studies are recommended to involve larger, more diverse samples and alternative school contexts to improve the generalizability and robustness of the findings.

These findings support the theoretical framework of self-regulated learning (Panadero, 2017), which states that students with higher autonomy tend to regulate their cognitive processes more effectively, enabling them to generate more flexible and original ideas during mathematical problem solving.

This result is consistent with Akhdiyat & Hidayat (2018), who reported that students' mathematical creative thinking abilities are predominantly influenced by independence in learning. Similarly, Sarjana et al. (2022) found that increases in creative thinking ability and learning independence both contributed to better academic performance. Ratnasari & Nasrullah (2022) also emphasized that creative thinking supports autonomy in learning mathematics. Taken together, these studies and the present findings suggest a reciprocal relationship between learning independence and creativity, reinforcing the idea that independent learners are more likely to think creatively. At the same time, creative thinkers are better positioned to manage their own learning.

Nevertheless, critical reflection is needed. The exceptionally high correlation (r = 0.970) in this study may be inflated by the limited sample size (n = 30), its homogeneity, and potential overlap among the measurement constructs. Thus, while the results support earlier findings, they should be interpreted cautiously and not generalized prematurely.

From a practical perspective, these findings highlight the importance of designing mathematics learning environments that foster both autonomy and creativity. Teachers can implement student-centered approaches, inquiry-based problem-solving, and reflective practices that simultaneously strengthen independence and creative abilities, ultimately improving mathematical achievement (Afnan et al., 2020; Sari et al., 2021).

IV. Conclusion

Based on the results and discussion, this study concludes that there is a very strong and significant relationship between learning independence and creative thinking ability among 10th-grade multimedia students (n = 30). Students with higher levels of learning independence tend to show better creative thinking skills, particularly in aspects of fluency, flexibility, originality, and elaboration. This finding supports the idea that independent learning plays an important role in enhancing students' capacity to think creatively in mathematics.

Theoretically, these results reinforce recent perspectives in educational psychology that emphasize the link between self-regulated learning and higher-order cognitive abilities. Independence in learning provides students with opportunities to regulate their own processes, which in turn encourages the development of creative solutions when faced with mathematical problems.

From a practical perspective, the findings highlight the importance of creating a classroom environment that simultaneously fosters independence and creativity. Teachers can

promote these abilities by implementing student-centered strategies, inquiry-based learning, and reflective practices. Such approaches allow students to become more autonomous while also encouraging them to generate diverse and original solutions.

However, these conclusions should be interpreted with caution. The exceptionally strong correlation observed in this study (r = 0.970) may be influenced by the limited sample size and its homogeneity, as all participants came from the same grade and school, as well as by the nature of the instruments, which may partially overlap in what they measure. Future research should therefore consider using larger and more diverse samples, alternative instruments, and replication studies across different contexts to provide stronger evidence and broader generalizability.

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