# Relationship between Students' Mathematical Literacy and Creative Thinking Ability

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**Abstract.** The purpose of this study is to examine the relationship between students' mathematical literacy and creative thinking ability. This study used an exploratory mixed-methods research design to investigate the relationship between mathematical literacy and creative mathematical thinking capabilities. The participants were 203 students from 7 classes in vocational and pre-professional high school (Sekolah Menengah Kejuruan or SMK), comprising 114 females and 89 males aged 16-17 years. Data were collected through literacy and creative ability tests, videos, and interviews. The findings showed a strong relationship between creative mathematical thinking abilities and mathematical literacy skills. Students with high creative thinking abilities and high mathematical literacy skills exhibited the following characteristics: (1) a good ability to interpret data and diagrams, (2) always double-checking their answers, and (3) greater flexibility in calculations and interpretations. Students with high creative thinking abilities but low mathematical literacy skills exhibited the following characteristics: (1) low self-confidence in their abilities, (2) frequent calculation errors, (3) more structured and easily understandable solutions, and (4) a tendency to rush. Students with low creative thinking abilities but high mathematical literacy skills exhibited the following characteristics: (1) the ability to answer only similar questions or those encountered previously, (2) reliance on formulas, (3) the ability to solve problems using everyday experiences, and (4) a constant focus on quantitative information. Furthermore, students with both low creative thinking abilities and low mathematical literacy skills exhibited the following characteristics: (1) difficulty understanding numerical problems and (2) a lack of focus on the given problems.

## 1 Introduction

Modern civilization relies on mathematical literacy and creative thinking as interrelated skills that enable individuals to adapt to and contribute to the complexities of the modern world. Education systems and societal support for these skills are critical for the continued advancement of civilization. Educational systems play a vital role in nurturing mathematical literacy and creative thinking among students. Dede [1] states that 21st-century skills consist of a wide range of skills and abilities, including creative problem-solving, which are necessary for success in a technological world. Schools should aim to develop both mathematical skills and creative problem-solving abilities to prepare students for the challenges of contemporary civilization. Mathematical literacy can foster creative thinking by encouraging students to explore and apply mathematical concepts in innovative ways.

The correlation between creative thinking ability and mathematical literacy is an interesting and complex one. Creative thinking ability and mathematical literacy are not mutually exclusive. In fact, these can be complementary skills. Creative thinkers can use


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mathematical literacy to express and refine their innovative ideas, while individuals with strong mathematical literacy can apply creative thinking to solve complex problems in novel ways. Mathematical literacy provides a structured and systematic approach to problem-solving. Creative thinking, on the other hand, encourages thinking outside the box. Together, these skills can lead to innovative solutions to real-world problems.

Mathematical literacy and creative thinking can offer different perspectives on problem-solving. Mathematical approaches tend to be more structured, while creative thinking allows for more open-ended exploration. Combining these perspectives can lead to more robust solutions. When individuals possess both strong mathematical skills and creative thinking abilities, they are better equipped to tackle a wide range of challenges and contribute to innovation and problem-solving in various fields. Moreover, a crucial life skill that must be taught in addition to mathematical literacy is creative thinking [2]; creativity is the process of creating a novel and appropriate product, idea, or problem solution valuable to the person or society [3]. By encouraging divergent, original thinking, curiosity, generating predictions and forecasts, and testing, one can build creative activities that incorporate imagination, intuition, and discovery [4].

Studies have found a relationship between creative thinking and mathematical literacy [5, 6, 7], but it has remained limited to identifying the relationship itself. There is a need to explore the relationship between both mathematical literacy and creative thinking abilities in depth to reveal diverse characteristics regarding students' cognitive skills in solving mathematics problems. Therefore, this study explores the relationship between creative thinking and mathematical literacy skills in students more profoundly by examining students' cognitive abilities in solving mathematical literacy problems.

### 1.1 Research Questions

The research question below addresses the purpose of this study:

Is there any relationship between students' mathematical literacy and creative thinking ability?

## 2 Literature Review

### 2.1 Mathematical Literacy

Developing literacy skills that can be applied to the issues of contemporary life is one way to fulfill the demands of the 21st century. According to Mevarech Z. R., Halperin C., and Vaserman [8], mathematical literacy is the capacity to apply mathematical concepts, methods, facts, and instruments to describe, explain, and forecast occurrences. The role of mathematical literacy is to train learners to have the ability to analyze, provide reasoning, value mathematics, and communicate creative solutions to problems in various situations and contexts [9].

### 2.2 Creative Thinking Abilities

Creativity encompasses certain habits of thought to produce unexpected, adaptive, and useful original work [10]. In addition, creative thinking can be defined as a combination of logical thinking and divergent thinking based on intuition but has a realized purpose [11]. According to Silver [12], there are four indicators of creative thinking: (1) fluency (the ability to generate many ideas); (2) flexibility (the ability to generate varied ideas); (3) originality

(the ability to generate new or previously nonexistent ideas); and (4) elaboration (the ability to develop or expand on ideas to create detailed ones. In the context of creative thinking in mathematics, only three aspects are commonly referred to: fluency, flexibility, and originality. Fluency relates to ideas/concepts, flexibility relates to the ability to offer different ideas, and originality is linked to innovative ideas or individual products ([13], [14]). However, theories regarding these indicators have mainly focused on professional mathematicians [15].

The definition of creative mathematical thinking in the school context differs significantly from that of professional mathematicians [16, 17]. In the school context, creative mathematical thinking is the ability of students to offer new insights or solutions to mathematical problems based on the mathematics they have learned in school, their prior experience in problem-solving, and the contributions they provide as students. Someone with good creative mathematical thinking abilities will have sensitivity to mathematical concepts that align or are relevant to the problem they are facing [18]. Based on this, they then develop how to formulate the problem into its mathematical form for subsequent resolution. Therefore, it requires a process of mathematical literacy thinking, defined as the ability to formulate, use, and interpret mathematics in the context of the real world [19]

# 3 Method

## 3.1 Design and Research Setting

This study employed an exploratory mixed methods research design [20, 21, 22]. This research design was chosen because the researcher aimed to investigate the relationship between mathematical literacy skills and creative mathematical thinking abilities while exploring the cognitive characteristics of students in solving mathematical literacy problems. The study was conducted in phases over a period of 5 months, from April to August. At the beginning of the school semester, the researcher distributed questionnaires to assess mathematical literacy and creative mathematical thinking abilities to 203 students of SMK in Makassar. They were observed for four weeks to understand the nature of their participation. Subsequently, the student's test scores were analyzed to examine the relationship between mathematical literacy skills and creative mathematical thinking abilities. Following that, four categories of student characteristics were selected based on their answers to the questions and interviews: (1) subjects with high creative thinking abilities and high mathematical literacy skills, (2) subjects with high creative thinking abilities but low mathematical literacy skills, (3) subjects with low creative thinking abilities but high mathematical literacy skills, and (4) subjects with low creative thinking abilities and low mathematical literacy skills. Data were collected progressively to explore and identify emerging patterns within each category.

## 3.2 Participant

A total of 102 participants in this study were students from SMK in Makassar, consisting of 114 females and 89 males aged 16-17 years. Participant profiles, such as gender, social status (parental occupation, family income, and wealth), age, and religion, were obtained from the respective school records and formed part of the data collection.

## 3.3 Data Collection

The data collection technique used to examine the relationship between mathematical literacy skills and creative mathematical thinking abilities among students involved using instruments

comprising a test consisting of 4 creative mathematical thinking questions and 3 mathematical literacy questions. The Instrument for Creative Thinking in Mathematics (ICTM) was used to assess creative thinking abilities, while the Instrument for Mathematical Literacy (IML) was used to assess mathematical literacy skills. In addition to the test instruments, videos, and interview transcripts were used to explore the characteristics of each category.

### 3.4 Data Analysis

The data from the ICTM and IML tests were analyzed using statistical correlation tests to examine the relationship between mathematical literacy and creative mathematical thinking abilities. The correlation analysis included prerequisite tests such as tests for normality and linearity. Once these prerequisites were met, hypothesis testing was conducted using simple correlation tests, followed by significance tests to determine the significance of the research findings. Furthermore, the interview results underwent a multi-stage analysis: (1) data reduction, (2) data presentation, which encompassed data categorization and identification, and (3) drawing conclusions and verifying them [23]. Continuous observation was carried out to ensure the credibility of the data. During these observations, we spent an adequate amount of time at the school, observing student activities. Additionally, we engaged in discussions with fellow researchers to triangulate and validate the data.

## 4 Results

### 4.1 Results of Quantitative Analysis

The frequency distribution interval data for the results of the mathematical literacy skills test and the creative mathematical thinking abilities test are presented in Table 1 and Table 2 below.

**Table 1.** Analysis of Students' Mathematical Literacy Skills

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 20-27 | 10 | 4.9 | 4.9 | 4.9 |
| | 28-35 | 11 | 5.4 | 5.4 | 10.3 |
| | 36-43 | 9 | 4.4 | 4.4 | 14.8 |
| | 44-51 | 19 | 9.4 | 9.4 | 24.1 |
| | 52-59 | 5 | 2.5 | 2.5 | 26.6 |
| | 60-67 | 24 | 11.8 | 11.8 | 38.4 |
| | 68-75 | 38 | 18.7 | 18.7 | 57.1 |
| | 76-83 | 28 | 13.8 | 13.8 | 70.9 |
| | 84-91 | 59 | 29.1 | 29.1 | 100.0 |
| | Total | 203 | 100.0 | 100.0 | |

Source: SPSS Analysis 2023

**Table 2.** Analysis of Mathematical Thinking Abilities

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 25-32 | 6 | 3.0 | 3.0 | 3.0 |
| | 33-40 | 11 | 5.4 | 5.4 | 8.4 |
| | 41-48 | 7 | 3.4 | 3.4 | 11.8 |
| | 49-56 | 11 | 5.4 | 5.4 | 17.2 |
| | 57-64 | 8 | 3.9 | 3.9 | 21.2 |
| | 65-72 | 36 | 17.7 | 17.7 | 38.9 |
| | 73-80 | 68 | 33.5 | 33.5 | 72.4 |
| | 81-88 | 44 | 21.7 | 21.7 | 94.1 |
| | 89-96 | 12 | 5.9 | 5.9 | 100.0 |
| | Total | 203 | 100.0 | 100.0 | |

Source: SPSS Analysis 2023

Based on Table 1 and Table 2, 61.57% of the students achieved a high level of mathematical literacy, and about 78.82% of the students achieved a high level of creative thinking ability. However, students' mathematical literacy abilities are still considered low compared to their creative thinking abilities. Furthermore, to determine whether both variables are normally distributed or not, the researcher conducted a residual normality test, which is used to examine whether the disturbance or residual variable has a normal distribution. The normality test method used is the Kolmogorov-Smirnov test. The SPSS results of this test can be seen in Table 3 below.

**Table 3.** One-Sample Kolmogorov-Smirnov Test Analysis

| | | Unstandardized Residual |
|---|---|---|
| N | | 203 |
| Normal Parameters[a,b] | Mean | .0000000 |
| | Std. Deviation | 1.49574682 |
| Most Extreme Differences | Absolute | .072 |
| | Positive | .072 |
| | Negative | -.039 |
| Kolmogorov-Smirnov Z | | 1.022 |
| Asymp. Sig. (2-tailed) | | .247 |

a. Test distribution is Normal.

Source: SPSS Analysis 2023

The calculation results in Table 3 indicate that the Asymp. Sig is 0.247, which is greater than 0.05. Therefore, it can be said that the data is normally distributed.

The next prerequisite test is the linearity test. This test determines whether the two variables have a significant linear relationship. Linearity testing for X and Y is performed separately. The linearity test between mathematical literacy skills and mathematical creative thinking skills is conducted in simple linear regression. The results of this test can be seen in Table 4.

**Table 4.** Linearization Test Analysis (**ANOVA Table)**

| | | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|---|
| Creative Thinking Ability * Mathematical Literacy | Between Groups | (Combined) | 24980.298 | 20 | 1249.015 | 10.114 | .000 |
| | | Linearity | 20438.304 | 1 | 20438.304 | 165.502 | .000 |
| | | Deviation from Linearity | 4541.994 | 19 | 239.052 | 1.936 | .014 |
| | Within Groups | | 22352.182 | 181 | 123.493 | | |
| | Total | | 47332.480 | 201 | | | |

Source: SPSS Analysis 2023

Based on the table above, the SPSS output for testing linearity resulted in $F_0 = 1.936$ with $sig = 0.014 < 0.05$. Therefore, it can be concluded that the data on mathematical creative thinking skills and mathematical literacy skills have a non-linear relationship.

The next test is hypothesis testing. Hypothesis testing is performed using simple linear regression or Pearson's product-moment correlation. Simple regression analysis is used to test the relationship between one independent variable and one dependent variable. The results of the simple regression test can be seen in Table 5.

**Table 5.** Correlation Analysis of Creative Thinking Skills and Mathematical Literacy Skills

| | | Mathematical Literacy | Creative Thinking Ability |
|---|---|---|---|
| Mathematical Literacy | Pearson Correlation | 1 | .664** |
| | Sig. (2-tailed) | | .000 |
| | N | 203 | 203 |
| Creative Thinking Ability | Pearson Correlation | .664** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 203 | 203 |

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

Source: SPSS Analysis 2023

Based on Table 5, the analysis results show a correlation of 0.664 between mathematical literacy skills and creative thinking skills. To determine whether the relationship between mathematical literacy skills and creative thinking skills is significant, the value of Sig. (2-tailed) was examined. It was found that the correlation is significant at the 0.01 level (2-tailed) when compared to $\alpha = 0.05$.

From the presentation, it is evident that the Pearson product-moment correlation coefficient of 0.664 indicates a strong correlation. This means that as students' mathematical literacy skills increase, their creative mathematical thinking skills also increase. Since the value is significant at the 0.01 level (2-tailed) and is smaller than $\alpha$ 0.05, it can be concluded that there is a significant relationship between mathematical literacy skills and creative mathematical thinking skills.

Furthermore, based on the Pearson correlation coefficient of 0.664 and the critical r-table value for 203 respondents, which is 0.138, using a significance level of 0.05 (5%), it can be

concluded that the Pearson correlation coefficient is greater than the critical r-table value. This indicates a positive relationship between the two variables. In other words, as students' mathematical literacy skills increase, their creative mathematical thinking skills also increase.

The research results indicate that there is a strong positive correlation between creative thinking ability and mathematical literacy ability. This means that as students' mathematical literacy ability increases, their creative thinking ability also tends to increase. This finding aligns with the results of previous research [5], which showed a significant relationship between mathematical literacy and students' creative thinking.

The categorization of students' abilities in solving mathematical problems is identified, namely: Students with high creative thinking ability and high mathematical literacy fulfill all indicators of mathematical creative thinking and exhibit the following characteristics: (1) Proficiency in interpreting data and figures, (2) Always double-checking their obtained answers, (3) Greater flexibility in calculations and interpretations., (4) Students with high creative thinking ability but low mathematical literacy may exhibit the following. Lower self-confidence in their abilities ; (1) Frequent calculation errors., (2) Solutions that are more structured and easily comprehensible; (3) A tendency to rush., (4) Students with low creative thinking ability but high mathematical literacy may. Only be able to solve similar or previously encountered problems ; (1) Heavily rely on formulas; (2) Apply real-world experience in problem-solving; (3) Always focus on quantitative information. Students with both low creative thinking ability and low mathematical literacy (1) Struggle to understand numerical problems; (2) Lack focus on the given problems. After further review, it becomes evident that students with a higher social status tend to perform better in solving the given problems. This research underscores the significant influence of students' social status on their mathematical comprehension. Previous studies have found that the frequency of exposure to formal mathematical concepts during classroom learning, influenced by differing social statuses, greatly affects students' mathematical literacy performance [24]. Students in higher social status groups experience greater improvements in mathematical literacy over time, even when they have the same curriculum-based mathematical knowledge and skills [25]. The development of mathematical literacy and creative thinking skills requires teachers' knowledge, confidence, and understanding.

## 5 Conclusion and Recommendations

There is a strong relationship between mathematical literacy skills and mathematical creative thinking abilities. Students with high creative thinking skills and high mathematical literacy skills meet all the indicators of mathematical creative thinking and mathematical creative thinking. The characteristics of these students include (1) the ability to interpret data and images well, (2) always double-checking their answers, and (3) being more flexible in calculations and interpretations. Students with high creative thinking skills but low mathematical literacy skills only meet all the creative thinking indicators. However, in terms of mathematical literacy, these students can only meet the "formulate" indicator. The characteristics of these students include (1) lack of confidence in their abilities, (2) frequent calculation errors, (3) more structured and easily understandable problem-solving, and (4) being more hasty. Students with low creative thinking skills but high mathematical literacy skills meet the "cognitive novelty" indicator, and in terms of mathematical literacy, they meet the "formulate" and "employ" indicators. The characteristics of these students include (1) the ability to answer similar questions that they have encountered before, (2) relying on formulas, (3) applying everyday experiences to problem-solving, and (4) always focusing on quantitative information. Students with both low creative thinking skills and low mathematical literacy skills do not meet any of the indicators. The characteristics of these

students include (1) difficulty understanding numerical problems and (2) a lack of focus on the given problems.

The distinct features observed among students concerning their mathematical literacy and creative mathematical thinking abilities, as identified in the aforementioned study, pave the way for future research to ensure that adequate attention is given to enhancing mathematical literacy skills for all students through effective school-based strategies. This could involve enhancing teacher competence in technology-based education, implementing personalized instructional approaches, and delivering improved motivation to students from disadvantaged socio-economic backgrounds to provide more effective mathematical guidance.

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