

Improving students' mathematical academic achievement through self-regulation skills and creativity during the COVID-19 pandemic

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Abstract

The COVID-19 pandemic has greatly affected the ability of mathematical self-regulation, creativity, and academic achievement in the learning process. This paper aims to identify the effect of mathematical self-regulation skills and creativity on students' achievement during the COVID-19 pandemic. The participants in this study were 63 junior high school students in the city of Malang, Indonesia. This study is quantitative study. Data analysis used multiple linear regression with SPSS 23 application. The normality test and homogeneity test were conducted before data analysis. The results showed that 82.3% of mathematical self-regulation skills and creativity increased students' academic achievement during the COVID-19 pandemic. The findings showed that 17.7% of supporting factors other than the ability of mathematical self-regulation and creativity affected students' academic achievement. The study results can provide educators with information to plan learning based on mathematical self-regulation skills and creativity to improve students' academic achievement during the COVID-19 pandemic.

Keywords: mathematical academic, academic achievement, self-regulation skills, creativity, COVID-19 pandemic.

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1. Introduction

The COVID-19 pandemic has greatly affected all aspects of education in the world. The COVID-19 pandemic affects the environment and emotions on learning achievement (Raccanello et al., 2022). The COVID-19 pandemic resulted in temporary school closures and the implementation of online learning, but many students lost study time and decreased learning (Wu et al., 2022). Learning during the COVID-19 pandemic demanded students' creativity in accessing information (Chisita et al., 2022). Creative learning creates meaningful learning and gives satisfaction to students. Satisfaction can affect academic achievement success during online learning during the Covid-19 Pandemic (S. Kim et al., 2022). Therefore, creativity is considered a predictor of academic achievement during the COVID-19 pandemic.

Several works of literature have studied the relationship between mathematical creativity and academic achievement. Studies conducted by Malekian & Baghbanbashi (2013); Nami et al. (2014); Verbree et al. (2021); Weng et al. (2022) showed a positive correlation between mathematical creativity and academic achievement. However, other studies showed a contradiction and concluded that creativity and academic achievement are not correlated. Studies by Balgiu & Adîr (2014); Furnham et al. (2003) showed that learning creativity impedes academic achievement. The absence of a correlation between creativity and academic achievement may inform that previous studies on the positive effect of creativity on academic achievement are still in doubt; Therefore, one of the hypotheses in this study is to determine the effect of mathematical creativity on student achievement.

Creativity also requires other supporting factors in order to improve student academic achievement. Roth et al. (2022) stated that creativity and self-concept are very good for strengthening academic achievement. Self-concept accompanied by self-regulation skills can improve student academic achievement (Soufi et al., 2014). Meanwhile, a study by Molenaar (2022) showed that students need to manage their learning progress by developing self-regulation skills for lifelong learning (future learning). Thus, self-regulation skills are expected to predict learning and improve student achievement.

Kinds of literature have reviewed the correlation of self-regulation skills with academic achievement. Studies by Cleary et al. (2017); Wagner et al. (2021); Wang et al. (2021) demonstrated the role of self-regulation in increasing student achievement. On the other hand, Lenes et al. (2020) stated that self-regulation directly affects students' academic achievement, spatial skills, and other skills. Thus, other skills are needed to moderate the relationship between self-regulation skills and academic achievement (Wagner et al., 2021)

Self-regulation skills with other skills can improve student academic achievement. Finders et al. (2021) stated that the role of self-regulation and executive function skills can improve students' academic achievement. Executive function leads to cognitive flexibility (Braak et al., 2022). Cognitive flexibility and original thinking refer to creativity (Kim, 2006). Functions that lead to flexibility and self-regulation can improve students' mathematical skills and achievements (Braak et al., 2022). So, the researchers suspect that there is an influence of self-regulation and creativity on student achievement. However, studies by Braak et al. (2022) and Finders et al. (2021) have yet to determine the effect of self-regulation and creativity on student achievement.

1.1. Conceptual or Theoretical Framework

Creativity and academic achievement

Research shows a link between mathematical creativity and academic achievement. Nami et al. (2014) stated that creativity is positively correlated with academic achievement related to science and mathematics. Malekian & Baghbanbashi (2013) designed a mathematics lesson that tested students' creativity to improve student achievement. Creativity positively affects student academic achievement in problem-solving (Verbree et al., 2021). In addition, creativity through real-world problems can support academic and student learning (Weng et al., 2022a). Therefore, mathematical creativity correlates with and has a positive effect on increasing student achievement.

However, other studies show no correlation between creativity and academic achievement. Balgiu & Adîr (2014) stated there is no relationship between creativity and academic achievement. Imaginative and creative learning styles and curiosity can hamper student achievement (Furnham et al., 2003). It shows the contradiction in the correlation between mathematical creativity and academic achievement.

Self-regulation and academic achievement

Research shows a link between self-regulation and academic achievement. Cleary et al. (2017) stated that self-regulation is a valid intervention for students' mathematics learning achievement. Wang et al. (2021) confirmed a positive relationship between student academic achievement and self-regulation. This positive relationship leads to the effect of self-regulation skills on academic achievement. Research from Lenés et al. (2020) demonstrated the direct effect of self-regulation on student achievement and other abilities and skills.

1.2. Purpose of the study

Based on the problems and hypotheses above, the study wanted to identify the simultaneous effect of self-regulation and creativity on student achievement. The research questions are as follows.

1. Do mathematical self-regulation skills and creativity affect students' academic achievement during the COVID-19 Pandemic?
2. How do mathematical self-regulation skills and creativity contribute to improving students' academic achievement during the COVID-19 Pandemic?

2. Methods and Materials:

2.1. Research design

This quantitative study applied a quasi-experiment (Creswell & Creswell, 2018); this study aims to find the effect of mathematical self-regulation skills and creativity on students' academic achievement during the COVID-19 pandemic. However, this study did not divide the control and experimental groups. Students' self-regulation skills, creativity, and academic achievement were identified in this study. The design of this study was the One-Group Posttest Only design (Creswell & Creswell, 2018); this study only used a post-test to identify students' academic achievement and did not use a pre-test. Students' self-regulation skills and creativity were also tested at the end of the lesson.

2.2. Participant

The participants were 63 junior high school students in the city of Malang, Indonesia. The selection of participants was conducted using a purposive sampling method because this method provides easy access to determine and select research participants based on the objectives of this study. Participants were selected because students have implemented distance learning using the Zoom platform so that they have consciously applied self-regulation skills and creativity independently when studying online. Participant selection criteria were students with an age limit of 13-16 years. Participants consisted of three different classes, for example, class P, class Q, and class R. Class P consisted of twenty-one (21) students, class Q consisted of twenty-three (23) students, and class R consisted of nineteen (19) students. The total participants were sixty-three (63) students. Sixty-three (63) participants filled out the same questionnaire and post-test.

2.3. Research Instruments

The research instrument consisted of a self-regulation skill questionnaire, a creativity questionnaire, and a post-test. The self-regulation skills questionnaire refers to three indicators by Zimmerman (2000), including thoughts, performance control, and self-reflection. The self-regulation questionnaire consists of 50 items, including seventeen items of indicators of thoughts, eighteen items of performance control indicators, and fifteen items of self-reflection indicators. At the same time, the creativity questionnaire refers to three indicators by Kim (2006), including fluency, flexibility, and originality. The creativity questionnaire consisted of fourteen (14) items, including five (5) items for fluency indicators, five (5) items for the flexibility indicator, and four (4) items for the originality indicator. The post-test consisted of three questions referring to OECD 2009 (Bertrand & Ischinger, 2009). Indicators of the self-regulation skills and creativity questionnaire are shown in Table 1.

Table 1. Design of Questionnaire

Questionnaire Type	Indicator
Creativity (Kim, 2006)	Fluency
	Flexibility
	Originality
Self-regulation (Zimmerman, 2000)	Thought
	Performance control
	Self-reflection

The instrument must be tested for validation and test reliability. The validity of the creativity and self-regulation questionnaire was tested through expert judgment. The expert validators were three people with the qualifications of a mathematics education lecturer. The questionnaire consisted of five scales: strongly disagree (1) to (5) strongly agree. The error rate in this study was $\leq 1\%$. The validation results were analyzed using the Aiken-V formula (Gregory, 2015). The Aiken-V score for the creativity questionnaire was $0.63 > 0.3$, and the Aiken-V score for the self-regulation questionnaire was $0.76 > 0.3$. It informs that the creativity questionnaire and self-regulation skills questionnaire are

valid to be used in research. The post-test was validated and analyzed qualitatively by three mathematics education lecturers. The validation results from the post-test indicated that the test was valid to be applied in the study.

The reliability test of the questionnaire was conducted on 34 junior high school students in the city of Malang, Indonesia. Students in this reliability test were different from students for the study. The test results were analyzed by Pearson analysis. Based on the results of Pearson analysis, Cronbach's alpha for the creativity questionnaire was $0.73 > 0.6$ and Cronbach alpha for the self-regulation skills questionnaire was $0.67 > 0.6$. It showed that the instrument was reliable to be applied in the study.

2.4. Data Analysis

Data analysis in this study consisted of four stages. The first stage was the normality test. The research data were first tested for normality through the Kolmogorov-Smirnov test the result of which is presented in Table 2. The normality test is also interpreted in Figures 1 and Figure 2.

Table 2. Normality Test

	Unstandardized Residual
Kolmogorov-Smirnov Z	0.845
Asymp. Sig. (2-tailed)	0.472

Table 2 shows that the Kolmogorov-Smirnov test result was 0.8545 and the probability was $0.472 > 0.05$. Therefore, the residual data was normally distributed.

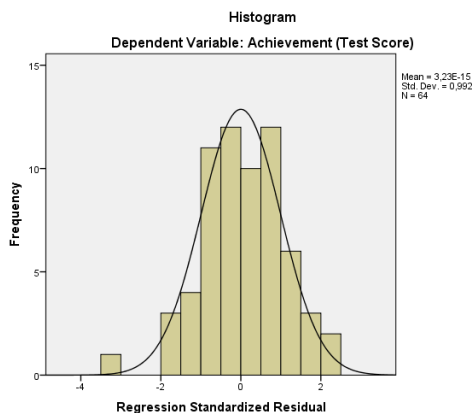


Figure 1. Histogram for Data Normality

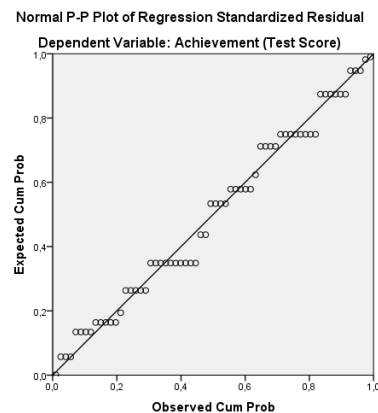


Figure 2. Scatterplots for Data Normality

Based on Figure 1, the histogram graph tends to follow a bell shape. Meanwhile, Figure 2 shows that the residual data tends to follow a straight line or curve. It indicates that the residual research data were normally distributed.

The second stage was multiple regression analysis to identify the simultaneous effect of mathematical self-regulation skills and creativity on students' academic achievement during the COVID-19 pandemic. The third stage was the coefficient of determination test. The coefficient of determination test aims to determine the percentage of the effect of mathematical self-regulation skills and creativity on students' academic achievement. The fourth stage was drawing conclusions based on research questions in the introduction. The data were analyzed using the SPSS-23 application.

3. Results

3.1. Identification of the effect of mathematical self-regulation skills and creativity on students' academic achievement during the COVID-19 Pandemic

Based on the first question, the simultaneous effect of mathematical self-regulation skills and creativity on students' achievement during the COVID-19 pandemic was shown from multiple linear regression analysis. The results of multiple linear regression analysis are presented in Table 3.

Table 3. Multiple linear regression test

	F _{statistic}	Sig.
Regression	120.447	0.000
Residual		

Table 3 shows that F_{statistic} was 120.447 with probability (Sig.) = 0.000 < 0.05. Thus, based on the results, it was interpreted that mathematical self-regulation skills and creativity simultaneously affected students' academic achievement during the COVID-19 pandemic. Identification of the simultaneous influence of mathematical self-regulation skills and creativity on students' academic achievement is shown in Table 4.

Table 4. Coefficients

	Unstandardized Coefficients	
	B	Std. Error
Mathematical self-regulation skills (X1)	43.692	0.052
Mathematical creativity (X2)	0.584	0.042

Table 4 shows the variable coefficients to identify the effect of mathematical self-regulation ability and creativity on students' academic achievement. The coefficient of mathematical self-regulation skills (X1) was + 43.692 with a standard error = 0.052, so it was interpreted that mathematical self-regulation skills (X1) had a positive effect on students' achievement. It means that the higher the students' mathematical self-regulation skills (X1) are, the higher the students' academic achievement (Y) will be. The coefficient of mathematical creativity (X2) was 0.584 with standard error = 0.042, so it was interpreted that the higher the student's mathematical creativity (X2) is, the higher the student's academic achievement (Y) becomes. Therefore, the empirical model for the study is "Y = 43.692 X1 + 0.584 X2".

3.2. Percentage of the influence of mathematical self-regulation ability and creativity on student learning achievement during the COVID-19 pandemic

Based on the second question, the percentage of the effect of mathematical self-regulation skills and creativity on students' academic achievement during the COVID-19 pandemic was analyzed using the coefficient of determination test. The coefficient of the determination test is shown in Table 5.

Table 5. The coefficient of determination test

Predictors	Dependent Variable:	R Square
Mathematical self-regulation skills, creativity	Academic achievement	0.823

Table 5 shows that R-square was 0.823. It showed a strong correlation between mathematical self-regulation skills and creativity and students' academic achievement during the COVID-19 pandemic. The simultaneous effect of mathematical self-regulation skills and creativity on student achievement was 82.3%, while the percentage for supporting factors other than mathematical self-regulation skills and creativity that affect students' academic achievement was 17.7%.

4. Discussion

The results of the first question showed that mathematical self-regulation skills and creativity simultaneously had a positive effect on student achievement. It means that the higher the mathematical self-regulation skills and creativity simultaneously are, the higher the student's learning achievement becomes. The role of self-regulation in learning causes a positive impact, and open and creative thinking is the best combination to get new and original ideas so that learning is meaningful; and students' academic achievement improves. It follows the opinion of Atabek (2020); Hidajat (2022); and Roth et al. (2022), stating that creativity and self-concept are a good combination in strengthening students' mathematical academic achievement. Self-concept is followed by performance control, and motivation refers to self-regulation skills (Soufi et al., 2014). On the other hand, open thinking, which refers to creativity, can support students' academic achievement (Verbree et al., 2021).

This study also answers the problem statement problem hypothesis in the introduction section regarding the effect of mathematical creativity on students' achievement. Balgiu & Adir (2014) stated that there is no correlation between creativity and student achievement. This study supports the research of Malekian & Baghbanbashi (2013); Nami et al. (2014); Verbree et al. (2021); Weng et al. (2022); because mathematical creativity partially has a positive effect on student achievement. The positive impact of creativity on students' academic achievement during the COVID-19 pandemic is caused by the independent development of creativity from students to overcome the inequality of academic achievement in online learning during the COVID-19 pandemic (Liao et al., 2022). However, the COVID-19 pandemic has resulted in online learning (Wu et al., 2022), so the independence of students' creativity is the primary key to learning during this COVID-19 pandemic. This is supported by Amponsah et al. (2019), discovering that a person's creativity is needed for conceptual

development and improving learning achievement. The person's creativity develops through self-regulation and different thoughts to produce correct and original perceptions (Sun et al., 2020).

The findings in this study also showed that mathematical self-regulation skills partially had a positive effect on student achievement. It means that the higher the student's self-regulation skills are, the higher the students' academic achievement becomes during the COVID-19 pandemic. It follows the opinion of Veen & Peetsma (2009); Vijayakumar et al. (2022); that self-regulation skills are best for solving academic problems and finding new ideas. Self-regulation skills are based on performance control and high motivation to form new knowledge from complex problem-solving (Alten et al., 2021). Self-regulation skills effectively improve student learning achievement (Muwonge et al., 2020; Wong et al., 2021). Therefore, self-regulation partially has a positive effect on increasing student academic achievement.

Based on the second question, the study results showed that mathematical self-regulation skills and creativity simultaneously contributed to increasing students' academic achievement during the COVID-19 pandemic, with a percentage of 82.3%. Other researchers have never presented the results of this study, so this study is original. However, the results of this study are supported by Sulisworo et al. (2020), concluding that self-regulation skills help students achieve learning goals and acquire new knowledge from the results of knowledge reflection. Self-regulation skills can construct students' motivation, learning objectives, behavior, and cognition to obtain positive and new values (Schunk, 2005). The behavior of new ideas or knowledge is the basic concept of creativity. This is the basis of this study. Based on previous research by Schunk (2005) and Sulisworo et al. (2020), they have yet to simultaneously discuss self-regulation skills and creativity to improve students' academic achievement. This study clearly shows the magnitude of the positive influence of mathematical self-regulation skills and creativity on students' academic achievement during the COVID-19 pandemic. However, other factors that affected student academic achievement were 17.7%. Other researchers can consider the percentage of 17.7% for other supporting factors, so the findings of this study can be a further research idea to improve students' academic achievement during the COVID-19 pandemic.

5. Conclusion

The study results inform that mathematical self-regulation skills and creativity simultaneously affect student academic achievement during the COVID-19 pandemic. In addition, the percentage of the effect of mathematical self-regulation skills and creativity simultaneously on student learning achievement was 82.3%. However, the findings of this study indicate that 17.7% of other identified factors that affect students' academic achievement other than mathematical self-regulation skills and creativity that were not included in the research model. In addition, the results showed that mathematical self-regulation skills partially had a positive effect on students' academic achievement and mathematical creativity partially had a positive effect on students' academic achievement during the COVID-19 pandemic.

6. Limitation

The research findings showed that 17.7% of supporting factors other than mathematical self-regulation skills and creativity affect students' academic achievement during the COVID-19 pandemic. This study has not explained 17.7% of these supporting factors. This study only confirms

that mathematical self-regulation skills and creativity simultaneously affect students' academic achievement during the COVID-19 pandemic, with a percentage of 82.3%.

7. Future Research

Based on the limitations above, future research is suggested to identify 17.7% of supporting factors other than mathematical self-regulation skills and creativity that can affect students' academic achievement during the COVID-19 pandemic. The percentage of 17.7% is a high enough percentage for educators to consider in improving students' academic achievement. This study implies that educators can design teaching materials that can improve students' self-regulation skills and creativity online and offline to improve students' academic achievement in mathematics.

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