



Optimizing students' mathematical critical and creative thinking skills through the flip-a-team model with e-learning

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Abstract

In the current digital era, the use of e-learning platforms in education is gaining increasing importance. This holds particularly true in the realm of Mathematics Education, where there exists a challenge of enhancing students' critical and creative thinking skills. The objective of this research was to examine the enhancement of students' critical and creative thinking abilities in mathematics through the implementation of a unique team project-based model called Flip-a-Team, within UNP's e-learning platform. A quasi-experimental research design was employed, utilizing a post-test control group approach. The sample consisted of 64 students from a mathematics study program who were enrolled in the July - December 2022 semester. These students were divided into two groups: the experimental group (Class A) comprising 32 students, instructed through the Flip-a-Team model, and the control group (Class B) consisting of 32 students, who underwent problem-based learning. Based on an independent t-test, the results unequivocally demonstrated that the mathematical learning process incorporating the Flip-a-Team model had a significant and positive impact on students' critical and creative thinking abilities in mathematics. Thus, the implementation of the Flip-a-Team model is highly recommended for mathematics instruction. The UNP e-learning platform serves as a viable solution for digitally-based mathematics education, particularly in the cultivation of students' critical and creative thinking skills in mathematics.

INTRODUCTION

The rapid advancement of the digital era presents both new opportunities and challenges in the field of mathematics education. Within this context, critical and creative thinking skills emerge as essential elements that students must comprehend and cultivate (Garrison, 1991; Nurkhin & Pramusinto, 2020). These competencies not only foster a deeper understanding but also enable students to apply their mathematical knowledge in novel and complex situations (Astuti et al., 2020; Parameswari & Kurniyati, 2020). However, educators often encounter obstacles when promoting critical and creative thinking in mathematics classrooms. As highlighted by Widodo et al. (2020), these challenges encompass the need to develop and implement innovative and effective teaching strategies while fostering a conducive learning environment. Concurrently, research by Yasinta et al. (2020) and Riwayati et al. (2020) suggests that leveraging technology can significantly facilitate critical and creative thinking in mathematics. Therefore, modern mathematics education must respond to these challenges with adaptability and innovation. Given the significance of critical and creative thinking in mathematics, targeted efforts to strengthen these skills among students are imperative (Hidayat & Evendi, 2022). The Flip-a-Team model, implemented on the e-learning platform of Padang State University (UNP), is envisioned as a means to enhance these dual capabilities.

In recent years, the Flip-a-Team model has garnered considerable research attention as an innovative strategy for promoting mathematical abilities in mathematics education (Han et al.,

2020; McCabe et al., 2019). This model integrates elements of the flipped classroom approach, where students independently study the material at home and then utilize class time for in-depth discussions and activities, along with team collaboration, fostering interaction and communication among students (Adnan, 2017; Hew et al., 2020; Le Roux & Nagel, 2018). Aligned with the research of Martha & Zega (2023), the implementation of the Flip-a-Team model has proven effective in enhancing students' mathematical abilities. In their study, students learning with the Flip-a-Team model exhibited significant improvements in their capacity to analyze, evaluate, and generate solutions for complex mathematical problems. Furthermore, the Flip-a-Team model empowers students to take ownership of their learning process, a crucial factor in facilitating critical and creative thinking. Consequently, this model holds substantial potential for addressing the aforementioned challenges in mathematics education. In this study, we delve deeper into the integration of the Flip-a-Team model into the UNP e-learning platform to enhance students' critical and creative thinking skills in mathematics.

Today, e-learning technology has become an integral component of education, including mathematics education. As indicated by research conducted by Siswanto et al. (2021), e-learning facilitates more effective and efficient mathematics teaching and learning. It achieves this by providing accessible learning materials anytime and anywhere, along with the ability to present content in engaging and interactive formats (O'keefe et al., 2020; Singh et al., 2022). Additionally, e-learning technology can help overcome various challenges associated with mathematics teaching. According to research by Sinaga et al. (2022), e-learning supports the development of student learning activities by providing a range of tasks specifically designed for this purpose. Thus, this technology allows for the implementation of innovative teaching strategies, such as the Flip-a-Team model, in a broader and more flexible context. The UNP e-learning platform, the focus of this study, offers a variety of tools and features that support mathematics teaching and learning. UNP's e-learning platform has the capability to accommodate a multitude of teaching methods, including the Flip-a-Team model. Here is an initial view of the UNP e-learning platform.

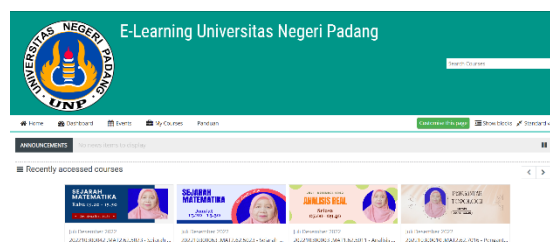


Figure 1. Initial Display of UNP's e-learning

While previous studies have extensively examined the efficacy of the Flip-a-Team model in enhancing students' critical and creative thinking skills in mathematics education (Han et al., 2020; Martha & Zega, 2023; McCabe et al., 2019), and other research has demonstrated the advantages of e-learning technology in mathematics education (Borba et al., 2016; Sinaga et al., 2022; Siswanto et al., 2021), there is still a notable research gap specifically regarding the utilization of the Flip-a-Team model within the e-learning context, particularly when implemented on the UNP e-learning platform. This gap necessitates further investigation. The

uniqueness of this research lies in its endeavor to bridge this gap by exploring how the integration of the Flip-a-Team model into the UNP e-learning platform can contribute to the facilitation and enhancement of students' critical and creative thinking abilities in mathematics. The primary objective of this research is to investigate the improvement in students' critical and creative thinking skills in mathematics through the implementation of the Flip-a-Team model within UNP's e-learning platform.

METHODS

Design

This study employed a quasi-experimental approach utilizing a post-test control group design (Fernández-Río et al., 2021). The objective was to assess the effectiveness of the Flip-a-Team model, implemented within UNP's e-learning platform, compared to a traditional problem-based learning approach.

Participants

The sample consisted of 62 mathematics students enrolled in the July-December 2022 semester. These students were evenly divided into two groups, with 32 individuals in each group. Class A constituted the experimental group, receiving instruction using the Flip-a-Team model, while Class B served as the control group and underwent problem-based learning.

Instruments

The instructional period spanned four weeks, with each week consisting of 150 minutes of online learning via UNP's e-learning platform for the experimental group. The control group, on the other hand, dedicated an equivalent amount of time to face-to-face team-based project learning. The control group followed a problem-solving model during their face-to-face learning sessions. The learning process concluded with a final examination, which included five essay-style questions related to the history of mathematics.

Data Analysis

To ensure the validity of the collected data, prerequisite tests such as Levene's Test for homogeneity and the Kolmogorov-Smirnov Test for normality were conducted (Salim & Tiawa, 2015). Following these prerequisite tests, hypothesis testing was carried out using the independent sample t-test, facilitated by the SPSS software, to analyze the research data.

RESULTS AND DISCUSSION

The data analysis revealed that the mathematical critical and creative thinking ability of students in the mathematics study program, who were taught using the Flip-a-Team model on UNP's e-learning platform, had a higher average value (final-test) compared to the data of students taught using problem-based learning. A comparison of the students' mathematical critical and creative thinking skills between the two learning groups is presented in Table 1.

Table 1. Descriptive Statistics of Control Class and Experimental Class Scores

	N	\bar{x}	SD	Max Score	Min Score
Control Class	32	55	9.58	73.33	33,33
Experimental Class	32	81.46	9.69	100	60

Table 1 illustrates that the average test results for critical and creative thinking skills in the experimental class were higher than those in the control class. The average difference between the control class and the experimental class was 26.46. Moreover, the variance of the test results in the experimental class was higher compared to the control class. This indicates that the critical and creative thinking skills of the experimental class, which used the Flip-a-Team model on UNP's e-learning platform, were higher and more consistent compared to the control class, which employed problem-based learning. To determine whether there was a significant improvement in students' mathematical critical and creative thinking skills, a normalized calculation was conducted in both learning groups (Ramadhani et al., 2020). The interpretation of the results was based on the P-value. If the P-value is greater than the significance level $\alpha = 0.05$, it indicates acceptance of the null hypothesis (H0). The P-value for each class can be seen in Table 2.

Table 2. Test Results of Sample Normality

Class	P-Value	Information
Control	0.055	Data is normally distributed
Experiment	0.063	Data is normally distributed

Based on the normality test results in the table above, it can be concluded that both classes exhibited a normal distribution since the P-value for each class was greater than the significance level ($\alpha = 0.05$). This is further supported by the Anderson-Darling test:

1. Control class AD: 0.179 with a P-Value of 0.055, indicating a normal distribution for the variable.
2. Experiment class AD: 0.694 with a P-Value of 0.063, indicating a normal distribution for the variable.

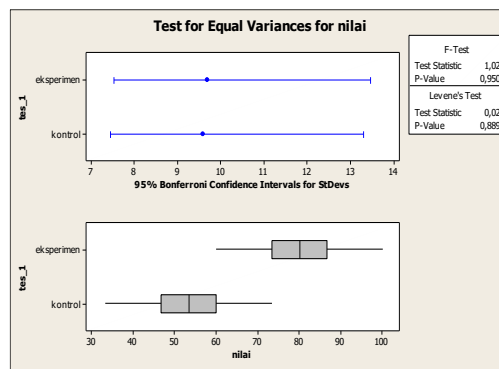


Figure 2. Test for Homogeneous of Variance

The test was performed with Levene's test. H0 is accepted or the variance of the data is homogeneous if the P-value (significant value) is greater than $\alpha = 0.05$ and rejected otherwise. The analysis carried out obtained a P-value = 0.889. That means P-value > α (0.05). Therefore, it can be concluded that the population has a homogeneous variance.

Based on the results of data normality and data homogeneity testing, which showed the results that the research data are normally distributed and homogeneous, then hypothesis testing can be done using the tidependent sample t-test. The results of hypothesis testing using the independent sample t-test using the SPSS Software can be seen in Table 4.

Hypothesis testing

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N Mean StDev SE Mean
Experiment 32 81.46 9.69 1.7
Control 32 55.00 9.58 1.7
Difference = mu (Experiment) - mu
(Control)
Estimate for difference: 26.46
95% lower bound for difference: 22.44
T-Test of difference =0 (vs >): T-
Value = 10.99 P-Value = 0.000, DF=
61 T table= 1.671

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Based on Hypothesis testing, it is obtained that t count is 10.99 and $df = 62$ with t table = 1.645 for an error level of 5%, thus t count falls in the area of hypothesis rejection $t_{hitung} \geq t_a$ at an error level of 5%. Meaning that the final test of the control class is worse than the final test of the experimental class. The interpretation of this test can also be seen by paying attention to the P value. Because the P value = 0.000 obtained is smaller than the significant level $\alpha = 0.05$ which is set, then reject H_0 . It means the test of critical and creative thinking skills in the experimental class was better than the control class.

Based on the obtained results, it can be concluded that there is an improvement in students' mathematical critical and creative thinking skills when taught using the Flip-a-Team model on UNP's e-learning platform. Problem-based learning plays a significant role in enabling students to investigate problems and find solutions. The investigative approach provides students with the opportunity to critically analyze the extent to which a problem can be addressed and to propose applicable solutions.

The statistical hypothesis testing results demonstrate a significant difference in critical and creative thinking skills between students taught using the Flip-a-Team model on UNP's e-learning platform and those taught using problem-based learning. This finding aligns with the study by Han et al. (2020), which emphasizes the effectiveness of the Flip-a-Team model in enhancing students' mathematical abilities. Moreover, these results provide empirical evidence supporting the existing literature advocating for the integration of innovative teaching models, such as Flip-a-Team, in e-learning platforms to promote critical and creative thinking (Martha & Zega, 2023; McCabe et al., 2019).

This study reinforces previous research findings, particularly those of Sinaga et al. (2022) and Siswanto et al. (2021), which underscore the significant role of e-learning technologies in optimizing mathematics instruction. The results presented here lend further support to these previous works, illustrating how the digital format can serve as an effective channel for delivering mathematics education. Our research contributes an additional dimension to this understanding by highlighting the superiority of the Flip-a-Team model implemented through UNP's e-learning platform in terms of enhancing students' performance. The successful utilization of digital technology in conjunction with an innovative teaching model has the potential to revolutionize the teaching and learning of mathematics.

Furthermore, the notable improvement in performance observed in the experimental group substantiates the notion that technology-enhanced pedagogical models, such as Flip-a-Team, can foster more engaging and stimulating learning environments. These models not only

capture students' attention more effectively but also encourage active participation, thereby enriching the learning process. Such active engagement offers students ample opportunities to employ their critical and creative thinking skills to analyze, evaluate, and generate solutions for complex mathematical problems.

Finally, this study underscores the potential of the Flip-a-Team model when combined with e-learning technology to enhance students' mathematical abilities. The significant progress exhibited by students in the experimental group in tackling intricate mathematical problems validates the effectiveness of technology-based teaching models. This observation represents a step forward in addressing the challenges faced by educators in enhancing students' critical and creative thinking skills in mathematics. It sets the stage for further exploration and implementation of innovative, technology-based teaching models in mathematics instruction, promising a transformative approach to mathematics education.

CONCLUSIONS

Based on the aforementioned research findings, it can be concluded that the utilization of the Flip-a-Team model on UNP's e-learning platform has a significant impact on enhancing students' mathematical critical and creative thinking abilities. Apart from developing these skills, students also acquire new experiences through their participation in digital-based learning. They become more adept at critically and creatively approaching the presented problems, effectively preparing themselves to formulate plans and draw conclusions during the problem-solving process. The advantages of digital learning with the Flip-a-Team model on UNP's e-learning platform also indirectly benefit the teachers who serve as learning facilitators. The collaboration between online-based learning (utilizing the Flip-a-Team model on UNP's e-learning platform) and face-to-face learning (employing problem-based learning models) has proven to be an easily applicable digital learning solution within the mathematics learning process. Teachers still play a pivotal role in fostering student motivation and acting as facilitators to enhance students' understanding of the instructional material, thus reinforcing scaffolding techniques.

AUTHOR CONTRIBUTIONS STATEMENT

Based on his contribution to this research, AA as the lead researcher, prepared the research as a whole and wrote the articles. HS contributed as wrote down the findings during the study. RNI contributed as a reviewer and editor in writing articles.

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