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Mathematical problem solving ability through teams games tournament assisted by gimkit based on mathematical resilience

Cantika Hanif Khoirunnisa[1], Mashuri[2]

[12]Mathematics Education Department, FMIPA, Universitas Negeri Semarang, Jawa Tengah, Indonesia

Correspondence: cantika1394@students.unnes.ac.id

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Abstract

Mathematics is a universal science that underlies the development of modern technology and plays an important role in advancing human thinking. One essential ability for students is mathematical problem-solving ability. However, In reality, Indonesian students' mathematical problem-solving ability is still considered low, partly due to the implementation of less effective teaching approaches. Therefore, innovation is needed through the implementation of the Teams Games Tournament (TGT) learning model assisted by Gimkit. This study aims to: (1) examine the effectiveness of the Gimkit-assisted TGT model on students' mathematical problem-solving ability; and (2) describe students' problem-solving ability in terms of their mathematical resilience. This study employed a mixed-methods approach. The quantitative phase used a true experimental design with a posttest-only control design involving 33 students in the experimental group and 30 students in the control group. Quantitative data were analyzed using the Wilcoxon test for average completeness, the binomial test for classical completeness, the Mann–Whitney test for differences between two groups, and the chi-square test for proportional analysis. Meanwhile, qualitative data were analyzed through data reduction, data presentation, and conclusion drawing. The results show that: (1) the Gimkit-assisted TGT model is effective in improving students' mathematical problem-solving ability; and (2) students with high mathematical resilience are able to meet all problem-solving indicators (understanding problems, planning, implementing strategies, and reviewing results), students with moderate resilience fulfill most indicators but are less optimal in reviewing results, while students with low resilience only fulfill the indicator of understanding problems.

Keywords: Mathematical Problem-Solving; TGT; Gimkit; Mathematical Resilience

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INTRODUCTION

Mathematics is a universal science that supports the advancement of modern technology and plays a crucial role across disciplines andn developing human reasoning (Ibrahim & Suparni, 2012). In mathematics education, one essential competency is mathematical problem-solving ability, which is closely related to higher-order thinking skills (HOTS). Mathematical problem-solving skills are cognitive abilities that can be trained and developed in students, enabling them to apply mathematics to real-life problems (Amam, 2017). Problem solving requires students not only to apply mathematical procedures but also to analyze, evaluate, and construct appropriate strategies to solve non-routine problems (Pólya & Behnke, 1949).Furthermore, teaching students to utilize problem-solving processes in mathematics learning equips them to tackle complex real-life challenges, rather than merely expecting them to answer given questions or routine tasks (Putra et al., 2023).

This aligns with the demands of the Kurikulum Merdeka, which emphasizes the development of critical and creative thinking skills and encourages students to solve contextual problems (Kemendikbukristek, 2022). Furthermore, international assessments such as PISA highlight the importance of students' ability to apply mathematical knowledge in real-life situations rather than merely performing routine calculations (OECD, 2019). However, several studies indicate that students' mathematical problem-solving abilities are still relatively low, particularly when dealing with non-routine and contextual problems (Riyanto & Amidi, 2024). Therefore, developing students' mathematical problem-solving ability becomes a critical issue in contemporary mathematics education.

In reality, students' mathematical problem-solving ability in Indonesia is still relatively low. This can be seen in the results of the Program for International Student Assessment (PISA) international study organized by the Organiz*ation for Economic Co-operation and Development* (OECD). Indonesia's PISA scores over several years are shown in Table 1.

Table 1. Results of Indonesian PISA scores in Mathematics

Tahun	Average Score	Indonesian State Score (Mathematics)
2012	500	375
2015	500	386
2018	500	379
2022	500	366

The average result in 2022 indicates a decline compared to 2018. According to OECD (2019), the PISA 2022 results show that Indonesian students' mathematics proficiency remains very low. Only 18% of Indonesian students reached at least Level 2, far below the OECD average of 69%. This low achievement suggests that the majority of students still struggle to understand basic mathematical concepts and are unable to connect contextual problems with mathematical models. Furthermore, almost no Indonesian students reached Levels 5 or 6, whereas in East Asian countries the proportion ranges from 23% to 41%. At these highest levels, students are expected to model complex situations, select the most appropriate solution strategies, evaluate alternative solutions, and employ high-level reasoning. These findings indicate that Indonesian students' mathematical problem-solving ability remains weak, as learning tends to focus primarily on computational skills rather than on reasoning and problem-solving(OECD, 2019).

The low mathematical problem-solving ability of students is also evident from a mathematical problem-solving test conducted on Class X students at SMA Negeri 2 Demak. The results indicated that students' problem-solving skills remained underdeveloped, with an average score of 69.7 out of 100 and only 40% meeting the proficiency criteria (Riyanto & Amidi, 2024). Based on structured observations and semi-structured interviews with mathematics teachers at SMA Negeri 2 Demak, it was found that students have been learning using the Problem-Based Learning (PBL) model. In this model, the teacher serves as a facilitator, presenting contextual problems and guiding students in solving them (Hmelo-Silver, 2004; Savery, 2006).

However, during the implementation, the teacher often emphasizes worked examples, and students tend to follow the demonstrated steps rather than independently devising solution strategies. This indicates that the issue lies not in the PBL model itself, which is recognized as an effective approach for developing higher-order thinking and problem-solving skills, but in its classroom implementation. As a result, students' mathematical problem-solving abilities have not been optimally developed, particularly when faced with more complex or non-routine problems.

In response to these conditions, teachers need to implement strategies that actively engage students and foster independent problem-solving. One such strategy is the use of learning models that not only accommodate students' needs but also promote active participation and enjoyable learning experiences. Engaging learning can be created through various approaches, one of which is by selecting innovative learning models that are capable of attracting students' interest and enhancing their motivation to learn (Sya'adah et al., 2023). The Teams Games Tournament (TGT) type cooperative learning model is particularly suitable in this context. Based on cooperative learning theory, structured group interactions can enhance students' understanding, motivation, and higher-order thinking skills (Johnson & Johnson, 2009). Furthermore, from a social constructivist perspective, learning is most effective when students construct knowledge collaboratively through interaction with peers and the social environment (Vygotsky, 1980). Unlike traditional PBL, which may rely heavily on teacher-guided examples, TGT encourages students to actively participate, compete in teams, and develop independent strategies as they solve problems, thereby addressing the limitations observed in previous PBL implementations.

The *Teams Games Tournament (*TGT) model is one of the types of cooperative learning developed by Slavin and has been proven effective in improving social interaction, motivation, and student learning outcomes. In this model, students work in heterogeneous groups to study the material, then compete in academic tournaments to earn scores for their groups (Slavin, 1995). Through this model, students work together in groups to understand the material, then compete healthily through games related to the material.

The use of gamification technology in learning has been recognized as an effective way to enhance students' interest and engagement, allowing them to learn while playing (Deterding et al., 2011; Landers, 2014). In line with this, the Teams Games Tournament (TGT) model can be integrated with Gimkit, an educational gamification platform, to make learning more interactive and enjoyable. Gimkit offers features such as digital tournaments, interactive game elements, virtual points, and leaderboards that foster healthy competition and motivation among students (Landers, 2014; Septyana et al., 2024).

From the perspective of gamification learning theory, these elements promote intrinsic motivation and sustained engagement by providing immediate feedback, goal-setting, and reward mechanisms (Kapp, 2012). Furthermore, engagement and motivation theories suggest that active participation in game-based activities increases cognitive involvement, encourages strategic thinking, and supports the development of higher-order skills such as problem-solving (Fredricks et al., 2004). In practice, using Gimkit in the TGT model allows students to collaboratively plan strategies, solve problems under time constraints, and receive instant feedback on their performance, thereby systematically enhancing their mathematical problem-solving abilities.

In addition to instructional models and learning media, students' mathematical problem-solving ability is also influenced by affective factors, among which mathematical resilience plays a critical role. Mathematical resilience is defined as a positive attitude that encourages students to persist when facing difficulties in solving mathematics problems, both during collaborative discussions and individual assessments (Hafiz et al., 2017). Empirical studies have shown that mathematical resilience is significantly related to problem-solving ability (Maharani & Bernard, 2018). They can explain up to 32.7% of the variance in students' problem-solving performance (Athiyah et al., 2020).

Cognitive factors include students' reasoning, strategy planning, and knowledge application, while affective factors include mathematical resilience, persistence, and motivation. Students with high mathematical resilience are more likely to engage actively with complex problems, attempt multiple solution strategies, and persist despite difficulties, thereby improving their overall problem-solving ability (Hafiz et al., 2017; Maharani & Bernard, 2018).

This study aims to: (1) examine the effectiveness of the Gimkit-assisted TGT model on students' mathematical problem-solving ability; (2) describe the pattern of students' mathematical problem-solving abilities reviewed from the students' mathematical resilience in the *Gimkit-Assisted* Teams Games Tournament learning model.

METHODS

A mixed-methods design was employed in this study, integrating quantitative and qualitative research methodologies. The quantitative research method uses *a true experimental design with a posttest-only control group.* The study involved two groups: an experimental group and a control group, with the experimental group receiving the Teams Games Tournament learning model assisted by Gimkit. Meanwhile, the control group received treatment through the PBL model learning. After receiving the treatment, both groups will be administered a posttest (Creswell, 2013). Meanwhile, the qualitative method is used to deepen the analysis of previously obtained quantitative data. So it can be used to describe mathematical problem-solving skills using the Teams Tames Tournament model assisted by Gimkit, as reviewed in terms of students' mathematical resilience.

This research was conducted at SMA Negeri 2 Demak, using trigonometry as the material. The study population comprised all Grade X students at SMA Negeri 2 Demak in the 2026/2027 academic year. Using simple random sampling, class X-1 was designated as the experimental group, whereas class X-3 was assigned as the control group. Prior to the treatment, both groups were tested for equivalence to ensure that they had similar initial abilities. The results indicated that there was no significant difference in students' initial mathematical ability between the two groups. The subject of this study uses *the purposive sampling* technique. This technique involves deliberately selecting subjects based on specific considerations or predefined criteria. The criteria used in this study were students' mathematical resilience levels (high, medium, and low), determined by the mathematical resilience questionnaire. Two students were selected from each category to represent the variation in resilience levels (Sugiyono, 2018).

Data collection methods in this study encompassed tests, questionnaires, interviews, observations, and documentation. The learning process was conducted over several meetings (4 meetings) during the implementation of the trigonometry topic. The experimental group was taught using the Gimkit-assisted TGT model, while the control group used the Problem-Based Learning (PBL) model. At the end of the learning sessions, a posttest was administered to measure students' mathematical problem-solving ability. The research instruments consisted of mathematical problem-solving assessments, mathematical resilience questionnaires, and interview protocols. The instructional materials included teaching modules, the Gimkit platform, and student worksheets. The instrument testing in this study comprises item validity testing, reliability testing, discrimination power analysis, and item difficulty testing.

Meanwhile, the data analysis techniques used include both quantitative and qualitative methods. Quantitative data analysis was conducted using descriptive and inferential statistics. Descriptive statistics were used to summarize the data, including mean, minimum score, maximum score, and standard deviation. Inferential statistical tests included the normality test (Shapiro–Wilk test) and homogeneity test as prerequisite tests. Since the data were not normally distributed, nonparametric tests were applied, including the Wilcoxon test for average completeness, the Binomial test for classical completeness, the Mann–Whitney test for comparing two groups, and the Chi-square test for comparing proportions. All statistical analyses were performed using IBM SPSS Statistics 26 with a significance level of 0.05. The decision criteria were established as follows: H_0 is rejected and H_1 is accepted if the significance value (Sig.) is less than 0.05, indicating a statistically significant result. Conversely, H_0 is accepted if the significance value (Sig.) is greater than 0.05, indicating that there is no statistically significant difference or effect.

Qualitative data analysis was conducted in three stages: data reduction, data presentation, and conclusion drawing. The qualitative analysis aimed to describe students' mathematical problem-solving abilities in relation to their resilience levels.

RESULTS AND DISCUSSION

1. *The Effectiveness of the Implementation of the Gimkit-Assisted Teams Games Tournament Learning Model on Mathematical Problem-Solving Ability*

At the planning stage, the research instruments were pilot-tested in a designated trial class. The results of analyzing the mathematical problem-solving test questions, including item validity, reliability, discrimination index, and difficulty level, demonstrated that all five items met the required criteria and were suitable for use. Moreover, all 30 items of the mathematical resilience questionnaire were also deemed appropriate for the study.

Furthermore, the Gimkit-assisted TGT learning model was implemented in the experimental group, whereas the PBL model was employed in the control group. After the learning stage is completed and students take the posttest on mathematical problem-solving skills, posttest data are collected. Following data analysis, the results for the experimental and control groups are summarized in Table 2.

Table 2. Posttest Recapitulation of Experimental and Control Groups

Groups	N	$\bar{x}$	Me	X_{max}	X_{min}
Experimental	33	78,18	80	96	10
Control	30	65,6	68	92	8

The next stage is to analyze the posttest data on students' mathematical problem-solving ability obtained to test the research hypothesis. However, before analysis, a prerequisite test must be performed.

The final posttest data on students' mathematical problem-solving ability were tested for normality using the Shapiro–Wilk test in IBM SPSS Statistics 26 for both the experimental and control groups, as presented in Table 3.

Table 3. Results of the *Posttest* Normality Test of Students' Mathematical Problem-Solving Ability

Groups	Statistic	df	Sig.	Decision
Experimental	0,786	33	0,000	Non-Normal
Control	0,931	30	0,054	Normal

Based on Table 3. A value of Sig. = 0.000 was obtained for the experimental group, and a value of Sig. = 0.054 for the control group. Sig. = 0.000 < 0.05 was obtained, so H_0 was rejected because the experimental class data were not normally distributed. Meanwhile, for the control class, Sig. = 0.054 > 0.05 was obtained, so H_0 It was accepted that the control class data were normally distributed. Thus, samples were obtained for the experimental group from normally distributed populations and for the control class from non-normally distributed populations.

Based on the results of the prerequisite test analysis, it is concluded that the homogeneity test does not need to be carried out because the posttest data on mathematical problem-solving ability were not normally distributed.

Given that the population data were not normally distributed, testing is carried out with nonparametric tests, including: (1) average completeness test (Wilcoxon Test); (2) classical completeness test (Binomial Test); (3) the difference test of two groups (Mann-Whitney Test); (4) two-group proportional test (Chi-Square Test).

Average Completeness Test

Because the posttest data in the experimental class were not normally distributed, the Wilcoxon test was conducted in IBM SPSS Statistics 26, and the results are displayed in Table 4.

Table 4. Wilcoxon Test Results

One-Sample Wilcoxon Signed Rank Test Summary	
Total N	33
Test statistic	393,500
Standards Error	55,898
Standardized Test Statistic	2,022
Asymptotic Sig. (2-sided test)	0,043

Based on Table 4, the Asym value is obtained. Sig (2-tailed) = 0.043. Because the test uses a one-party test, the value of Sig. = 0.0215 < 0.05 is obtained, so H_0 rejected and H_1 accepted. Thus, it can be concluded that the average mathematical problem-solving ability of students using the Teams games Tournament model assisted by Gimkit is higher than the KKTP score of 75.

Classical Completeness Test

The classical completeness test was conducted using the Binomial Test in IBM SPSS Statistics 26, and the results are presented in Table 5.

Table 5. Binomial Test Results

Binomial Test						
		Category	N	Observed Prop.	Test Prop.	Exact Sig. (1-tailed)
Status_ Ketuntasan	Group 1	1,00	25	0,76	0,75	0,000
	Group 2	0,00	8	0,24		
	Total		33	1,00		

Based on Table 5, the value of Exact Sig. (1-tailed) = 0.000 < 0.05, so H_0 rejected and H_1 accepted. Thus, it can be concluded that the percentage of students who demonstrate posttest mathematical problem-solving skills using the Teams games Tournament model assisted by Gimkit is greater than 75% of those who achieve KKTP. Thus, students' mathematical problem-solving skills under the Gimkit-assisted Teams Games Tournament model achieved classical completeness.

Difference Test for Two Groups

The difference between the two research groups was tested with the Mann-Whitney Test using IBM SPSS Statistics 26. So that the results in Table 6 are obtained.

Table 6. Hasil Uji Mann-Whitney

Test Statistics	
Mann-Whitney U	283,000
Wilcoxon W	748,000
Z	-2,922
Mann-Whitney U	283,000

Based on Table 6. An Asymp value is obtained. Sig (2-tailed) is 0.003. Because the research hypothesis is a one-party test, the value of Sig. = 0.0015 < 0.05, thus, so H_0 rejected and H_1 accepted, indicating that the average mathematical problem-solving ability of students who learn using the $H_0 H_1$The Teams Games Tournament model, assisted by Gimkit, yields higher scores than those of students who learn using the problem-based learning model.

Two-Group Proportions Test

The proportion of the two research groups was tested using the Chi-Square Test in IBM SPSS Statistics 26, with the results presented in Table 7.

Table 7. Chi-Square Test Results

Chi-Square Tests					
	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5,602	1	0,018		

Based on Table 7. An Asymp value is obtained. Sig (2-tailed) is 0.018. Because the research hypothesis is a one-party test, the value of Sig. = 0.009 < 0.05, so H_0 rejected and H_1 accepted. It can be concluded that the proportion of students' mastery of mathematical problem-solving skills with the Gimkit-assisted Teams Games Tournament model is higher than with the Problem-Based Learning model.

Based on the results of the analysis, it was found that (1) the average mathematical problem-solving ability of students has met the KKTP criteria; (2) the average mathematical problem-solving ability of students has reached classical completeness; (3) the average mathematical problem-solving ability of students in classes using the Gimkit-assisted Teams Games Tournament model is higher than in classes using the Problem Based Learning model; (4) the proportion of students achieving completeness in mathematical problem-solving skills using the Gimkit-assisted Teams Games Tournament model is higher than that of students taught using the Problem Based Learning model. Therefore, the Gimkit-assisted Teams Games Tournament model is considered effective in enhancing students' mathematical problem-solving abilities.

2. Description of Mathematical Problem-Solving Ability Reviewed from Mathematical Resilience in the Gimkit-Assisted Teams Games Tournament Learning Model.

The categorization of mathematical resilience was based on the results of the mathematical resilience questionnaire completed by students in the experimental group. Mathematical resilience was further classified into three categories: high, medium, and low. The distribution of students across these categories is shown in Figure 1.

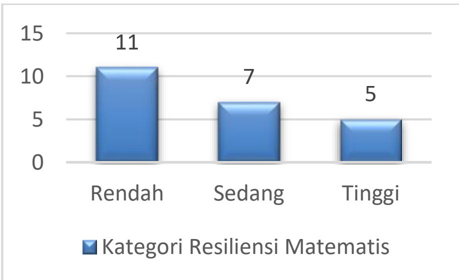

Figure 1. Mathematical Resilience Grouping Diagram of Pupils

The subjects of this study were six students from an experimental group: two with high resilience, two with moderate resilience, and two with low resilience. The analysis of mathematical problem-solving ability is carried out with indicators consisting of: (1) the ability to identify known and unknown elements as well as the sufficiency of the required information; (2) the ability to formulate mathematical problems or construct mathematical models; (3) the ability to implement strategies to solve problems within or beyond mathematics; (4) the ability explain or interpret results in relation to the original problem.

Following a comprehensive analysis of the mathematical problem-solving test data, interview data, and data triangulation, the results regarding students' mathematical problem-solving abilities were obtained. The analysis was conducted with respect to three levels of mathematical resilience: high, medium, and low to identify the patterns and characteristics of problem-solving abilities associated with each level of resilience.

Mathematical Problem-Solving Ability Reviewed from a High Level of Mathematical Resilience

The research subjects with high resilience in mathematical problem-solving are M18 and M32. Based on the posttest results for mathematical problem-solving ability, the subjects met four indicators of problem-solving skills. Figure 2 shows one of the answers from students with high resilience.

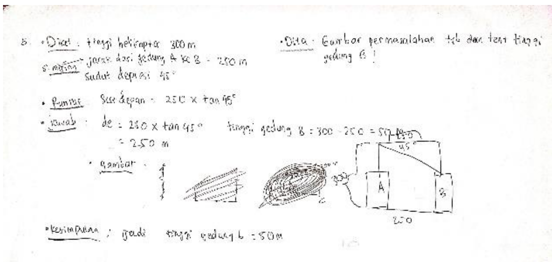

Figure 2. High Resilience Student Answers

Based on the interviews, M18 and M32 subjects were able to understand and identify known problems or information, and asked questions about well-presented problems. Subjects M18 and M32 can formulate problems and compile mathematical models from well-presented problems. Subjects M18 and M32 can also apply strategies to solve problems effectively. Subjects M18 and M32 also provided well-justified answers to the initial problem. Thus, students with high resilience can meet the four indicators of mathematical problem-solving ability well.

Mathematical Problem-Solving Ability Reviewed from Medium Mathematical Resilience Level

The research subjects with moderate resilience in mathematical problem-solving were M10 and M25. Based on the posttest results for mathematical problem-solving ability, the subjects met only three indicators of problem-solving skills. Figure 3 shows one of the students' answers with moderate resilience.

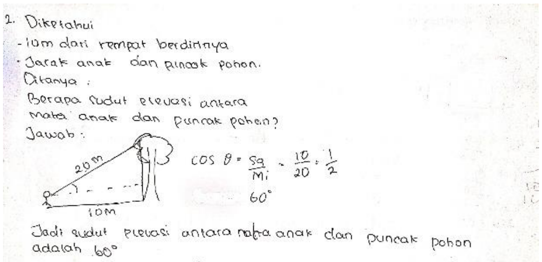

Figure 3. Answers for Medium Resilience Students

Based on the interview results, the M10 and M25 subjects were able to understand and identify problems or information that were known and asked about in the well-presented problem. Subjects M10 and M25 can formulate problems and compile mathematical models from well-presented problems. M10 and M25 subjects can also apply strategies to solve problems and do so well. However, subjects M10 and M25 tended to be unable to restate their answers in accordance with the initial problem, resulting in improper conclusions. Therefore, students with moderate resilience are considered capable of effectively fulfilling three indicators of mathematical problem-solving ability.

Mathematical Problem-Solving Ability Reviewed from Low Mathematical Resilience Levels

The research subjects with low resilience in mathematical problem-solving were M11 and M15. Based on the posttest results on mathematical problem-solving ability, the subjects met only one indicator of problem-solving skills. Figure 4 shows one of the students' answers with low resilience.

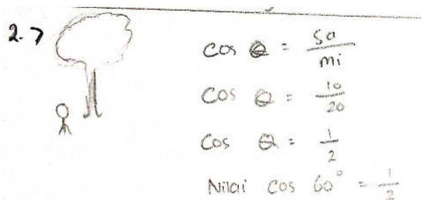

Figure 4. Low Resilience Student Answers

Based on the interview results, the M11 and M15 subjects were unable to understand or identify the problems or the information that was known and asked about in the well-presented problem. Subjects M11 and M15 are also unable to formulate problems and compile mathematical models of well-presented problems. Subjects M11 and M15 can also apply strategies to solve problems and do so well. Subjects M11 and M15 tend not to explain their answers properly in accordance with the initial problems related to the conclusion. Thus, students with low resilience can meet only one indicator of mathematical problem-solving ability.

Based on the results of the above data analysis, it was described that (1) students with high resilience have high mathematical problem-solving skills by being able to meet the four indicators of mathematical problem-solving ability well; (2) Students with moderate levels of resilience demonstrate a moderate level of mathematical problem-solving ability, as they can fulfill three indicators effectively. Meanwhile, students with low resilience exhibit limited mathematical problem-solving skills, as they can only adequately meet one indicator.

CONCLUSION

Based on the analysis and discussion, it can be concluded that the Gimkit-assisted Teams Games Tournament learning model is effective in improving students' mathematical problem-solving skills. This is indicated by average scores exceeding the minimum mastery criterion, the attainment of classical completeness, and significant differences showing that students taught using the Gimkit-assisted TGT model outperform those taught using the Problem-Based Learning model. In addition, the proportion of students achieving mastery in the experimental group is higher than in the control group; students' mathematical problem-solving ability varies with their level of mathematical resilience. Students with high resilience can fulfill all four indicators of problem-solving ability; students with moderate resilience can fulfill three indicators; and students with low resilience can fulfill only one indicator.

However, this study is limited by the relatively small sample size and its implementation in a single research setting, which may affect the generalizability of the findings. Therefore, future research is suggested to involve a larger and more diverse sample, extend the duration of the study, and explore other variables such as motivation or self-efficacy to obtain more comprehensive results.

DECLARATIONS

Author Contribution : CHK: Conceptualization, Writing - Original Draft, Editing and Visualization, Writing, Editing, Formal analysis, and Methodology; M: Review, Validation, and Supervision.

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Conflict of Interest : The authors declare no conflict of interest.

Additional Information : This study utilizes data from SMA Negeri 2 Demak, and permission to use this data has been officially granted by the school.

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