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The Effect of Reciprocal Teaching Assisted by Wordwall Media on Students' Mathematical Communication and Resilience

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ABSTRACT

This study aims to analyze the differences in students' mathematical communication and resilience skills between conventional learning and reciprocal teaching assisted by Wordwall. The study was conducted due to the limited research combining the reciprocal teaching method with interactive media to improve students' communication skills and resilience. The research population consist of eighth-grade students at a junior high school in Cirebon Regency, with samples taken using purposive sampling. The samples taken from classes VIII B and E, totaling 65 students. Using a quantitative approach with a pretest-posttest control group design and instruments in the form of tests and questionnaires, the results showed that the average posttest score for mathematical communication in the experimental class was 75.27, higher than the control class, which was 31.25. Conversely, the posttest score for mathematical resilience in the control class was 81.50, higher than that of the experimental class, which was 74.03. These findings indicate that the integration of reciprocal teaching and Wordwall has the potential to improve students' mathematical communication, although further research is needed to identify effective strategies for maintaining students' resilience.

Keywords: reciprocal teaching, mathematical communication, mathematical resilience

ABSTRAK

Penelitian ini bertujuan untuk menganalisis perbedaan kemampuan komunikasi dan resiliensi matematis siswa antara pembelajaran konvensional dan reciprocal teaching berbantuan Wordwall. Penelitian dilatarbelakangi oleh terbatasnya kajian yang menggabungkan metode reciprocal teaching dengan media interaktif untuk meningkatkan kemampuan komunikasi dan resiliensi siswa. Populasi penelitian mencakup siswa kelas VIII di salah satu SMP Kabupaten Cirebon dengan sampel diambil secara purposive sampling. Sampel diambil dari kelas VIII B dan VIII E dengan total 65 siswa. Menggunakan pendekatan kuantitatif dengan pretest-posttest kontrol grup desain serta instrumen berupa tes dan angket, hasil menunjukkan bahwa rata-rata skor posttest komunikasi matematis di kelas eksperimen yaitu 75.27, lebih tinggi dibanding dibanding kelas kontrol yaitu 31.25. Sebaliknya, skor posttest resiliensi matematis siswa kelas kontrol yaitu 81.50, lebih tinggi dibandingkan kelas eksperimen yaitu 74.03. Temuan ini menunjukkan bahwa integrasi reciprocal teaching dan Wordwall berpotensi meningkatkan komunikasi matematis siswa,

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meskipun diperlukan penelitian lanjutan untuk mengidentifikasi strategi yang efektif dalam mempertahankan resiliensi siswa.

Kata Kunci: reciprocal teaching, komunikasi matematis, resiliensi matematis.

INTRODUCTION

A key goal of mathematics education is to improve students' ability to communicate mathematical ideas effectively, as mathematics is a science of logic that can enhance students' critical thinking skills (Hodiyanto, 2017). Mathematics is not only about solving problems or doing calculations but also about conveying ideas, concepts, and reasoning in mathematics clearly to people (U. F. Utami, Laelasari, Maharani, & Hartono, 2024). In this context, students' mathematical communication fulfills a vital role in the classroom learning process, as it allows them to convey mathematical ideas through symbols, language, and notations. These skills enable learners to interpret information, build representations of mathematical relationships, and reformulate real-world phenomena into structured mathematical expressions, whether spoken or written (Lubis, Meiliasari, & Rahayu, 2023). A person will not understand the concept and solution of a mathematical problem or may misinterpret it if the concept and solution are not communicated using appropriate mathematical language (Jusniani & Nurmasidah, 2021).

Findings in schools indicate that students continue to struggle with mathematical communication, as their skills remain weak (Aisah, Nasir, & Santi, 2018; Nugrawati, Nuryakin, & Afrilianto, 2018). This limited proficiency stems from low student engagement, excessive teacher control in lessons, and repetitive teaching strategies. In the context of 21st-century education, mathematical communication skills have become increasingly important—not only for mastering content but also for fostering critical thinking, collaboration, and problem-solving abilities. Consequently, the teacher’s role is essential in addressing this need. Beswick and Fraser (2019) assert that mathematics teachers must embody and promote communication, collaboration, critical thinking, and creativity in order to effectively support integrated STEM learning. Furthermore, Mursalin et al. (2025) emphasize that effective teacher communication both verbal and nonverbal helps create an inclusive classroom environment that enhances student interaction, motivation, and higher-order thinking in mathematics. However, efforts to improve students' mathematical communication cannot be separated from the psychological challenges faced in the learning process, one of which is anxiety about mathematics which can hinder students' active participation in discussing and conveying ideas. Enhancing students' ability to communicate mathematically in learning often encounters multiple obstacles, one of which is anxiety, which makes some students tend to avoid math. However, these challenges can be overcome through resilience, which is characterized by an attitude of earnestness, perseverance, and self-confidence (Maharani & Bernard, 2018). In solving a math problem, good self-confidence is essential, as students with high self-confidence are less likely to be influenced by others' answers (Putri, Nasir, & Maharani, 2023).

Mathematical resilience refers to students’ ability to manage internal anxiety related to mathematics and maintain a positive mindset when facing mathematical challenges (Hutauruk &

Naibaho, 2020; W. B. Utami, Dewi, & Widodo, 2024). Resilience is also defined as a positive mindset that enables students to manage anxiety, fear, and obstacles in learning mathematics and to persist through challenges until they reach a solution (Asih, Isnarto, Sukestiyarno, & Wardono, 2019). The importance of mathematical resilience is evident in mathematics education research, as students often encounter various difficulties, obstacles, and anxiety when learning mathematics, which can ultimately lead to a dislike for the subject. Gokhool, Lawson, & Hodds (2022) found a negative correlation between mathematics anxiety and mathematical resilience, emphasizing that students with higher resilience are more likely to engage proactively with academic support services in mathematics. Students who exhibit greater resilience in the face of adversity are generally more motivated to pursue and accomplish academic goals (Laelasari, Darhim, & Prabawanto, 2022).

The reciprocal teaching method can be an effective way to enhance students' mathematical communication skills and build their resilience in learning mathematics. In Lev Vygotsky's social constructivist theory, reciprocal teaching is based on active socialization between teachers and students or among students, where knowledge is constructed through dialogue rather than through the transfer of knowledge from teachers to students. Students with good mathematical resilience can face the challenges of learning mathematics and still effectively communicate concepts and problem solutions using appropriate mathematical language. The reciprocal teaching approach highlights the role of language in communication, comprehension, and application. It engages students as peer instructors, while the teacher serves as a model, facilitator, and mentor throughout the learning process (Maulani, Suyono, & Noornia, 2017; Pradja & Firmansyah, 2020).

A major sign of effective learning is the level of active participation students demonstrate in classroom activities (Wihartanti, 2022). To enhance students' communication and mathematical resilience through reciprocal teaching, engaging learning media are essential to foster active participation. One type of learning media that can be utilized is the Wordwall game, an online, web-based software. Wordwall provides a variety of interactive games and practice questions, enabling teachers to seamlessly integrate learning materials and assessments through engaging gameplay (Puspitarini, 2023). Teachers can utilize this interactive application to enhance student participation and encourage a more dynamic classroom environment.

Previous studies have explored the effectiveness of Wordwall in improving aspects of mathematics learning, such as students' understanding of mathematical concepts using a contextual learning model (Putra, Baiduri, & Zukhrufurrohmah, 2024), or improving learning outcomes through a culturally responsive approach (Kayniya, Purnamasari, & Nurhayati, 2025). On the other hand, the reciprocal teaching model has a positive effect on mathematical critical thinking skills through discursive interactions within groups (Suri, Putri, & Netriwati, 2021). However, there has been no research that explicitly integrates reciprocal teaching with interactive digital media such as Wordwall to simultaneously develop mathematical communication and mathematical resilience, which is students' ability to bounce back from difficulties when facing mathematical learning challenges. This gap is significant because Wordwall offers elements of interactivity and instant feedback, which, when combined with discussion and reflection strategies in reciprocal teaching, have the potential to strengthen both aspects. Therefore, this study presents novelty through the integration of

pedagogical methods (reciprocal teaching) and digital technology (Wordwall), with the aim of filling the research gap in the synergistic relationship between interactive media and cooperative teaching strategies to enhance students' mathematical communication and resilience.

The topic of the System of Linear Equations in Two Variables (SLETV) is closely connected to students' mathematical communication and resilience skills. Within this context, students need to articulate given information and the problem's requirements, utilize mathematical symbols and models to clarify the problem, and interpret the solution derived from the system of equations. This process often presents conceptual and procedural challenges that can test students' resilience in thinking and problem solving. Therefore, SLETV becomes a relevant and strategic context for examining the effectiveness of the Wordwall-assisted reciprocal teaching approach in developing good mathematical communication and resilience skills. Students with strong mathematical expression abilities generally demonstrate high curiosity, engage in reflection, conduct research, and draw from diverse sources to solve problems (Rosa, Halini, & Hamdani, 2021).

The core problem examined in this research is how the integration of reciprocal teaching with Wordwall media influences students' mathematical communication and resilience, especially within the topic of Systems of Linear Equations in Two Variables (SLETV). Based on the provided description, this study aims to: 1) Analyze the differences in mathematical communication skills between students taught using conventional methods and those engaging in reciprocal teaching supported by Wordwall media. 2) Analyze the differences in mathematical resilience between students receiving conventional learning and those adopting the reciprocal teaching model with Wordwall media integration.

METHOD

A quantitative research approach was employed using a quasi-experimental design, specifically the pretest-posttest control group design. This design involved two groups: an experimental group that received instruction through reciprocal teaching assisted by Wordwall media, and a control group that received conventional instruction. Pretests and posttests were administered to both groups to evaluate changes in two key constructs: mathematical communication ability and mathematical resilience. The mathematical communication ability test was designed to assess the extent to which students can convey understanding and solve mathematical problems clearly and effectively. This test was given at the beginning and end of the study to evaluate the differences in students' communication skills after applying the reciprocal teaching method with the help of Wordwall media. The Mathematical Resilience Questionnaire was employed to assess students' ability to persevere through mathematical challenges and their determination to solve complex problems. This approach allows measurement of variables, analysis of relationships between variables, and hypothesis testing through statistical analysis to objectively assess the effectiveness of reciprocal teaching learning assisted by Wordwall media (Asy'ari, Makalao, & Irawan, 2023; Kurniawati & Rindrayani, 2025).

The study population consisted of eighth-grade students from a junior high school in Cirebon Regency, with samples chosen through purposive sampling aimed at determining which class would

serve as the experimental group and which as the control group. Two classes participated: Class VIII-E (33 students) as the experimental group and Class VIII-B (32 students) as the control group. The experimental group engaged in reciprocal teaching supported by Wordwall media, which involved structured group discussions, student-led question generation, summarizing, and clarifying concepts collaboratively, with interactive quizzes delivered through the Wordwall platform, whereas the control group followed a conventional, lecture-based, teacher-centered approach, and the learning activities focused on teacher explanations followed by student practice using printed worksheets, without the use of digital tools or structured peer collaboration (Fahrudin, Ansari, & Ichsan, 2021).

This study employed an experimental design, comparing two groups through pre-tests and post-tests to measure students' communication and mathematical resilience skills. The research design utilized in this study is presented in Table 1.

Table 1. Research Design

Group	Pre-test	Treatment	Post-test
E	O	X_1	O_1
K	O	X_2	O_1

Description:
E: Experimental Class
K: Control class
X_1: Reciprocal teaching model with Wordwall media assistance
X_2: Conventional model
O: Pre-test
O_1: Post-test

This study included independent variables, specifically the reciprocal teaching-learning model assisted by Wordwall media; dependent variables, namely students' mathematical communication and resilience skills; and the comparison was made with a control group that received conventional instruction. Additionally, several variables were controlled across both groups to minimize confounding factors, such as instructional time, teacher, and learning materials. Data collection was conducted through assessments of mathematical communication ability and resilience questionnaires. To facilitate the process, the instruments used comprised test questions on mathematical communication related to the System of Linear Equations in Two Variables (SLETV) and questionnaire sheets measuring mathematical resilience. The topic of SPLDV was chosen because it is conceptually rich and allows students to engage in various forms of mathematical representation, reasoning, and problem solving—key components of mathematical communication. Moreover, SPLDV is a fundamental topic in the junior high school curriculum and serves as a bridge to more advanced algebraic thinking

The indicators of mathematical communication in this study were developed based on the NCTM (2000) process standards, which emphasize students' ability to express mathematical ideas clearly, use representations, and justify reasoning in both oral and written forms. The mathematical communication ability test, consisting of essay-type questions, was designed to assess students' clarity and effectiveness in conveying understanding and solving mathematical problems. This test was given at the beginning and end of the study to evaluate the differences in students'

communication skills after applying the reciprocal teaching method assisted by Wordwall media. The test instruments underwent validation for content validity, reliability, item difficulty, and discriminating power. Validity testing was conducted using Pearson's product-moment correlation, with r-count values ranging from 0.457 to 0.9, indicating that all items were valid (r-table = 0.361, N = 30). Reliability was tested using Cronbach's Alpha, yielding a coefficient of 0.761, which indicates high reliability. In addition, item difficulty indices ranged from 0.3 to 0.7 (moderate level), while item discrimination indices ranged from 0.30 to 0.75, demonstrating good discriminatory power. Meanwhile, the mathematical resilience questionnaire was employed to assess students' ability to persevere through mathematical challenges and their determination to solve complex problems. This Likert-scale instrument measured aspects such as motivation, adaptability to setbacks, and the capacity to stay composed and focused when confronted with difficulties in learning mathematics.

The research data consists of pretest and posttest results from assessments of mathematical communication ability and resilience questionnaires. Prior to stastitical analysis, prerequisite tests were conducted, including including normality tests (using the Shapiro-Wilk test) and homogeneity tests (using Levene's test). If the data meet the assumptions of normal distribution and homogeneity, hypotheses are tested using the independent samples t-test. However, if the data are not normally distributed, the Mann-Whitney U test is used instead. These analyses aim to determine whether there are statistically significant differences between the experimental and control groups in terms of students' mathematical communication skills and resilience. All data analyses were conducted using SPSS statistical software.

The hypotheses examined in this study are as follows: (1) H_{01}: There is no significant difference in students' mathematical communication skills between the group taught using conventional methods and the group taught using reciprocal teaching assisted by Wordwall media; H_{11}: There is a significant difference in students' mathematical communication skills between the two groups (2) H_{02}: There is no significant difference in students' mathematical resilience levels between the group receiving conventional instruction and the group using the reciprocal teaching model assisted by Wordwall media; H_{12}: There is a significant difference in students' mathematical resilience levels between the two groups.

RESULT AND DISCUSSION

Result

This study aims to determine the effect of the reciprocal teaching learning model assisted by Wordwall media on students' mathematical communication and resilience ability. Data were obtained from pretest and posttest results in the experimental class and the control class. The results of the mathematical communication and mathematical resilience ability of students in both groups can be seen in Table 2 and Table 3.

Table 2. Students' Mathematical Communication Ability Data

Group	Type of Test	N	Range	Minimum	Maximum	Mean	Std. Deviation
Control	Pre-test	32	66	4	70	21,50	15,641
	Post-test	32	66	0	66	31,25	12,441
Experimental	Pre-test	33	96	0	96	34,36	27,292
	Post-test	33	74	24	98	75,27	16,739

As evidenced by the results in Table 2, the experimental class experienced a substantially greater improvement in post-test scores compared to the control class. The experimental group, which utilized the reciprocal teaching model with Wordwall media assistance, began with a pre-test average of 34.36, which then rose significantly to 75.27 in the post-test. These results indicate that the intervention given to the experimental class appears to be very effective in improving students' communication skills, both in terms of average scores and the distribution of results.

Table 3. Students' Mathematical Resilience Ability Data

Group	Type of Test	N	Minimum	Maximum	Mean	Std. Deviation
Control	Pre-test	32	63	89	78,94	6,283
	Post-test	32	61	96	81,50	7,436
Experimental	Pre-test	33	56	88	72,64	7,644
	Post-test	33	59	90	74,03	8,335

According to the results in Table 3, the post-test scores of the control group exhibited a greater increase. The control class had an average pre-test score of 78.94 for mathematical resilience, which increased to 81.50 following conventional learning. Meanwhile, the experimental group, which engaged in reciprocal teaching with Wordwall media, recorded a pre-test average of 72.64, rising to 74.03 in the post-test. These findings indicate that the intervention provided to the experimental class did not have a significant impact on improving students' resilience. To assess the distribution characteristics of the data of students' mathematical communication and resilience ability, the Shapiro-Wilk normality test was conducted. The results of this test are displayed in the Table 4.

Table 4. Normality Test Results

Ability Type	Class	Type of Test	Shapiro-Wilk		
			Statistic	df	Sig.
Mathematical Communication	Control Class	Pre-test	,609	32	,000
		Post-test	,920	32	,020
	Experimental Class	Pre-test	,875	33	,001
		Post-test	,882	33	,002
Mathematical Resilience	Control Class	Pre-test	,958	32	,236
		Post-test	,972	32	,558
	Experimental Class	Pre-test	,970	33	,478
		Post-test	,975	33	,636

The normality test results in Table 4 indicate that the mathematical communication ability data for all groups have significance values below 0.05, so it can be concluded that the data are not normally distributed. Conversely, the data on mathematical resilience ability showed significance values above 0.05, which means that the data is normally distributed. These findings imply that

further statistical analysis for mathematical communication ability will use a non-parametric test (Mann Whitney U test), while for mathematical resilience ability will use a parametric test (independent samples t-test). The results of the statistical tests can be seen in Table 5 and Table 6.

Table 5. Mann-Whitney U Test Results of Student Mathematical Communication Ability

Description	Result
Mann-Whitney U	45,000
Wilcoxon W	573,000
Z	-6,351
Asymp. Sig. (2-tailed)	,000

As evidenced by the results in Table 5, the post-test data for students' mathematical communication skills produced an Asymp. Sig. (2-tailed) value of 0.000. Since this value falls below 0.05, H_{01} is rejected and H_{11} is accepted, confirming a significant difference in mathematical communication skills between students who received conventional instruction and those who engaged in reciprocal teaching with Wordwall media support. Additionally, as indicated in Table 2, incorporating Wordwall media into reciprocal teaching leads to a statistically significant improvement in students' mathematical communication abilities.

Tabel 6. Independent Sample T-test Results of Student Mathematical Resilience Ability

Description	F	Sig.	t	df	Sig.	Mean Difference	Std. Error Difference
Equal variances assumed	1,232	,271	3,809	63	,000	7,470	1,961
Equal variances not assumed			3,815	62,573	,000	7,470	1,958

Referring to the statistical details in Table 6, Levene's test for equality of variances yielded a significance value of 0.271, exceeding 0.05, confirming that the assumption of equal variances between the control and experimental groups is met. Moreover, Table 6 presents a Sig. (2-tailed) value of 0.000, which is below the 0.05 threshold, leading to the rejection of H_{02} and the acceptance of H_{12}. These findings indicate a significant difference in students' mathematical resilience between those receiving conventional instruction and those engaging in reciprocal teaching with Wordwall media. However, as demonstrated in Table 4, the difference suggests that students in the control group achieved a higher mean score in mathematical resilience than those in the experimental group.

Discussion

Based on the results and explanation above, the results of this study indicate that the use of reciprocal teaching assisted by Wordwall media significantly improved students' mathematical communication skills. This aligns with previous research indicating that technology-enhanced reciprocal peer tutoring fosters active mathematical communication, reflection, and co-construction of ideas (Oikarinen, Oikarinen, & Havu-Nuutinen, 2022). Through structured dialogue involving predicting, questioning, clarifying, and summarizing, students are encouraged to

externalize their reasoning, which directly supports the development of mathematical communication. The incorporation of Wordwall media likely enhanced this process by providing interactive and visual stimuli that sustained student interest and participation. Research has shown that digital tools facilitate differentiated instruction by allowing educators to tailor content to students' individual needs (Schmid, Pauli, Stebler, Reusser, & Petko, 2022), while also promoting greater student motivation through interactive and multimodal learning environments (Estaiteyeh & DeCoito, 2024).

Surprisingly, based on the result in Table 3, the control class exhibited higher mathematical resilience levels than the experimental group. This unexpected finding may be attributed to the novelty and cognitive demands of the reciprocal teaching model. While promoting metacognitive dialogue, the approach may also have introduced unfamiliar structures and peer dependencies that some students found challenging, especially in a high-stakes learning context. According to Martin and Marsh (2006) theory of academic resilience, learners tend to demonstrate stronger persistence when instructional methods align with their prior learning habits and perceived self-efficacy.

This discrepancy may also point to a limitation in the implementation fidelity of the intervention. Teachers and students may require more time and scaffolding to adjust to the collaborative and reflective nature of reciprocal teaching. Moreover, the gamified elements in Wordwall, while engaging, might have inadvertently shifted students' focus away from sustained effort toward task completion and competition, potentially impacting their resilience in problem-solving tasks. These findings suggest important theoretical and practical implications. Theoretically, the study reinforces the social-constructivist foundation of reciprocal teaching, where communication is a key pathway to knowledge construction (Vygotsky, 1978). Practically, it underscores the need for balanced integration of educational technology to support resilience-building in learners.

CONCLUSION

From the findings and analysis, this study highlights the significant role of instructional models in shaping students' mathematical communication skills and resilience. The findings indicate that the reciprocal teaching model, when integrated with Wordwall media, effectively enhances students' mathematical communication abilities, as evidenced by the substantial improvement in the experimental group's post-test performance compared to the control group. This suggests that combining interactive teaching strategies with digital tools can foster more active engagement and deeper understanding in mathematics learning. However, the data also reveal an intriguing contrast in mathematical resilience, where students taught using conventional methods exhibited higher resilience levels than those exposed to reciprocal teaching assisted by Wordwall media. This outcome may be influenced by several non-instructional factors, such as students' initial unfamiliarity with the collaborative learning structure, limited time for adaptation, uneven participation in discussions, and varying levels of intrinsic motivation.

These findings have theoretical implications by reinforcing the relevance of the social-constructivist approach to mathematics learning, as well as demonstrating the potential for utilizing digital media to support students' communication skills. Practically, these results encourage the need

for a more planned application of the reciprocal teaching model by ensuring that students are adequately prepared for collaborative engagement and are given sufficient time to adapt and actively participate. Future research is encouraged to explore the long-term effects of reciprocal teaching with digital media in diverse classroom contexts, while also considering student characteristics and teacher readiness. Moreover, in-depth qualitative studies could provide richer insights into how students interact and adapt to innovative instructional strategies over time.

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