Media Pendidikan Matematika
Program Studi Pendidikan Matematika FSTT UNDIKMA
https://e-journal.undikma.ac.id/index.php/jmpm

Juni 2025, Vol. 13, No. 1
P-ISSN: 2338-3836
E-ISSN: 2657-0610

The Effect of Using Cross Rope Media on Learning in Elementary Schools

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Abstract: *This study aims to examine the effect of implementing string-crossing media on the mathematics achievement of elementary school students, specifically focusing on multiplication. The research was motivated by the low performance of students in understanding multiplication concepts, which is often linked to the conventional lecture-based teaching approach and the limited use of concrete instructional tools. Employing a quantitative research method with a posttest-only control group design, the study involved 36 third-grade students from SDN Batobella 1, randomly assigned into experimental and control groups. The experimental group received lessons supported by string-crossing media, while the control group was taught using conventional methods. Data were gathered through a validated achievement test. After confirming the assumptions of normality and homogeneity, data analysis was conducted using an independent samples t-test. The results demonstrated a statistically significant difference in mean scores between the experimental group (M = 81.11) and the control group (M = 70.00), with p < 0.05. These outcomes suggest that incorporating string-crossing media substantially improves students' learning results in mathematics. The media effectively transforms abstract multiplication concepts into concrete, visual, and interactive experiences, which particularly support students with visual and kinesthetic learning preferences. Therefore, it is recommended as a viable instructional alternative for contextual learning, especially in areas with limited access to digital educational technologies.*

Keywords: *string crossing media, learning outcomes, multiplication, elementary education*

Abstrak: Penelitian ini bertujuan untuk mengkaji pengaruh penerapan media tali-silang (string-crossing) terhadap prestasi belajar matematika siswa sekolah dasar, khususnya pada materi perkalian. Penelitian ini dilatarbelakangi oleh rendahnya kemampuan siswa dalam memahami konsep perkalian, yang kerap dikaitkan dengan pendekatan pembelajaran konvensional berbasis ceramah dan keterbatasan penggunaan alat bantu pembelajaran konkret. Penelitian ini menggunakan metode kuantitatif dengan desain *posttest-only control group*. Subjek penelitian terdiri atas 36 siswa kelas III SDN Batobella 1 yang dibagi secara acak ke dalam kelompok eksperimen dan kelompok kontrol. Kelompok eksperimen mendapatkan pembelajaran dengan dukungan media tali-silang, sedangkan kelompok kontrol diajarkan menggunakan metode konvensional. Data diperoleh melalui tes hasil belajar yang telah divalidasi. Setelah mengonfirmasi asumsi normalitas dan homogenitas, analisis data dilakukan menggunakan uji *t* sampel independen. Hasil penelitian menunjukkan adanya perbedaan yang signifikan secara statistik pada nilai rata-rata antara kelompok eksperimen (M = 81,11) dan kelompok kontrol (M = 70,00), dengan p < 0,05. Temuan ini menunjukkan bahwa penggunaan media tali-silang secara signifikan meningkatkan hasil belajar matematika siswa. Media ini secara efektif mengubah konsep perkalian yang abstrak menjadi pengalaman belajar yang konkret, visual, dan interaktif, yang secara khusus mendukung siswa dengan preferensi belajar visual dan kinestetik. Oleh karena itu, media ini direkomendasikan sebagai alternatif pembelajaran yang kontekstual, terutama di daerah yang memiliki keterbatasan akses terhadap teknologi pendidikan digital.

Kata kunci: media tali-silang, hasil belajar, perkalian, pendidikan dasar

INTRODUCTION

Education plays a vital role in preparing younger generations to effectively face the challenges of modern life. It extends beyond the mere transmission of knowledge

and skills by nurturing moral, ethical, and civic values that are crucial for shaping responsible and resilient individuals. In the context of globalization and rapid developments driven by the Fourth Industrial Revolution, education is increasingly focused on cultivating 21st century competencies such as critical thinking, collaboration, creativity, and communication that are essential for navigating dynamic social, economic, and technological transformations (Addzaky, 2024).

Enhancing the standard of education should be regarded as a core priority within the overall context of national development. The Indonesian government, through programs such as the Merdeka Curriculum, emphasizes student-centered and contextualized learning that fosters local potential. One key measure of educational quality is students' mastery of foundational competencies across subjects, particularly mathematics, which is recognized as a core discipline in primary education.

Effective mathematics learning requires the integration of appropriate instructional media to support contextual, student-centered approaches. alternative instructional media can enhance learning motivation, bridge abstract mathematical concepts, and provide meaningful experiences especially at the elementary level (Surur, 2018).

Mathematics plays an essential role in developing logical, systematic, analytical, and critical thinking skills from an early age. According to Miftahul Jannah & Miftahul Hayati (2024), mathematical competence is vital for solving real-world problems. This perspective is reinforced by Putri et al. (2024), who assert that understanding students' misconceptions enables educators to design more effective teaching strategies. Hence, elementary mathematics education should move beyond rote memorization of formulas and procedures, aiming instead to promote conceptual understanding and real-life application.

Despite this, challenges in teaching mathematics remain prevalent, particularly in primary schools. Many students perceive the subject as difficult and monotonous. Data from SDN Batobella 1 (2023) revealed that only 42% of third-grade students achieved scores above the minimum mastery criteria (KKM) in multiplication. This discrepancy between learning goals and classroom realities signals an urgent need for innovative instructional strategies and media. Several factors contribute to low mathematics achievement, including limited teaching variation, an overreliance on lectures, insufficient use of concrete media, and low student engagement.

Suyanti (2021) highlight that traditional methods often fail to meet the diverse needs of learners, whereas alternative learning tools such as manipulatives, games, and visual supports can significantly aid students' comprehension of mathematical content. External factors like remote school locations and students' socioeconomic status also influence their learning motivation and conceptual grasp (Yunianta, 2023). These conditions necessitate contextual, engaging, and student-friendly instructional strategies. Aisyah et al. (2025) affirm that educational games and visual representations are highly effective in helping young learners comprehend abstract mathematical ideas, especially during early learning stages.

Multiplication is a foundational concept that must be mastered early, as it supports students' understanding of more advanced topics such as division, fractions, and mixed operations. In daily life, multiplication is closely related to budgeting, calculating expenses, and understanding unit pricing (Sofiyah et al., 2024). Consequently, multiplication instruction should be supported by instructional media that facilitates concrete and enjoyable learning experiences.

To address these instructional challenges, the use of visual and tangible media has become more prominent in mathematics education. One such medium is the string-crossing method, which visually represents multiplication through intersecting strings. This approach enhances motor coordination while clarifying numerical relationships, making it especially beneficial for students with visual or kinesthetic learning styles (Ikhsan et al., 2021).

Simple media like string-crossing has been shown to foster student engagement by encouraging active exploration and interaction. Furthermore, this medium can be produced using affordable materials, making it a practical solution for schools with limited technological infrastructure (Hairunnisa, 2025).

This aligns with findings by Ulya et al. (2024), it was discovered that employing simple, tactile learning tools like string boards and numerical cards can greatly enhance students' engagement and retention, particularly in basic mathematics education. Similarly, Millah et al. (2025) emphasize that media allowing for direct manipulation of numbers and mathematical symbols offers students greater opportunities for exploration and independent meaning-making. Prior studies have shown that such tools can be used autonomously by students, with positive impacts on their conceptual understanding (Sauri, M. S., & Nurdian, 2024). As a result, students go beyond rote memorization and gain a visual and hands-on understanding of multiplication processes.

Numerous studies have reported that simple instructional media can significantly improve students' academic performance. For instance, Lestari (2024) found that comic-based instructional tools greatly enhanced multiplication skills among early-grade students compared to conventional teaching. Similarly, Haryadi & Mudzakkir (2024) emphasized the role of contextual media in promoting meaningful and enjoyable learning experiences.

Although string-crossing media has been introduced in mathematics instruction, the literature exploring its use remains limited particularly in terms of its instructional design, implementation contexts, and empirical evaluation. Most existing studies rely on descriptive or quasi-experimental approaches, which may not offer robust evidence of its effectiveness. Therefore, more rigorous and systematic studies are needed to evaluate the impact of string-crossing media, especially among third-grade students transitioning from concrete to abstract thinking.

This research employs a posttest-only control group approach to evaluate the impact of the string-cross media on enhancing elementary students' performance in multiplication. This study adopts a posttest-only control group design to rigorously examine the impact of using string-cross instructional media on improving the

multiplication performance of elementary school students. The purpose is to determine whether this hands-on and visually engaging learning tool leads to measurable improvements in students' understanding and mastery of multiplication concepts. This study is anticipated to offer meaningful contributions toward the formulation of practical, media-integrated instructional approaches that can be effectively implemented across diverse elementary school environments (Tan et al., 2024).

Furthermore, the findings are anticipated to support improved mathematics instruction, particularly in regions with limited access to digital technology. They may also serve as useful references for educators, curriculum developers, and policymakers in designing contextual and student-centered learning strategies. In doing so, mathematics education can become more inclusive, meaningful, and empowering for all learners.

METHOD

The research utilized a quasi-experimental framework within a quantitative methodology, specifically a posttest-only approach with a control group and non-equivalent participants, in accordance with established research procedures by Sugiono (2019). This research sought to evaluate and compare the mathematics performance of two groups of third-grade students, with one group receiving instruction through a novel teaching method and the other following traditional teaching practices as a control group. Although random selection was used to form the groups, the distribution of participants into each group was conducted randomly from the existing classes.

The study was conducted at SD Batobella 1, located in Bangkalan Regency. The study involved 36 third-grade students who were randomly assigned to two groups, each comprising 18 participants. Instruction for the experimental group was delivered using the string-crossing media, whereas the control group received traditional teaching methods, such as lectures and standard practice exercises.

The research instrument comprised a learning outcome test consisting of multiple-choice and essay questions, developed based on the basic competencies and learning indicators for whole number multiplication. Instrument validation was performed through expert judgment to ensure content and construct validity aligned with the predetermined learning objectives.

To assess the students' grasp of the material, a post-test was given after a single teaching session. To ensure consistency and enable a valid comparison of outcomes, the same test was provided to both the control and experimental groups. Before carrying out the statistical evaluation, preliminary tests were conducted to verify assumptions, to check if the data adhered to the assumptions of normality and equal variance, the Kolmogorov-Smirnov procedure was conducted to evaluate whether the data followed a normal distribution, and Levene's test was used to examine variance homogeneity. The data analysis was conducted through IBM SPSS Statistics (v29).

With all assumptions confirmed, the study applied an independent samples t-test to analyze significant outcome differences between the control and experimental

groups, adopting a 0.05 significance level. The null hypothesis (H_0) proposed that there was no meaningful variation in the learning outcomes of students between the two groups, whereas the alternative hypothesis (H_1) suggested the existence of a significant difference. The criteria for decision-making dictated that H_0 would be rejected if the p-value was below 0.05, thus supporting the acceptance of H_1.

This approach seeks to offer empirical support on the impact of utilizing string-crossing media to enhance the mathematical performance of third-grade elementary students. Furthermore, it is intended to act as a practical reference for educators in applying contextual learning tools tailored to the specific traits and requirements of their students.

RESULTS AND DISCUSSION

Results

The study examines the impact of Cross Rope media on third-grade students' success in learning mathematics, specifically targeting their proficiency in performing whole number multiplication. As the class comprised 36 students, all were involved in the study and were randomly selected and assigned into two equally sized groups. The experimental group, consisting of 18 students, received instruction using the Cross Rope media, which integrates physical activity with visual learning tools. Meanwhile, the control group, also comprising 18 students, was taught using conventional teaching strategies typically applied in classroom settings.

Descriptive Statistics by Class/Group

Descriptive statistical analysis was conducted to provide an overview of students' learning outcomes following the instructional process within each group. The control group was instructed using conventional teaching approaches without incorporating any innovative tools, while the experimental group utilized the Cross Rope media, which is specially developed to improve students' visual and interactive comprehension of multiplication concepts.

The objective of this study was to investigate students' academic achievement trends through an analysis of their average marks, standard deviation, and standard error, which together offer a deeper understanding of data variability and the level of consistency in performance across groups. Assessing these descriptive statistics is crucial for detecting possible differences in learning outcomes between the groups before carrying out inferential statistical procedures, an explanation is provided in the following table.

Table 1. Descriptive Statistics for the Control and Experimental Groups

Variable	Group	N	Mean	Std. Deviation	Std. Error Mean
Learning Outcomes	Control	18	70.00	13.284	3.131
	Experimental	18	81.11	12.783	3.013

The posttest results displayed in the table above were obtained following the instructional process in both groups, aiming to assess students' academic performance. According to the statistical findings, the experimental group outperformed the control group by a notable margin, with a mean score of 81.11 (SD = 12.783), indicating improved learning achievement and relatively low variability among participants. Conversely, the average score for the control group was 70.00, accompanied by a standard deviation of 13.284, suggesting less favorable outcomes and slightly greater dispersion in performance. This difference of 11.11 points indicates that the use of rope-crossing media positively influences students' academic performance.

Normality Test

A proper assessment of the treatment's influence on students' academic performance using parametric statistics requires an initial examination of the necessary assumptions. This initial step ensures that key requirements such as data normality, equal variance, and independence are met, thereby validating the appropriateness of subsequent statistical procedures. Among these tests, the normality assessment is particularly important, as it evaluates whether the data distributions in both the control and experimental groups approximate a normal distribution. Ensuring this assumption is met is vital for the reliability and validity of the results obtained from parametric tests (Sugiono, 2019).

This research analyzed the distribution of learning outcome data from the experimental and control groups by applying the Shapiro-Wilk and Kolmogorov-Smirnov tests to assess normality. Based on previous studies, the Shapiro-Wilk test is recognized as more reliable for smaller samples (under 50 participants), while the Kolmogorov-Smirnov test is generally applied to larger samples and serves as a supplementary validation method (Mohd Razali & Bee Wah, 2011). The results of these normality tests are presented in the following table

Table 2. Results of Normality Tests for Control and Experimental Groups

Group	Test	Statistic	df	Sig.
Control	Kolmogorov-Smirnov	0.167	18	0.200*
	Shapiro-Wilk	0.937	18	0.256
Experimental	Kolmogorov-Smirnov	0.146	18	0.200*
	Shapiro-Wilk	0.924	18	0.155

Normality tests, specifically the Kolmogorov-Smirnov and Shapiro-Wilk methods, were utilized to verify the distribution of the data prior to performing the difference analysis. The analysis showed that data from the control and experimental groups met the normality assumption, as evidenced by significance levels above 0.05 in both tests. The control group recorded significance levels of 0.200 (Kolmogorov-Smirnov) and 0.256 (Shapiro-Wilk), while the experimental group reported corresponding values of 0.200 and 0.155. The results demonstrate that the data conform

to the normality assumption, this affirms the suitability of parametric approaches for the next phase of analysis.

Test of Homogeneity of Variances

Prior to performing any further inferential analysis, it is necessary to ensure that the data satisfy the key assumptions underlying parametric statistical methods. One important assumption is the equality of variances, meaning that the groups being compared should exhibit similar variance levels. Confirming this assumption is essential to validate the application of parametric tests such as the independent samples t-test, which depends on the homogeneity of variances between groups.

This research examined whether the variances in learning outcomes differed between students instructed with Cross Rope media and those taught using traditional approaches. To assess the homogeneity of variance, Levene's Test was conducted. Table 3 contains the core findings derived from the test:

Table 3. Results of the Homogeneity Test for Learning Outcomes

Test Criterion	Levene Statistic	df1	df2	Sig.
Based on Mean	0.009	1	34	0.925
Based on Median	0.000	1	34	1.000
Based on Median with Adjusted Degrees of Freedom	0.000	1	33.721	1.000
Based on Trimmed Mean	0.003	1	34	0.954

Levene's Test showed a p-value of 0.925, suggesting no significant difference in variance between the two groups, thus satisfying the homogeneity of variances requirement. This confirmation justifies employing a parametric independent samples t-test, as both groups demonstrate comparable variance.

Mean Difference Test

After completing the instructional interventions in both groups, data were collected through the assessment of students' learning outcomes to evaluate the effectiveness of the Cross Rope media in enhancing their mastery of whole number multiplication concepts. Inferential statistics were utilized through an independent samples t-test to examine the proposed hypothesis, with the objective of determining whether the implementation of Cross Rope learning media resulted in a significant difference in students' academic achievement compared to traditional teaching methods.

Prior to conducting the t-test, the homogeneity of variances assumption was assessed to ensure that the data satisfied the requirements for applying parametric statistical analysis. The assumption of equal variances was supported by the outcome of Levene's Test, enabling the application of the "Equal variances assumed" method. The details of this analysis are presented in the table, along with a thorough report of the t-test findings.

Table 4. Results of the Independent Samples Test

Variable	Equal Variances Assumed	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
Learning Outcome	Equal variances assumed	-2.557	34	0.008	0.015	-11.111	4.345	Lower: -19.942; Upper: -2.280
	Equal variances not assumed	-2.557	33.950	0.008	0.015	-11.111	4.345	Lower: -19.942; Upper: -2.280

The analysis indicated a statistically meaningful variation in learning outcomes between the two groups. Based on the Independent Samples t-Test, the computed t-value was -2.557 with 34 degrees of freedom, and the associated p-value was 0.008. Since this value falls below the 0.05 threshold, the null hypothesis was rejected. This study reveals that incorporating Cross Rope instructional media markedly boosts third-grade students' proficiency in whole number multiplication, achieving better results compared to traditional teaching methods.

Students demonstrated a marked improvement in academic performance as a result of using Cross Rope media, as evidenced by an average score increase of 11.111 points. This improvement is supported by a 95% confidence interval ranging from -19.942 to -2.280, indicating that the observed effect is unlikely due to random chance.

DISCUSSION

The study's results indicate that incorporating Cross Rope media into teaching significantly enhances elementary students' performance in mathematics, especially in mastering whole number multiplication. The superiority of the experimental group's performance is evident from the parametric statistical results, which show a higher mean post-test score of 81.11, compared to 70.00 in the control group an 11.11-point difference. This notable improvement indicates that the use of Cross Rope media played a key role in strengthening students' understanding of the concepts taught.

This finding aligns with and extends previous research that emphasizes the critical role of concrete and visual learning aids in enhancing mathematical understanding at the elementary level. It supports Bruner's (1996) learning theory, which highlights the enactive (concrete), iconic (visual), and symbolic phases of representation as foundational in mathematics learning. Cross Rope media exemplifies this framework by providing students with tangible tools that transition their understanding from physical manipulation to symbolic abstraction, thus fostering durable learning outcomes.

Furthermore, the findings align with Nurhasanah et al. (2022) meaningful learning theory, emphasizing the importance of linking new content to learners' existing knowledge through relevant and contextual learning experiences. The manipulative and interactive nature of Cross Rope media actively engages students in constructing mathematical meaning, which is consistent with the principles of constructivist pedagogy Hes & Reider (1985). This reinforces findings from Kurniasih et al. (2024) and Laimeheriwa (2025), who argue that instructional media that integrates concrete experiences can significantly assist students in comprehending abstract mathematical operations.

Several earlier empirical studies support this conclusion. For example, Jabeen et al., (2021) found that visual-manipulative learning tools significantly improved students' conceptual understanding in basic arithmetic operations. Similarly, Wathoni (2024) demonstrated that the use of concrete instructional aids, such as number ropes and counting sticks, enhanced students' numerical reasoning and problem-solving skills in primary school settings. However, compared to these prior studies, the current research fills a notable gap by introducing Cross Rope media as a structured, engaging, and innovative method tailored specifically to multiplication material, which had not been previously explored in depth.

Furthermore, This study builds upon prior research highlighting the benefits of using concrete and visual learning tools in mathematics, while also contributing new insights by introducing Cross Rope media as an innovative and research-backed instructional approach. This also addresses the gap identified in the introduction, where many traditional methods of teaching multiplication remain reliant on rote memorization and lack physical or interactive learning components.

Active student engagement using the Cross Rope media is another critical outcome observed in this study. The media fosters a more dynamic learning environment where students engage not only with content but also with peers, facilitating collaborative learning. This engagement enhances learning motivation and focus, which are essential for internalizing mathematical concepts. These findings echo the observations by Susanti et al. (2025) and Marbun et al. (2025), who emphasize that manipulatives increase student attention and reduce cognitive overload during abstract problem solving.

Although the statistical results indicate a notable effect of the media on student achievement, it is equally essential to recognize that the teacher's pedagogical skills significantly influence how effectively any instructional media is utilized. As such, teacher training and professional development in the use of alternative learning tools like Cross Rope must be prioritized. Without sufficient support and understanding of how to integrate such tools into daily instruction, even the most innovative media may fail to reach its potential (Andini & Laili, 2024).

In conclusion, this study not only confirms previous findings regarding the value of concrete and visual aids in mathematics education but also extends the scope by presenting Cross Rope media as a novel, evidence-based instructional alternative. Its

success demonstrates the potential for reimagining traditional arithmetic instruction through active, tangible, and student-centered learning strategies. Future research should explore the scalability of this media across diverse learning environments and its impact on other mathematical domains beyond multiplication.

CONCLUSION AND RECOMMENDATIONS

The results of this research demonstrate that implementing Cross Rope as an instructional medium considerably improves elementary school students' performance in mathematics, especially in multiplication. This learning tool provides a more tangible and engaging experience by integrating visual support with hands-on activities. These results reinforce the idea that educational tools involving simple motor skills can effectively address students' difficulties in grasping basic mathematical operations. Moreover, students' active participation during lessons using the Cross Rope media contributed to increased motivation and concentration, which positively influenced their academic performance.

That said, the study contains a number of limitations that should be acknowledged with careful reflection. First, the scope of the study is confined to a single mathematical topic (multiplication) and one grade level, which limits the generalizability of the findings to other topics or educational levels. Second, the implementation period of the media was relatively short, so its long-term effects on learning retention or higher-order thinking skills cannot be definitively determined. Third, the study primarily focuses on cognitive outcomes, while affective and psychomotor domains were not comprehensively assessed.

Based on these conclusions, several practical and strategic recommendations are proposed:

1. For educational practitioners, particularly elementary school teachers, it is recommended to integrate Cross Rope media into mathematics instruction, especially for abstract concepts such as multiplication. This media enhances the effectiveness and appeal of learning through visual and kinesthetic approaches.
2. For educational institutions, it is essential to provide support and opportunities for the development of concrete-based learning innovations. This can be achieved through professional development programs that train teachers to design and implement alternative instructional media tailored to students' developmental needs.
3. For future researchers, it is advised to explore the application of Cross Rope media in other mathematical topics and to examine its effects on non-cognitive variables such as learning motivation, student engagement, and critical thinking skills. Further research should also investigate the scalability of this media across different school settings and its long-term impact on student achievement. Such efforts can broaden the contribution of this study to educational policy and the advancement of mathematics learning at the elementary level.

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