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Enhancing remedial learning outcomes using micro-lecture videos: The case of trigonometry

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Abstract

This study aimed to evaluate the effectiveness of micro-lecture videos in improving remedial learning outcomes in trigonometry. A total of 100 high school students needing support in trigonometry were selected based on their previous scores and were provided with micro-lecture videos over four weeks. A quasi-experimental design was used to examine the intervention's impact. Pre- and post-test scores were compared using a paired t-test, and an analysis of variance (ANOVA) was conducted to analyze differences between student groups. ANOVA analysis indicated a significant difference in performance among student groups, with grade 12 natural science students achieving the highest improvement (mean post-test score of 78.6%, $F [3, 95] = 7.394$, $p < .001$, $\eta^2 = 0.19$). The findings revealed significant improvements across all questions, with post-test scores consistently higher. These results suggest that micro-lecture videos are effective in enhancing students' understanding of trigonometry, particularly for older students or those specialized in natural science. The implications of the findings highlight the need for personalized instructional tools in remedial education, especially for abstract subjects like trigonometry. Further research is recommended to explore how micro-lectures can be tailored to different learning needs and their long-term impact on academic performance.

Keywords: micro-lecture video, remedial, trigonometry, learning outcome

INTRODUCTION

Remedial education is important for students who are struggling with subjects like mathematics. It provides extra support to help them catch up with their peers. In Greece, for example, 70% of students in remedial programs improve their academic performance. However, these programs sometimes benefit more privileged students more than the students who really need the help, which can make the achievement gap worse (Papadogiannis et al., 2023). Still, remedial education is crucial for helping students, especially when it follows learning theories like Vygotsky's, which focuses on giving students the right level of support based on their individual needs (Taukeni, 2019).

Trigonometry is one of the difficult topics for students because it involves a lot of abstract ideas. For many students, understanding where to put numbers or variables in equations is confusing. This makes it harder for them to solve problems and follow the right steps (Ngu & Phan, 2020). Traditional teaching methods don't always explain these concepts well, leaving students frustrated and confused. On top of that, the ways teachers usually help struggling students can sometimes fall short. Traditional remedial strategies often don't personalize the learning experience enough, meaning that students who need more attention don't always get the help that works best for them. When teaching is the same for everyone, some students miss out on the chance to fully understand the topic.

Existing digital tools for remedial education often lack customization to address the specific challenges faced by students struggling with difficult topics like trigonometry. Many tools focus on general content delivery without targeting the specific learning gaps or adapting to individual student needs. This limitation highlights the need for innovative approaches that combine accessibility with personalization to ensure more effective learning outcomes.

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Contribution to the literature

- The study demonstrates the effectiveness of micro-lecture videos as a personalized instructional ability for improving remedial learning outcomes in trigonometry. This addresses a gap in the literature, as most prior studies focus on general academic performance rather than tailored interventions for struggling students in a specific subject like trigonometry.
- By analyzing the performance of different student groups (e.g., Grade 12 Natural Science students), the paper provides empirical evidence that micro-lecture videos are particularly effective for older students or those in natural science streams. This highlights the importance of differentiated instruction in remedial education, contributing to the growing body of research on personalized learning strategies.
- The paper bridges theoretical frameworks (e.g., cognitive load theory and Vygotsky's Zone of Proximal Development) with practical applications, showing how micro-lectures reduce cognitive load and provide scaffolding for students.

A new approach is using micro-lecture videos to help students learn. These short, focused videos are a way for students to review difficult topics. Research shows that students who use videos see a big improvement in their scores, moving from just satisfactory to very satisfactory (Rebong, 2022). Another advantage of micro-lecture videos is that they are easy to access and download, allowing students to study at their own pace whenever they want (De Oca et al., 2024).

Micro-lecture videos are especially helpful because they break down complex topics into simpler parts. By focusing on specific areas where students struggle, these videos help improve understanding and learning outcomes. Studies have shown that students learn better with these videos because they are tailored to address learning gaps (Jiang et al., 2022). When these videos are combined with interactive tools like 3D simulations, they make learning even more effective, helping students understand difficult concepts more easily (Supriadi et al., 2020).

To date, while micro-lecture videos have shown promise in improving learning outcomes, there is limited research on their specific application in remedial education for challenging subjects like trigonometry. Most studies focus on their general effectiveness in enhancing academic performance but do not address how these videos can be tailored to meet the unique needs of struggling students in remedial settings. Therefore, this study explores how micro-lecture videos can improve remedial education, especially helping students understand trigonometry.

LITERATURE REVIEW

Remedial education is crucial for helping students fill in learning gaps, especially in subjects like math. It gives extra support to students who struggle, helping them catch up with their classmates and build a better understanding of difficult concepts. This support is particularly important in topics like trigonometry, which many students find hard to grasp because of its abstract ideas. By focusing on areas where students need more help, remedial education can make a big difference in their academic success.

The theoretical foundation of the proposed remedial program is rooted in learning theories like Vygotsky's zone of proximal development (ZPD), which emphasizes providing the right level of support to learners based on their specific needs (Taukeni, 2019). ZPD highlights the importance of scaffolding, which is particularly relevant to remedial education as it ensures that learners receive assistance that gradually decreases as they build competence. This approach aligns with modern pedagogical methods, which aim to balance learner autonomy with guided instruction, fostering both understanding and confidence.

Despite its benefits, prior research on remedial education has faced limitations. Many studies fail to address the diverse needs of learners within remedial programs, instead employing a "one-size-fits-all" approach (Cotton et al., 1978). Additionally, traditional methods, such as rote repetition or extended tutoring, have shown limited success in addressing conceptual misunderstandings in abstract subjects like mathematics (Urrutia et al., 2019). This critique highlights the need for innovative methods that tailor instruction to individual needs, linking directly to this study's exploration of micro-lecture videos as a potential solution.

Trigonometry is often challenging for students due to its abstract nature. Many students struggle with understanding key concepts, leading to mistakes in solving problems. For example, they might mix up where variables should go in an equation, causing confusion (Yudhi et al., 2024). This difficulty isn't just for students–teachers also find it hard to explain these concepts clearly. As a result, both students and teachers face challenges when working with trigonometry in high school and beyond (Urrutia et al., 2019).

Traditional methods of helping students with remedial work, like extra tutoring or repeating lessons, often aren't enough for subjects as complex as trigonometry. While these methods can be helpful, they don't always address the deeper issues students have with understanding abstract topics. For instance, simply repeating lessons doesn't solve the problem of conceptual misunderstandings (Cotton et al., 1978). More creative approaches, like using different teaching methods together, tend to be more effective in addressing students' learning needs.

Recent research highlights the potential of digital tools in mathematics education. Recent studies have demonstrated how technology-driven interventions enhance conceptual understanding and engagement. For instance, interactive software that incorporates gamification elements has been shown to improve student motivation and problem-solving skills in algebra and geometry (El Hajj & Harb, 2023). Similarly, adaptive learning platforms have proven effective in identifying individual learning gaps and providing tailored resources to address these deficits, leading to better learning outcomes in mathematics (Pabst et al., 2023).

One alternative to traditional remedial strategies is the idea of corequisite remediation. In this approach, students get help while learning new material, rather than after they've already struggled. This ongoing support has been shown to help students succeed more than traditional methods. By giving students help as they go through the material, they build confidence and a stronger understanding of the subject (Logue et al., 2019). This approach helps students stay on track and avoid falling behind.

Technology has played a major role in changing how remedial education is delivered. New digital tools have made learning more interactive and engaging, which is especially useful in subjects that students find difficult. Educational technology, like software and interactive videos, helps students better understand complicated ideas by making the learning process more interesting (El Hajj & Harb, 2023). For example, in biology, using a computer application has been shown to improve learning, and similar tools can be just as helpful in math (Brendan et al., 2019).

Micro-lecture videos are one of the tools that have become popular in remedial education. These short, focused videos help students concentrate on specific topics they find challenging. Unlike longer lectures, micro-lectures are designed to be watched in small sections, making it easier for students to understand and review the content at their own pace (De Oca et al., 2024). This flexibility is particularly helpful for subjects like trigonometry, where students often need more time to fully understand the material.

Studies have shown that micro-lecture videos are effective in helping students close learning gaps, especially in math. By focusing on specific problem areas, these videos allow students to revisit concepts they might have missed during regular lessons. In one study, students who used micro-lecture videos to target their weaknesses saw improvements in both their performance and understanding of the material (Abadies et al., 2023). Additionally, creating their own videos can motivate students and improve their learning outcomes, as shown in another study where self-made videos led to better academic results (Micae, 2024).

Recent studies reinforce the value of micro-lecture videos in closing learning gaps in mathematics. Jiang et al. (2022) emphasized that these videos not only improve student performance but also enhance learning satisfaction through their concise and targeted approach. Recent advancements include integrating interactive features like quizzes and problem-solving tasks directly within the videos, fostering active engagement and immediate feedback for learners (Abadies et al., 2023). Additionally, research on video annotation tools reveals that students who can highlight and comment on key points in micro-lectures achieve better retention and understanding (Torres, 2024).

Another advantage of micro-lecture videos is their compatibility with emerging educational trends, such as personalized learning and blended learning models. Platforms now offer data analytics to track student progress and adapt content delivery accordingly. These innovations allow for a more dynamic and individualized approach to remedial education, particularly for challenging subjects like trigonometry (Lopez, 2024). Furthermore, virtual reality (VR) and augmented reality enhancements in micro-lectures have gained traction, offering immersive experiences that help students visualize abstract mathematical concepts in three-dimensional space (Supriadi et al., 2020).

In mathematics, micro-lecture videos have been particularly useful for breaking down difficult topics into easier-to-understand sections. Students who use these videos tend to perform better than those who rely on traditional teaching methods (Tang et al., 2022). The usefulness of these videos goes beyond just improving scores–they also help students feel more satisfied with their learning experience. Research has found that students who see micro-lectures as helpful report higher levels of satisfaction and better academic performance (Jiang et al., 2022).

The integration of digital tools, such as micro-lectures, adaptive platforms, and VR-enhanced lessons, underscores a significant shift in mathematics education. These technologies align with cognitive load theory by simplifying complex information into manageable segments, reducing mental strain while improving comprehension (Lopez, 2024). As education systems continue to embrace digital innovations, the role of tools like micro-lectures will likely expand, offering more personalized and effective learning experiences for students struggling with abstract subjects like trigonometry.

Another advantage of micro-lecture videos is that they allow students to learn at their own pace. Students can pause, rewind, and rewatch videos as many times as they need to, giving them control over their learning. This flexibility helps students manage their learning, especially when they are dealing with complex subjects like trigonometry (De Oca et al., 2024). The short format of the videos also makes it easier for students to stay focused, as they can tackle one concept at a time without feeling overwhelmed (Torres, 2024).

Finally, cognitive load theory supports the use of micro-lecture videos for learning. By breaking down information into shorter, focused videos, students experience less mental overload, allowing them to concentrate on what's important. These videos also reduce distractions, helping students focus on the key concepts they need to learn (Lopez, 2024). When combined with engaging content, micro-lectures help students process information more deeply, leading to better retention and understanding (De Oca et al., 2024). This makes micro-lecture videos an effective tool for improving learning, especially in subjects like trigonometry.

Micro-lecture videos offer a promising approach to helping students with remedial education. Their flexibility, ability to target specific learning gaps, and support for self-paced learning make them a valuable tool for students who need extra help. As education continues to evolve with technology, tools like micro-lectures will likely become even more important in helping students succeed, particularly in challenging subjects like mathematics.

METHODOLOGY

Research Design

The study employed a one-group pre- and post-test experimental design to investigate the impact of micro-lecture videos on enhancing remedial learning outcomes in trigonometry. This design involved measuring the participants' baseline understanding of trigonometry concepts through a pre-test, administering an intervention consisting of micro-lecture videos, and subsequently evaluating the outcomes with a post-test. The approach focused on assessing changes in learning outcomes within the same group of students, providing a controlled environment to examine the effectiveness of the intervention

The study employed a case study design to explore the impact of micro-lecture videos on enhancing remedial learning outcomes in trigonometry. This approach allowed for an in-depth examination of a single group of students who were provided with micro-lecture videos as part of their remedial learning. By focusing on this group, we were able to gain rich insights into the students' experiences, learning processes, and improvements in understanding. The case study design enabled us to capture detailed, context-specific data, highlighting how the intervention affected their learning outcomes without requiring comparison to a control group (Creswell & Creswell, 2017).

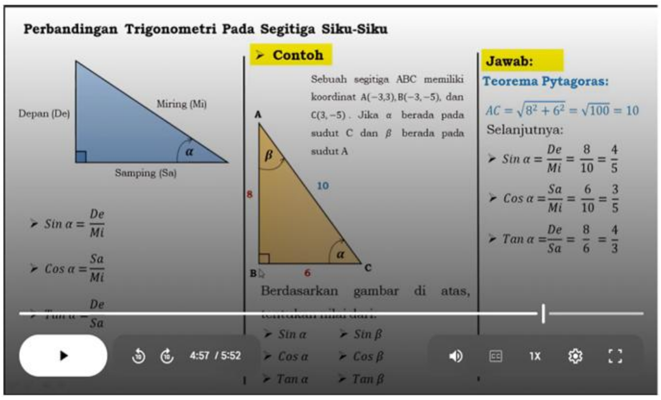

Figure 1. Capture of video about trigonometric ratios in a right triangle (Source: Authors' own elaboration)

Participants

The study included 100 high school students who were identified as needing remedial support in trigonometry. Participants were selected based on their previous semester's trigonometry scores, with eligibility determined by those who scored below the 40th percentile. Additionally, the selection process emphasized students demonstrating specific learning challenges in trigonometry, such as difficulty in conceptualizing abstract mathematical principles. This targeted selection was intended to focus the study on individuals most likely to benefit from the intervention, ensuring that the findings are relevant to similar populations.

It is important to note a discrepancy in the participant numbers. While the research design section initially mentions 100 students, we present data for 99 participants. Upon review, one student was excluded from the final analysis due to incomplete test responses, which affected the validity of their data. This adjustment was made to ensure the accuracy and reliability of the statistical analysis.

Materials

The main resource used in this study was a set of short micro-lecture videos designed specifically to help students with trigonometry. Each video lasted 4-6 minutes and focused on key trigonometric subtopics, including angles and their measures, trigonometric functions, graphing trigonometric equations, and solving trigonometric identities (for example, see Figure 1). These subtopics were chosen to address common areas of difficulty for students.

The instructional strategies employed in the videos included step-by-step problem-solving demonstrations, real-life applications of trigonometry (e.g., calculating heights and distances), and frequent use of questioning to engage critical thinking. Visual aids such as

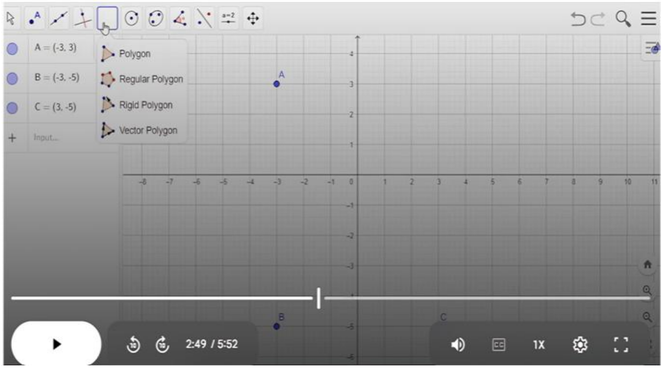

Figure 2. Capture of video about animation using GeoGebra (Source: Authors' own elaboration)

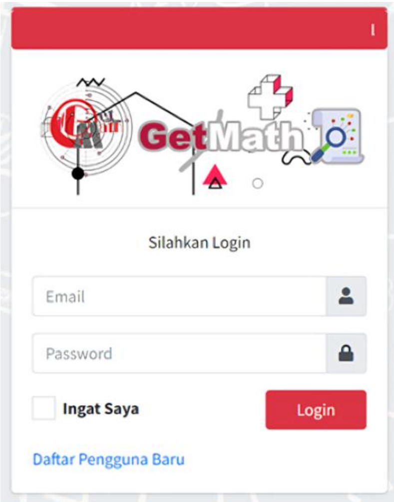

Figure 3. Frontpage of Getmath.id (Source: Authors' own elaboration)

animations (e.g., GeoGebra, see **Figure 2**), graphs, and diagrams were extensively used to illustrate abstract concepts, making them more accessible and easier to understand. For example, animations showing the unit circle were included to help students visualize angle measures and corresponding sine and cosine values.

In addition to the videos, students received practice worksheets that reinforced the content covered and online quizzes for immediate feedback. These materials were designed to complement the videos and encourage active engagement with the subject matter. All content was hosted on an easy-to-use website called getmath.id, allowing students to access the materials on demand (**Figure 3**).

The test used was in the form of multiple-choice questions. The test was designed by the researcher and consisted of 10 multiple-choice questions covering the topic of trigonometry. The quality assessment of the research instrument involves item validity and reliability. This assessment was carried out by administering the instrument to 25 grade 11 students.

Table 1 presents the results of the item validity test for 10 questions. The validity was determined using the point-biserial correlation coefficient (r_{pbi}).

Table 1. Validity of items

Questions	T (r_{pbi})	Interpretation
Item 1	0.4854	Valid
Item 2	0.6058	Valid
Item 3	0.3950	Valid
Item 4	0.5665	Valid
Item 5	0.6137	Valid
Item 6	0.4616	Valid
Item 7	0.7263	Valid
Item 8	0.4956	Valid
Item 9	0.5550	Valid
Item 10	0.9070	Valid

The next step is measuring the reliability of the instrument. he reliability of the test items is measured using the Kuder-Richardson formula (r_{II}). The reliability score of the test items is 0.8218, indicating that the items have a very high level of reliability

Procedure

After identifying the participants through a diagnostic test and dividing them into groups, all students took a pre-test to check their starting level of understanding in trigonometry. The experimental group then began using the micro-lecture videos and worked through the series over four weeks, using extra materials like worksheets and quizzes along the way. At the end of the four weeks, the student took a post-test to see how effective the learning methods were.

Data Collection and Analysis

We collected data from the pre- and post-tests taken by the group of students. These standardized tests helped us measure their progress in learning trigonometry. In addition to test scores, we tracked engagement metrics from the digital platform, such as how many times students watched the videos and how long they spent on the materials. However, in this paper, we only present the results of pre- and post-test. To analyze the results, we used a paired t-test to compare their pre- and post-test scores.

The analysis of the study's data included both descriptive and inferential statistical techniques to evaluate the impact of the intervention. Pre- and post-test scores were analyzed using paired t-tests to measure overall improvement in students' understanding of trigonometry concepts. To enhance interpretability, effect sizes were calculated using Cohen's d, with thresholds of 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively.

In addition, analysis of variance (ANOVA) was employed to examine differences in performance across subgroups categorized by academic track and grade level. Post-hoc Tukey HSD tests were used to identify specific group differences when ANOVA results indicated statistically significant effects. A significance level of $p < 0.05$ was set as the criterion for interpreting results, ensuring that findings were robust and meaningful.

RESULTS

This section presents results of the comparison of pre- and post-test scores to evaluate the effectiveness of the intervention. The analysis focuses on identifying changes in participants' performance before and after the intervention, using statistical methods such as paired t-tests and descriptive statistics. The results are further analyzed across different groups to explore variations in performance and assess the consistency of improvements.

Results For Each Item

In this section, we present the results, starting with the descriptive statistics to give an overview of the data. Then, we present the paired t-test results to see if there are any significant differences between the pre- and post-intervention scores.

Finally, we show the results from the ANOVA to investigate if there are any significant differences between groups. These analyses will help us understand the patterns in the data and the effects of the intervention.

Results of descriptive analysis

Table 2 shows that for all questions the mean values in the post-test are higher than in the pre-test, indicating improvement after the intervention. Most of the questions also show a decrease in standard deviation in the post-test, meaning that participants' scores were more consistent after the intervention. The degree of improvement varies, with some questions showing larger gains and more reduced variability than others.

Comparison of pre- and post-test

Table 3 shows the paired t-test results which indicate that there are significant differences between the pre- and post-test scores for all ten pairs of questions. For each pair, the mean differences between pre- and post-test scores are negative, showing an increase in post-test scores (since the post-test values are higher than the pre-test values). The t-values for all pairs are large and negative, which, combined with the very low p-values (all less than .001), suggest that these differences are highly statistically significant. For instance, pair 1 shows a mean difference of -0.42, with a 95% confidence interval of the difference ranging from -0.53 to -0.31, and a t-value of -7.584, indicating a significant improvement from pre- to post-test.

Similarly, question 8 exhibits the largest mean difference (-0.55), suggesting a strong improvement in post-test scores, with a t-value of -11.000, the highest among all pairs, further supporting the strength of the difference. The confidence intervals for all pairs do not include zero, indicating that the improvements observed

Table 2. Results of descriptive analysis (N = 100)

		M	SD	SEM
Q1	PreQ1	.54	.501	.050
	PosQ1	.96	.197	.020
Q2	PreQ2	.62	.488	.049
	PosQ2	.94	.239	.024
Q3	PreQ3	.39	.490	.049
	PosQ3	.84	.368	.037
Q4	PreQ4	.51	.502	.050
	PosQ4	.71	.456	.046
Q5	PreQ5	.67	.473	.047
	PosQ5	.88	.327	.033
Q6	PreQ6	.34	.476	.048
	PosQ6	.71	.456	.046
Q7	PreQ7	.42	.496	.050
	PosQ7	.84	.368	.037
Q8	PreQ8	.29	.456	.046
	PosQ8	.84	.368	.037
Q9	PreQ9	.25	.435	.044
	PosQ9	.49	.502	.050
Q10	PreQ10	.46	.501	.050
	PosQ10	.81	.394	.039

Note. Q: Question; M: Mean; SD: Standard deviation; & SEM: Standard error mean

Table 3. Results of paired t-test (df = 99)

		Paired differences					t	Significance	
		M	SD	SEM	95% CI of the difference			One-sided p	Two-sided p
					Lower bound	Upper bound			
Q1	PreQ1-PosQ1	-.420	.554	.055	-.530	-.310	-7.584	< .001	< .001
Q2	PreQ2-PosQ2	-.320	.510	.051	-.421	-.219	-6.273	< .001	< .001
Q3	PreQ3-PosQ3	-.450	.539	.054	-.557	-.343	-8.350	< .001	< .001
Q4	PreQ4-PosQ4	-.200	.550	.055	-.309	-.091	-3.633	< .001	< .001
Q5	PreQ5-PosQ5	-.210	.478	.048	-.305	-.115	-4.396	< .001	< .001
Q6	PreQ6-PosQ6	-.370	.525	.053	-.474	-.266	-7.045	< .001	< .001
Q7	PreQ7-PosQ7	-.420	.554	.055	-.530	-.310	-7.584	< .001	< .001
Q8	PreQ8-PosQ8	-.550	.500	.050	-.649	-.451	-11.000	< .001	< .001
Q9	PreQ9-PosQ9	-.240	.474	.047	-.334	-.146	-5.064	< .001	< .001
Q10	PreQ10-PosQ10	-.350	.557	.056	-.461	-.239	-6.280	< .001	< .001

Note. Q: Question; M: Mean; SD: Standard deviation; SEM: Standard error mean; & CI: Confidence interval

Table 4. Result of descriptive statistics for each group

	N	M	SD	SE	95% CI for M		Minimum	Maximum
					Lower bound	Upper bound		
NS 11	28	.6325	.08801	.01663	.5984	.6666	.50	.83
SS 11	27	.5915	.13671	.02631	.5374	.6456	.33	.83
NS 12	20	.7860	.16602	.03712	.7083	.8637	.50	1.00
SS 12	24	.6208	.19622	.04005	.5380	.7037	.33	1.00
Total	99	.6495	.16275	.01636	.6170	.6820	.33	1.00

Note. M: Mean; SD: Standard deviation; SE: Standard error; & CI: Confidence interval

Table 5. Result of ANOVA

	Sum of squares	df	Mean square	F	Significance
Between groups	.491	3	.164	7.394	< .001
Within groups	2.104	95	.022		
Total	2.596	98			

are consistent and not due to chance. Overall, these results suggest that the intervention had a significant positive impact on participants' performance, as reflected by the consistent increase in post-test scores across all questions.

The effect size, measured by Cohen's d, was 0.65, indicating a medium to large effect size. This suggests that the difference in scores between pre- and post-test is significant and not just due to random variation.

Results of Comparison of Pre- and Post-Test According to Different Groups

In this section, we present the descriptive statistics for the performance scores of students across four groups: grade 11 natural science (NS 11), grade 11 social science (SS 11), grade 12 natural science (NS 12), and grade 12 social science (SS 12). These groups were analyzed to compare their mean scores and assess the variability in performance between and between groups. The descriptive data include the mean, standard deviation, and confidence intervals, providing insights into the central tendencies and dispersion of scores. This initial analysis sets the foundation for further comparison and examination of whether there are statistically significant differences in performance across these student groups.

Table 4 shows the mean scores, standard deviations, and confidence intervals for four groups of students: NS 11, SS 11, NS 12, and SS 12. Among these groups, NS 12 students have the highest mean score (.7860), with a wider range of scores (minimum .50, maximum 1.00) and the largest standard deviation (.16602), indicating greater variability within this group. In contrast, SS 11 students have the lowest mean score (.5915) and a relatively high standard deviation (.13671), showing notable variation within the group as well. Overall, the total mean score for all groups combined is .6495, with scores ranging from .33 to 1.00 across all students. The 95% confidence intervals suggest that the true population means for each group will likely fall within the specified ranges.

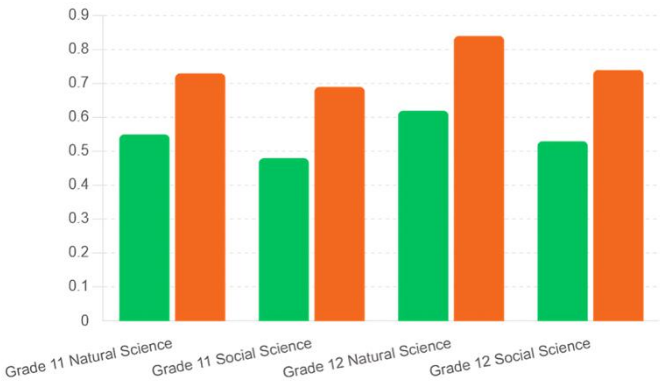

Figure 4. Comparison means of pre-test and post-test across the groups (Source: Authors' own elaboration)

Table 5 shows the ANOVA results which indicate a statistically significant difference in the mean scores between the four groups of students, as evidenced by the F-value of 7.394 and a p-value of < 0.001. This means that the variation in scores between the groups is greater than the variation within each group, suggesting that at least two of the groups have significantly different mean scores. With the p-value being less than the commonly accepted threshold of 0.05, we can conclude that there is a significant difference in performance across the groups. This comparison is also presented in **Figure 4**.

Figure 4 illustrates the comparison of pre- and post-test mean scores across four groups: NS 11, SS 11, NS 12, and SS 12. In all groups, post-test scores (orange bars) are consistently higher than pre-test scores (green bars), indicating improvement. NS 11 shows a rise from approximately 0.6 to 0.8, while SS 11 improves from 0.5 to 0.7. NS 12 demonstrates the most significant increase, with scores rising from 0.4 to 0.8. Similarly, SS 12 shows an improvement from 0.5 to 0.7. These results suggest that the intervention or method applied was effective in enhancing performance across all groups, with NS 12 showing the greatest improvement.

The post-hoc Tukey HSD results show that there are significant differences in mean scores between some of the student groups. Specifically, students in NS 12

Table 6. Results of post-hoc: Multiple comparisons (Tukey HSD)

(I) Group	(J) Group	Mean difference (I-J)	Standard error	Significance	95% confidence interval	
					Lower bound	Upper bound
NS 11	SS 11	.04102	.04014	.737	-.0640	.1460
	NS 11	-.15350*	.04357	.004	-.2674	-.0396
	SS 12	.01167	.04140	.992	-.0966	.1199
SS 11	NS 11	-.04102	.04014	.737	-.1460	.0640
	NS 12	-.19452*	.04391	< .001	-.3093	-.0797
	SS 12	-.02935	.04175	.896	-.1385	.0798
NS 12	NS 11	.15350*	.04357	.004	.0396	.2674
	SS 11	.19452*	.04391	< .001	.0797	.3093
	SS 12	.16517*	.04506	.002	.0473	.2830
SS 12	NS 11	-.01167	.04140	.992	-.1199	.0966
	SS 11	.02935	.04175	.896	-.0798	.1385
	NS 12	-.16517*	.04506	.002	-.2830	-.0473

Note. *The mean difference is significant at the 0.05 level

performed significantly better than those in NS 11 with a mean difference of 0.15350 ($p = 0.004$), as well as those in SS 11 with a mean difference of 0.19452 ($p < 0.001$), and SS 12 with a mean difference of 0.16517 ($p = 0.002$). However, no significant differences were found between NS 11 and SS 11 ($p = 0.737$), NS 11 and SS 12 ($p = 0.992$), or SS 11 and SS 12 ($p = 0.896$). These results indicate that NS 12 students outperformed the other groups, while the performance differences between the other groups were not statistically significant.

ANOVA results (see **Table 6**) confirm significant differences between groups, with post-hoc Tukey HSD tests identifying specific pairs showing differences. The Tukey HSD method was chosen due to its robustness in controlling for type I error while handling multiple comparisons across groups of unequal sizes. Partial eta-squared (η^2) was used to measure effect size, with values of 0.01, 0.06, and 0.14 representing small, medium, and large effects, respectively. Notable discrepancies included smaller effect sizes for SS 11 compared to NS 12, highlighting areas where interventions might require improvement.

DISCUSSION

The findings of this study indicate a significant positive impact of the intervention, as demonstrated by the paired t-test results. All ten pairs of pre- and post-test scores show substantial improvements, with consistently negative mean differences and large t-values, signaling that the post-test scores were significantly higher than the pre-test scores. These results suggest that micro-lecture video intervention effectively enhanced students' understanding of trigonometry. For example, Question 8 exhibited the largest improvement with a mean difference of -0.55, reinforcing the conclusion that the intervention had a strong effect. This aligns with prior studies emphasizing the benefits of targeted instructional tools in improving learning outcomes in challenging subjects like trigonometry (Jiang et al., 2022).

The descriptive statistics further support these findings by highlighting differences in performance across different student groups. NS 12 students outperformed all other groups, showing the highest mean score and the largest variability in scores. This suggests that the intervention might have had a more pronounced effect on older students or those in more specialized streams, such as the natural science track. In contrast, SS 11 students had the lowest mean scores, which may indicate the need for more targeted or differentiated instruction to meet the needs of students in this group. These differences are consistent with previous research showing that personalized and tailored approaches are critical to remedial education (Taukeni, 2019).

The ANOVA results confirm that there is a statistically significant difference in the performance of students across the four groups, with the F-value of 7.394 and a p-value of less than 0.001. This suggests that the intervention was more effective for certain groups, such as NS 12 students, who showed significantly higher scores compared to their peers. The post-hoc Tukey HSD test further clarifies these differences, showing that NS 12 students performed significantly better than NS 11, SS 11, and SS 12 students. These results align with existing literature that highlights the effectiveness of differentiated instruction for students in advanced or specialized streams, who may benefit more from technology-enhanced learning tools like micro-lecture videos (Supriadi et al., 2020).

Interestingly, no significant differences were found between some groups, such as NS 11 and SS 11, or SS 11 and SS 12. This suggests that for certain students, the intervention may not have been as effective, pointing to the need for further refinement in how remedial education is delivered. Traditional methods of remediation, which often lack personalization, may not be sufficient for all students, especially those struggling with abstract subjects like trigonometry (Cotton et al., 1978). This underscores the importance of incorporating more engaging and individualized strategies, such as micro-lecture videos, that can address specific learning gaps (Micae, 2024).

The literature review supports the use of micro-lecture videos as a valuable tool for improving students' understanding of complex subjects. The positive results of this study echo the previous findings that show how micro-lecture videos can help break down difficult topics into more manageable parts, enabling students to learn at their own pace (De Oca et al., 2024). The ability to pause, rewind, and rewatch content allows students to engage more deeply with the material, which may explain the improvements seen in post-test scores. Additionally, by targeting specific problem areas, these videos help students focus on where they need the most help, leading to more significant improvements in their overall performance (Abadies et al., 2023).

Furthermore, cognitive load theory provides a strong theoretical foundation for understanding the effectiveness of micro-lecture videos. By reducing extraneous cognitive load and breaking down information into shorter, more focused segments, students can process and retain information more effectively. This is particularly important in subjects like trigonometry, where students often struggle with abstract concepts. The results of this study support this theory, as students demonstrated significant improvements in understanding after engaging with micro-lectures (Lopez, 2024).

The significant improvements observed in post-test scores and the consistent findings across different groups suggest that micro-lecture videos offer a promising solution to the challenges of remedial education. These tools not only help students better understand difficult concepts but also provide the flexibility needed for personalized learning. The findings highlight the potential of micro-lecture videos to close learning gaps, particularly in abstract subjects like trigonometry, where traditional methods may fall short (Rebong, 2022).

In conclusion, the results of this study demonstrate the effectiveness of micro-lecture videos in improving students' understanding of trigonometry, particularly for older students or those in specialized streams like the natural science track. However, the variation in effectiveness across different groups suggests that a more tailored approach may be needed to ensure all students benefit equally from the intervention. Future studies should explore how to further personalize these tools to meet the diverse needs of students and investigate their long-term impact on learning outcomes.

Limitations and Future Research

Despite the positive outcomes, this study has limitations that warrant consideration. The impact of the intervention was notably less noticeable among social science students compared to their natural science peers. This discrepancy suggests that the content or delivery of micro-lectures may require adaptation to better align with the learning styles and needs of different academic tracks. Additionally, the study's focus on short-term intervention limits the understanding of whether these learning improvements are sustained over time.

To address these limitations, future research should consider conducting longitudinal studies to evaluate the persistence of learning improvements achieved through micro-lectures. Such studies could provide insights into the long-term retention of trigonometry concepts and the role of periodic reinforcement in maintaining learning gains. Furthermore, exploring differentiated micro-lecture designs tailored to specific demographics or academic disciplines could help clarify the context in which this instructional approach excels or requires adaptation. For instance, integrating discipline-specific examples or varied instructional strategies might enhance the effectiveness of micro-lectures for social science students. These findings and recommendations underline the need for continuous enhancement of instructional tools to ensure they are effective for diverse student populations.

CONCLUSION

This study demonstrates the effectiveness of micro-lecture videos in improving students' understanding of trigonometry, particularly for students in NS 12, who showed the most significant improvement. The paired t-test results confirm that the intervention led to a substantial increase in post-test scores across all groups, indicating the positive impact of these videos on students' learning outcomes. The ANOVA and post-hoc analyses further reveal that NS 12 students outperformed their peers, highlighting the potential of micro-lecture videos to enhance learning in specialized streams. However, the lack of significant differences between some groups, such as NS 11 and SS 11, suggests that the intervention may not be equally effective for all students. This suggests the need for a more tailored approach to remedial education, particularly for students struggling with abstract subjects like trigonometry. Traditional remedial methods may not be sufficient, and incorporating more personalized tools like micro-lecture videos can help address specific learning gaps and improve overall performance. In conclusion, micro-lecture videos offer a promising solution for enhancing student engagement and understanding in challenging subjects like trigonometry. The flexibility and focus provided by these videos allow students to learn at their own pace and revisit difficult concepts, leading to better retention and comprehension. Future research should explore how to further personalize these tools to cater to the diverse needs of students and assess their long-term impact on academic success. In addition, comparative studies involving control groups can provide additional insights into their relative impact compared to other remedial strategies. These approaches will help refine the application of micro-lectures and ensure their adaptability to diverse educational contexts, ultimately supporting the goal of bridging learning gaps across student demographics

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