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Contextual Teaching and Learning with Instructional Video Support: Its Impact on Mathematics Achievement across Levels of Prior Knowledge

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Abstract

Mathematics learning in secondary schools often encounters obstacles due to the abstract nature of the subject and students' negative perceptions of mathematics as a difficult discipline. This study examined the effect of Contextual Teaching and Learning (CTL) assisted by video on junior high school students' mathematics achievement, with prior ability considered as a moderating variable. A quasi-experimental design with a 2×2 factorial structure involved two Grade VII classes of SMP Semen Tonasa (N = 179). Instruments included validated and reliable tests of prior ability and mathematics achievement. Data met assumptions of normality and homogeneity and were analyzed using Two-Way ANOVA. Results showed that students taught through video-assisted CTL achieved higher scores (M = 78.39) than those with CTL only (M = 73.77). Significant main effects were found for treatment and prior ability, but no interaction effect. These findings underscore the role of video as a universal medium that enhances the effectiveness of CTL for all students without exacerbating achievement gaps.

Keywords: *contextual teaching and learning; instructional video; prior ability; mathematics achievement; quasi-experiment*

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INTRODUCTION

Education serves as a strategic foundation for improving the quality of human resources, with mathematics occupying a pivotal role in fostering critical, logical, and creative reasoning. At the junior high school level, classroom realities often reveal a gap between curricular demands and students' actual achievements (Clements et al., 2020; Watson et al., 2017). Many students continue to perceive mathematics as a collection of abstract procedures detached from everyday experiences, leading to low motivation and persistence in learning (Chang et al., 2020). When motivation weakens, cognitive and affective engagement also decline, thereby suppressing learning outcomes (Geretschläger & Donner, 2022). Both internal factors (such as interest, self-efficacy, and prior ability) and external factors (such as instructional strategies, media quality, and classroom climate) interact in complex ways to influence achievement (Bicer et al., 2018; Copur-Gencturk, 2021; Markovits & Forgasz, 2017). This situation is consistent with initial observations showing clear gaps in mathematics learning practices.

Preliminary classroom observations identified recurring patterns: students hesitated to begin tasks, relied heavily on peers for answers, and were reluctant to take intellectual risks. These tendencies are often rooted in prior experiences emphasizing rote memorization of formulas rather than conceptual understanding (Borji et al., 2022; Bunck et al., 2017). When teachers focus on procedural completion without building conceptual bridges to real-world contexts, students struggle to construct coherent knowledge schemes (Scheibling-Sève et al., 2020). Inequitable access to and use of learning media further widens performance disparities, particularly among students with low prior ability (Herbel-Eisenmann et al., 2016). Such tendencies often stem from instructional traditions emphasizing rote memorization over conceptual reasoning (Borji et al., 2022; Moore et al., 2024; Wilkie & Hopkins, 2024). These conditions highlight the urgent need for teaching strategies that embrace student diversity and present concepts more meaningfully.

One relevant approach is Contextual Teaching and Learning (CTL). CTL emphasizes the interconnection between subject matter and students' real-life experiences, making abstract concepts more meaningful (Mentari & Syarifuddin, 2020; Putri et al., 2022). Through CTL, learning shifts from "memorizing formulas" to "making sense of concepts" through experience, inquiry, and reflection (Ramda et al., 2023; Hobri et al., 2018). Learning activities are designed to encourage students to observe phenomena, formulate problems, reason, and draw conclusions, thereby facilitating deeper knowledge construction (Octaria et al., 2022). The strength of CTL lies in its ability to stimulate both cognitive and affective engagement, as contexts drawn from students' lives increase relevance and curiosity.

Similar trends are evident in mathematics classrooms worldwide, albeit with variations in form. In Singapore, for example, the concrete–pictorial–abstract approach aligns ideologically with CTL, guiding students from tangible experiences toward representational and formal symbolic understanding (Tohir, 2019). In Finland, cross-disciplinary thematic learning frequently incorporates real-life contexts to integrate mathematical concepts (Remillard et al., 2021). In the United States and Canada, problem- and project-based learning serves as a vehicle for contextualization, particularly in STEM projects requiring quantification and modeling (Jankvist et al., 2020). South Korea and Japan emphasize structured problem solving with guided classroom discussions, balancing contextualization with formalization (Yoon et al., 2021). These comparisons suggest that the successful implementation of CTL in Indonesia similarly depends on reinforcement through appropriate instructional media.

Instructional video occupies a strategic position in strengthening CTL due to its capacity to visually represent processes, dynamics, and change. Videos can present contextual phenomena, break problem-solving processes into traceable steps, and provide replay functions to support self-paced learning (Walkington et al., 2024). In the Indonesian context, where access to digital devices is expanding, video has the potential to act as an equalizer, enabling students to learn beyond classroom hours (Safrudiannur & Rott, 2019). By contrast, countries such as Australia and New Zealand have long utilized video in flipped classrooms, where face-to-face sessions are devoted to discussion and sense-making (Cevikbas & Kaiser, 2020). Nevertheless, despite the promise of video, a critical challenge remains-heterogeneity in students' prior ability.

Prior ability functions as a cognitive starting point: high-ability students can generalize more quickly, while low-ability students require more intensive scaffolding (Weldeana et al., 2023; Wilkie, 2021). Systems with traditions of tracking or differentiated instruction are relatively prepared to adjust cognitive load, whereas more homogeneous systems require strategies to accommodate ability variation(van Lieshout & Xenidou-Dervou, 2018). Video-assisted CTL has the potential to be more inclusive because videos allow low-ability students to review crucial segments while enabling high-ability students to accelerate and explore extensions. The lack of empirical clarity regarding how this combination works in heterogeneous contexts presents an important research opportunity.

Several studies have reported the positive impact of CTL on learning outcomes and attitudes toward mathematics, as well as the benefits of video on comprehension and motivation (Ramda et al., 2023; Nur, 2024). However, empirical studies explicitly examining the interaction between CTL, instructional video, and prior ability remain limited, particularly in the context of Indonesian junior high schools. Studies in the United States and Europe have largely focused on flipped CTL or context-rich problem solving with video, rarely testing prior ability as a moderator of learning outcomes (Soneira et al., 2018). In East Asia, emphasis is often placed on structured lessons and technology integration, but prior ability has not been consistently analyzed as a moderating variable (Rach & Ufer, 2020). This research gap provides a compelling rationale for the present study.

The novelty of this research lies in the integrated examination of three components: (a) CTL as a pedagogical framework, (b) instructional video as a medium for contextual reinforcement and self-paced learning, and (c) prior ability as a moderating variable influencing the magnitude of the effect on junior high school mathematics achievement. The design distinguishes between CTL with video versus CTL without video while comparing groups of high- and low-ability students. This approach moves beyond studies that examine single factors in isolation, yielding richer causal insights. Consequently, the study contributes both theoretically and practically.

The implications of this research extend across three levels. At the practical level, the findings guide teachers in designing learning units that contextualize concepts with curated video support while linking classroom activities to self-study at home. At the theoretical level, the results enrich the CTL framework by integrating media design and prior ability moderation, opening avenues for alignment with cognitive load theory and productive failure. At the school policy level, the findings provide a basis for investing in video infrastructure, developing contextual content banks, and implementing teacher capacity-building programs in video curation and production. These multi-level implications highlight that pedagogical innovations must be supported by ecosystems that ensure sustainability.

The primary contribution of this study is to provide empirical evidence on the relative effectiveness of video-assisted CTL compared to CTL without video, while also examining the moderating role of prior ability in shaping learning outcomes. An additional contribution involves offering practical design principles for integrating video into the CTL cycle (context exploration, concept construction, application, and reflection) in ways that adapt to heterogeneous abilities. Methodologically, this study encourages the reporting of interaction effects so that recommendations are not generic but tailored to specific student profiles. Thus, this research integrates theoretical relevance, practical significance, and policy value into a coherent framework.

The research questions are as follows: (1) Is there a significant difference in mathematics achievement between students taught using video-assisted CTL and those taught using CTL without video? (2) Is there a significant difference in mathematics achievement between students with high and low prior ability? and (3) Is there a significant interaction between the use of instructional video in CTL and students' prior ability on mathematics achievement?

METHODS

Research Design

This study employed a quasi-experimental design with a 2×2 factorial structure. The quasi-experimental design was chosen because, within the school context, it was not feasible to implement full randomization at the individual level, as intact classes needed to be used as whole groups. Beyond this practical consideration, the design is theoretically justified because it allows researchers to investigate causal relationships under natural classroom conditions while maintaining a reasonable level of internal validity through the use of control groups and pre–post testing. In educational research, this approach is considered appropriate for examining the effectiveness of instructional interventions where random assignment may disrupt authentic learning environments (Creswell, 2012). The factorial design was selected because it allows the researcher to examine not only the main effects of the instructional approach (CTL with vs. without instructional video) and prior ability (high vs. low) but also the interaction effect between them. Factorial designs are particularly relevant when researchers aim to determine whether the effectiveness of one independent variable depends on the level of another independent variable.

In this study, there were two treatment groups. Experimental Group I received instruction using the CTL approach assisted by instructional video, while Experimental Group II received CTL without video assistance. Furthermore, students in each group were categorized into high and low prior ability, which served as the moderating variable. The dependent variable was mathematics achievement, measured through a post-test. The intervention lasted for eight instructional sessions over four weeks, with each session lasting 80 minutes, aligned with the regular mathematics schedule. Both groups were taught by the same teacher using identical lesson plans, ensuring that the use of video was the only differentiating factor. The research design is presented in Table 1. To further clarify the main effects and interaction effects, the factorial structure can be illustrated in Table 2.

Table 1. Research Design

Group	Treatment	Prior Ability	Dependent Variable
Experiment I	CTL assisted by instructional video (A1)	High (B1)	Mathematics achievement (O)
		Low (B2)	Mathematics achievement (O)
Experiment II	CTL without instructional video (A2)	High (B1)	Mathematics achievement (O)
		Low (B2)	Mathematics achievement (O)

Table 2. Main and Interaction Effects in a 2×2 Factorial Design

	High Prior Ability (B1)	Low Prior Ability (B2)
CTL with Video (A1)	Achievement of high-ability students in CTL with video class (A1B1)	Achievement of low-ability students in CTL with video class (A1B2)
CTL without Video (A2)	Achievement of high-ability students in CTL without video class (A2B1)	Achievement of low-ability students in CTL without video class (A2B2)

Through this design, the study was able to test whether video-assisted CTL was more effective than CTL without video in improving mathematics achievement and whether such effects differed significantly between students with high and low prior ability.

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Population and Sample

The population of this study comprised all Grade VII students of SMP Semen Tonasa I and SMP Semen Tonasa II in the 2024/2025 academic year, consisting of eight classes with a total of 179 students. The distribution of students is presented in Table 3.

Table 3. Distribution of Grade VII Students at SMP Semen Tonasa

School	Class	Male	Female	Total
SMP Semen Tonasa I	VII A	16	4	20
	VII B	12	13	25
	VII C	15	11	26
	VII D	11	16	27
SMP Semen Tonasa II	VII A	14	6	20
	VII B	10	10	20
	VII C	10	10	20
	VII D	8	13	21
Total		**96**	**83**	**179**

The sample consisted of two classes selected from the eight available. One class was assigned as Experimental Group I (CTL assisted by instructional video), and the other as Experimental Group II (CTL without instructional video). The sample was selected using cluster random sampling, in which intact groups (classes) rather than individual students were chosen, to preserve the integrity of the classroom learning context. Both schools shared relatively similar student characteristics in terms of socioeconomic background and learning facilities, ensuring baseline equivalence between groups.

Instrument

The primary instruments in this study consisted of tests and observation sheets. The tests were used to measure students' cognitive abilities. Two types of tests were developed: (1) a Prior Ability Test, administered before the treatment to identify students' prerequisite knowledge; and (2) a Learning Achievement Test, consisting of 25 multiple-choice items, administered after the treatment to measure mathematics achievement at the levels of knowledge (C1), comprehension (C2), and application (C3). Before being administered, the tests underwent a series of quality analyses.

First, content validity was assessed by three mathematics education experts using Gregory's analysis. The results indicated an agreement index of 0.87, which falls into the high category and demonstrates that the instruments adequately represented the intended constructs. Second, empirical validity was examined using point-biserial correlations. Of the 25 items, 22 met the validity criteria ($r\_pb \geq 0.30$), while 3 items were eliminated for failing to meet the requirement. Third, the internal reliability of the instrument was calculated using the KR-20 coefficient. The result was 0.86, which is considered high (Siregar, 2019), indicating that the instrument consistently measured mathematics achievement. Fourth, Fourth, item difficulty levels were analyzed to ensure proportional distribution across categories, yielding 6 easy items (27%), 12 moderate (55%), and 4 difficult (18%). This composition indicates that the instrument had a proportional variation in difficulty levels. Fifth, item discrimination indices were calculated to assess the instrument's ability to distinguish between high- and low-ability students. The results showed that 18 items (82%) had good to very good discrimination power ($D \geq 0.30$), while 4 items fell into the fair category ($0.20 < D < 0.29$). No items had poor discrimination (D

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≤ 0.20). The average discrimination index was 0.36, suggesting that the instrument could adequately differentiate among students.

In addition to the tests, an observation sheet was used to record the implementation of instruction. Observations were conducted by two independent observers who monitored the teacher's consistency in applying the CTL approach in accordance with the prepared teaching module. The results indicated an implementation rate of 94%, which falls into the "very good" category (Arifin, 2009). Based on these procedures, the research instruments were shown to possess strong content validity, consistent reliability, balanced difficulty levels, and sufficient discrimination power, thereby ensuring that the data collected in this study were valid and reliable.

Procedure

This study was conducted in three main phases: preparation, implementation, and reporting. During the preparation phase, the researcher coordinated with the school regarding the research procedures, developed CTL-based teaching modules for both experimental groups, and prepared instructional videos specifically for Experimental Group I. The research instruments, consisting of a prior ability test and a learning achievement test, were developed, validated by experts, and pilot-tested on a limited scale. Once the instruments were deemed valid and reliable, Experimental Group I (CTL assisted by video) and Experimental Group II (CTL without video) were assigned using cluster random sampling.

The implementation phase spanned one semester. At the outset, students in both groups took the prior ability test to measure their prerequisite knowledge. Subsequently, Experimental Group I received instruction through CTL assisted by video, whereas Experimental Group II received CTL without video support. The treatments followed the prepared teaching modules, ensuring that the only substantive difference between the groups was the use of instructional video. After the treatment sessions, both groups completed a post-test to measure their mathematics achievement following the interventions.

The reporting phase involved both descriptive and inferential analyses to interpret the effects of video-assisted CTL and prior ability, followed by systematic documentation of results according to academic reporting standards. The findings were then used to draw conclusions about the effectiveness of video-assisted CTL, considering students' prior ability. Finally, the entire research process was compiled into a comprehensive report in accordance with academic conventions.

Data Analysis

The data obtained were analyzed in two stages: descriptive analysis and inferential analysis. Descriptive analysis was employed to portray the profile of students' mathematics achievement in each group, including mean scores, standard deviations, and score distributions. This analysis provided an initial overview of achievement trends prior to hypothesis testing. Before conducting inferential analysis, prerequisite tests were performed, namely tests of normality and homogeneity. The normality test was used to ensure that the data followed a normal distribution, while the homogeneity test was conducted to examine the equality of variances across groups. These two tests were essential in determining the appropriateness of applying parametric analysis.

Once the assumptions were satisfied, hypothesis testing was carried out using Two-Way Analysis of Variance (ANOVA). This analysis was selected because it matched the 2×2 factorial design employed, enabling simultaneous testing of three aspects: (1) differences in mathematics achievement between students taught through video-assisted

CTL and those taught through CTL without video, (2) differences in mathematics achievement between students with high and low prior ability, and (3) the interaction effect between instructional approach (with or without video) and prior ability on mathematics achievement. All analyses were performed using SPSS version 29.0 with a significance level of 5%. Furthermore, effect sizes (partial η^2) were computed to quantify the magnitude of each factor's influence on mathematics achievement, providing practical interpretability beyond statistical significance. Reporting effect sizes is important to complement statistical significance and emphasize the practical implications of the findings. The research hypotheses are presented in Table 4.

Table 4. Research Hypotheses

No	Research Question	Null Hypothesis (H_0)	Alternative Hypothesis (H_1)
1	Is there a difference in mathematics achievement between students taught using video-assisted CTL (A1) and those taught using CTL without video (A2)?	There is no difference in mathematics achievement between students taught with video-assisted CTL and those taught without video.	There is a difference in mathematics achievement between students taught with video-assisted CTL and those taught without video.
2	Is there a difference in mathematics achievement between students with high prior ability (B1) and those with low prior ability (B2)?	There is no difference in mathematics achievement between students with high and low prior ability.	There is a difference in mathematics achievement between students with high and low prior ability.
3	Is there an interaction between video-assisted CTL (A1/A2) and students' prior ability (B1/B2) on mathematics achievement?	There is no interaction between video-assisted CTL and students' prior ability on mathematics achievement.	There is an interaction between video-assisted CTL and students' prior ability on mathematics achievement.

RESULTS AND DISCUSSION

Descriptive analysis was conducted to provide an overview of students' mathematics achievement based on treatment groups and levels of prior ability. The statistics used included the number of students, mean scores, and standard deviations, as presented in Table 5. In general, the results showed that the group taught using the Contextual Teaching and Learning (CTL) approach assisted by video (A1) achieved higher mean scores compared to the group taught using CTL without video (A2).

Table 5. Descriptive Statistics of Mathematics Achievement

Treatment	Prior Ability	N	Mean	SD
CTL + Video (A1)	High (B1)	22	81.36	6.24
	Low (B2)	23	75.42	5.98
CTL – Video (A2)	High (B1)	21	77.19	7.11
	Low (B2)	22	70.36	6.75

Based on Table 5, students with high prior ability (B1) in Experimental Class I (A1B1) achieved a mean score of 81.36 (SD = 6.24), whereas students with high prior ability in Experimental Class II (A2B1) obtained a mean of only 77.19 (SD = 7.11). This indicates that the use of video in contextual learning contributed positively to improving

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achievement, even among students who already had relatively stronger initial ability. A more striking difference was observed among students with low prior ability (B2). The mean achievement score of the video-assisted CTL group (A1B2) was 75.42 (SD = 5.98), which was higher than that of the CTL without video group (A2B2), which reached only 70.36 (SD = 6.75). These findings demonstrate that the use of instructional video not only strengthens learning outcomes for high-ability students but also has an even more significant impact on low-ability students.

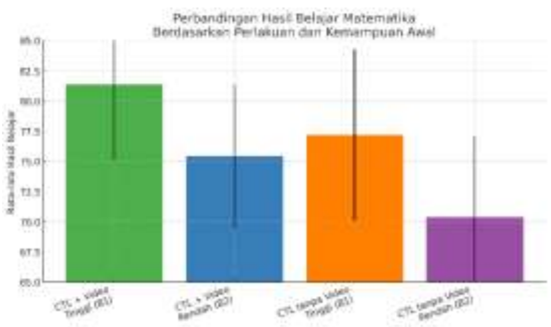

Figure 2. Comparison of Mathematics Achievement

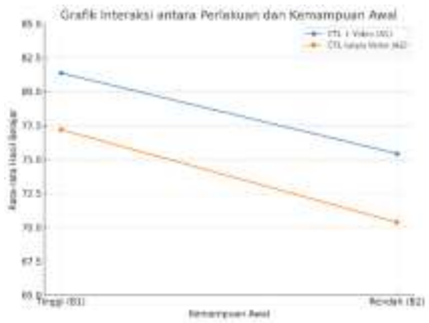

Figure 2. Interaction Between Treatment and Prior Ability

In Figure 1, it can be observed that the video-assisted CTL group (A1) consistently achieved higher mean scores compared to the CTL without video group (A2). In addition, students with high prior ability (B1) outperformed those with low prior ability (B2) in both treatments. The most notable difference appeared in the low-ability group: students who learned with video-assisted CTL (A1B2, M = 75.42) performed substantially better than those taught with CTL without video (A2B2, M = 70.36). This indicates that instructional video functioned as a supporting medium that helped low-ability students better understand the material, thereby reducing the achievement gap across ability groups. In Figure 2, the results show that video-assisted CTL (A1) yielded higher achievement for both high- and low-ability students. A similar pattern was also found for CTL without video (A2), but with lower means compared to A1. The two lines appear parallel (not intersecting), indicating no significant interaction between treatment and prior ability, consistent with the ANOVA results. In other words, the advantage of video-assisted CTL applied consistently to both ability groups: high- and low-ability students alike benefited from the use of video.

From these findings, it can be concluded that integrating instructional video into CTL helps reduce the learning achievement gap between students with different levels of prior ability. In other words, video served as a scaffolding medium that enabled low-ability students to visualize and concretize abstract concepts, allowing them to catch up with their high-ability peers. This finding is consistent with the international literature emphasizing the importance of multimedia learning in supporting the understanding of abstract concepts, particularly in mathematics.

Furthermore, before conducting hypothesis testing, assumption checks for normality and homogeneity were performed to ensure the appropriateness of parametric analysis. The normality test was conducted using the Kolmogorov–Smirnov test at a 0.05 significance level. The results showed that all groups followed a normal distribution, with significance values greater than 0.05 ($p > 0.05$). This indicates that the distribution of learning achievement scores in each treatment–ability combination did not significantly deviate from normality. The results of these tests are presented in Table 6.

Table 6. Results of Kolmogorov–Smirnov Normality Test

Kelompok	N	K–S Statistic	Sig. (p)	Description
CTL + Video High (A1B1)	22	0.142	0.200	Normal
CTL + Video– Low (A1B2)	23	0.128	0.200	Normal
CTL without Video High (A2B1)	21	0.133	0.200	Normal
CTL without Video Low (A2B2)	22	0.137	0.200	Normal

The homogeneity of variances was tested using Levene's Test. The results showed $F(3,84) = 1.27$ with $p = 0.289 > 0.05$, indicating that the variances across groups were homogeneous. The results of the test are presented in Table 7. Both main assumptions of parametric analysis were satisfied, allowing the two-way analysis of variance (Two-Way ANOVA) to be conducted.

Table 7. Hasil Uji Homogenitas Varians (Levene's Test)

Levene Statistic	df1	df2	Sig. (p)	Description
1.27	3	84	0.289	Homogen

Hypothesis testing was carried out using two-way analysis of variance (Two-Way ANOVA), which was designed to evaluate three main aspects: (1) the treatment effect, namely comparing the effectiveness of Contextual Teaching and Learning (CTL) assisted by video with CTL without video, (2) the prior ability effect, namely comparing learning outcomes between students with high and low prior ability, and (3) the interaction effect between the two factors, namely whether the impact of video use in CTL differs across students with different levels of prior ability. The results of the test are presented in Table 8, and overall indicate two significant main effects but no significant interaction.

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Table 8. Results of Two-Way ANOVA

Source of Variation	df	F	Sig. (p)	Decision
Treatment (A)	1	10.87	0.002	Significant
Prior Ability (B)	1	12.15	0.001	Significant
Interaction (A × B)	1	2.43	0.123	Not significant
Error	84	–	–	–
Total	87	–	–	–

Based on Table 8, the treatment effect (A) yielded $F(1,84) = 10.87$ with $p = 0.002$, which was significant at the 0.01 level. This indicates that, overall, the group taught using video-assisted CTL achieved higher mathematics learning outcomes compared to the group taught using CTL without video. In addition, the prior ability effect (B) also showed a significant difference, with $F(1,84) = 12.15$ and $p = 0.001 < 0.01$. This finding confirms that prior ability is a strong predictor of mathematics achievement, as students with high prior ability consistently obtained better scores than those with low prior ability. Conversely, the interaction effect between treatment and prior ability (A × B) was not significant, with $F(1,84) = 2.43$ and $p = 0.123 > 0.05$. This result indicates that although video-assisted CTL was generally more effective than CTL without video, the level of effectiveness was consistent across all categories of prior ability. In other words, the use of video in instruction provided relatively equal benefits for both high- and low-ability students.

Overall, these results reinforce that integrating video into the CTL approach is an effective strategy for improving mathematics learning outcomes, without being dependent on variations in students' prior ability. This finding has important practical implications for teachers, highlighting the need to utilize video-based learning media as a means to enhance clarity of instruction, particularly for abstract topics. Furthermore, it contributes theoretically by affirming that the effectiveness of visual-based media is not limited to specific groups but is universal in enhancing the quality of contextual learning.

Based on the results of the two-way ANOVA, effect sizes were calculated using partial η^2, as shown in Table 9.

Table 9. Effect Size Results (Partial η^2)

Source of Variation	F	p	Partial η^2	Interpretation (Cohen, 1988)
Treatment (A)	10.87	0.002	0.115	Medium to Large
Prior Ability (B)	12.15	0.001	0.127	Large
Interaction (A × B)	2.43	0.123	0.028	Small

Based on Table 9, the treatment effect (A): partial $\eta^2 = 0.115$ indicates that approximately 11.5% of the variance in learning outcomes was explained by differences in treatment (video-assisted CTL vs. CTL without video). This effect size falls in the medium-to-large category, suggesting that the use of video had a substantial impact on improving learning outcomes. In addition, the prior ability effect (B): partial $\eta^2 = 0.127$ shows that 12.7% of the variance in learning outcomes was explained by differences in prior ability (high vs. low). This large effect confirms that prior ability is a strong factor influencing mathematics achievement. Meanwhile, the interaction effect (A × B): partial $\eta^2 = 0.028$ indicates that the interaction between treatment and prior ability accounted for only about 2.8% of the variance in learning outcomes and was not statistically significant. Thus, the use of video in CTL consistently improved learning outcomes across all levels of prior ability, without producing differential patterns of effect between groups.

Effectiveness of Video-Assisted CTL on Learning Outcomes

This study found that video-assisted CTL was effective in improving students' learning outcomes. Video played a crucial role in reducing cognitive load by presenting abstract concepts visually and in a structured manner, making the information easier to process in working memory (Verschaffel et al., 2020). The simultaneous integration of verbal and visual input enabled students to build conceptual connections more efficiently, as explained in the Cognitive Theory of Multimedia Learning (van Lieshout & Xenidou-Dervou, 2018). Videos also strengthened mental representations by activating both visual and verbal channels, allowing information to be understood not only symbolically but also concretely, thereby enhancing retention and facilitating knowledge transfer (Tanudjaya & Doorman, 2020). Moreover, videos provided flexibility through self-paced learning, as students could pause, replay, or accelerate the presentation according to their needs (Suzuki, 2013). This flexibility reduced the time pressure of face-to-face learning and increased students' control over their learning process. Global research on video innovations in education has also confirmed that such control enhances both engagement and learning outcomes, particularly in mastering complex content (Engelbrecht et al., 2020; Jones & Pepin, 2016). Thus, video is not merely an auxiliary medium but a pedagogical strategy that optimizes CTL through cognitive load reduction, dual-channel memory reinforcement, and support for learner autonomy.

Beyond the role of media support, the effectiveness observed in this study is also attributable to the CTL approach itself. CTL is rooted in the principle that knowledge is more easily understood and retained when linked to real-life situations and students' daily experiences (Putri et al., 2022). By connecting mathematical concepts to relevant contexts, CTL fosters meaningful learning, where new information is not isolated but integrated into existing cognitive structures. This process aligns with constructivist perspectives that emphasize students' active role in building understanding through interactions with their environment (Hunt & Tzur, 2017). Furthermore, the CTL syntax—which includes constructivism, inquiry, questioning, learning community, reflection, and authentic assessment—promotes active engagement and collaboration among students, making learning experiences both individual and social (Ramda et al., 2023; Hobri et al., 2018). Hence, CTL provides a pedagogical framework that facilitates deep learning, enhances motivation, and strengthens critical thinking, ultimately contributing to improved mathematics achievement.

The Influence of Prior Ability on Learning Outcomes

Students with high prior ability consistently demonstrated better learning outcomes than their low-ability peers. One primary reason is their stronger knowledge schema, which provides a solid cognitive foundation that makes it easier to connect new concepts with prior knowledge (Weldeana et al., 2023; Wilkie, 2021). This enables them to grasp meaning more quickly, understand the logical structure of mathematics, and transfer knowledge to problem-solving situations (Scheiner & Pinto, 2019). Conversely, students with low prior ability often experience conceptual fragmentation, perceiving new material as disconnected and difficult to integrate. Another factor is self-efficacy and emotional readiness: high-ability students typically possess greater confidence due to positive prior experiences (Lee et al., 2019). They are more willing to try various strategies, more resilient to mistakes, and able to view failure as an opportunity to learn. In contrast, low-ability students tend to experience anxiety, hesitate in decision-making, and avoid challenges, which weakens their effort in developing mathematical understanding despite their latent potential.

In this study, video served as a form of scaffolding to bridge the gap between these groups. Visualizations of abstract concepts in the form of animations, dynamic diagrams, and concrete contextual examples helped low-ability students understand material that would otherwise be difficult to grasp through verbal explanations alone (Wilkie, 2021). The ability to replay the videos gave them a more flexible learning environment suited to their pace. For high-ability students, video functioned as reinforcement, deepening their existing understanding and accelerating connections to new ideas (Ingram et al., 2019). Thus, although prior ability remained a dominant factor, video provided inclusive support for all learners and contributed to narrowing achievement gaps between groups.

The Effect of Video-Assisted CTL Across All Levels of Prior Ability

Although significant differences in achievement were observed based on treatment and prior ability, the study found no significant interaction between the two. This indicates that the effectiveness of video was universal, benefiting both high- and low-ability students. For high-ability students, video enriched representations and accelerated understanding through structured visualization, while for low-ability students, video served as scaffolding to reduce cognitive barriers in learning abstract material (Hein & Prediger, 2024). Hence, video did not exacerbate achievement disparities but provided relatively equitable contributions to all learners. The role of CTL itself helps explain the consistency of these benefits. CTL emphasizes connecting material with real-world contexts, allowing all students to link mathematical concepts with everyday experiences regardless of prior ability (Noviasari, 2020). Through the CTL syntax, students are encouraged to actively co-construct understanding within learning communities (Putri et al., 2022). Within this framework, video strengthens contextual visualization, bridging diverse student needs by making concepts more concrete and relevant without diminishing the critical thinking challenges needed by high-ability students or the additional scaffolding required by low-ability students (Pepin, 2021). These findings affirm that the advantages of video-assisted CTL are not exclusive but inclusive, consistently benefiting all groups. CTL provides a contextual pedagogical foundation that fosters meaningful learning, while video serves as a visual catalyst that enhances absorption for all students. Together, they create not only effective but also equitable learning experiences that address the diversity of learners in the classroom.

Implications of the Findings

From a pedagogical perspective, this study highlights the need for mathematics teachers to integrate video not merely as a supplementary tool but as a core element of CTL implementation. Video plays a strategic role in supporting conceptual understanding by providing concrete visual representations of abstract material while simultaneously engaging students through interactive and appealing presentations (Björklund & Palmér, 2022). Moreover, the replay function in videos allows students to learn at their own pace, leading to deeper internalization of concepts and stronger retention of information. From a theoretical standpoint, the findings enrich the empirical literature supporting the Cognitive Theory of Multimedia Learning. The principles of dual coding and multimodal cognitive processing were shown to be highly relevant within the Indonesian contextual learning environment, particularly in mathematics, which is often perceived as abstract and difficult. Thus, the study not only adds evidence of the effectiveness of multimedia but also extends its application to context-based pedagogy, demonstrating that visual-verbal integration can bridge the gap between abstract theory and students' real-life experiences. From the perspective of policy and school practice, the findings emphasize the importance of systemic support in the form of adequate infrastructure. Schools need to ensure the availability of digital devices, internet access, and platforms that effectively facilitate the use of video. Additionally, teacher training is critical so that educators are capable of designing, selecting, and integrating videos that align with learning objectives and students' needs. With strong institutional support, video-assisted CTL can be implemented consistently and sustainably, thereby not only improving learning outcomes but also strengthening technology-based pedagogical innovation in schools.

CONCLUSION AND SUGGESTIONS

This study confirms that the integration of Contextual Teaching and Learning (CTL) assisted by video makes a substantial contribution to improving students' mathematics achievement. The first finding indicates that the use of video in CTL not only enriches learning experiences but also strengthens conceptual understanding, increases student engagement, and supports longer-term knowledge retention compared to CTL without video. The second finding reveals that prior ability remains a dominant factor differentiating achievement, as students with stronger cognitive readiness consistently demonstrated higher performance. The third finding shows that the effectiveness of video-assisted CTL applies consistently across all levels of prior ability, suggesting that video can be considered an inclusive pedagogical strategy that does not widen achievement gaps among students.

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Despite these contributions, the study has several limitations. The first finding indicates that integrating video into CTL not only enriches learning experiences but also strengthens conceptual understanding, enhances student engagement, and supports longer-term knowledge retention compared with CTL alone. Second, the relatively short treatment duration was insufficient to capture the long-term effects of video integration in CTL. Third, the study primarily focused on cognitive learning outcomes, whereas affective aspects, such as motivation, attitude, and higher-order thinking skills (critical and creative), were not examined in depth. In light of these limitations, future research is recommended to expand the sample across schools with diverse backgrounds, extend the treatment period to capture long-term effects, and broaden success indicators by including affective dimensions and 21st-century skills. Future studies could also integrate video-assisted CTL with other emerging technologies (such as interactive simulations, learning analytics, or adaptive platforms) to yield a richer understanding of context-based mathematics learning in the digital era.

From a theoretical perspective, this study reinforces the literature on the effectiveness of multimedia learning, emphasizing that the principles of dual coding and multimodal processing are highly relevant when integrated into the CTL framework. Practically, it offers guidance for teachers to position video not merely as a supplementary medium but as a core element that strengthens the connection between mathematical concepts and real-life contexts. At the policy level, the findings underscore the importance of institutional support in providing infrastructure, device access, and teacher training, ensuring that CTL-based innovations supported by video can be implemented sustainably and equitably.

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