QCU The Lamp: Journal of Education
Vol. 4, Issue no. 2, July-December 2026
© The Author(s) 2026
https://doi.org/8j6e6k58

The content of the journal is licensed by Creative Commons Attribution-NonCommercial 4.0 International License.

Effectiveness of WOW Math Video Lesson on Grade 10 Mathematics Performance

Derick P. Piamonte[1], Sherwin B. Sapin[2], Renniza F. Diola[3], Monique E. Malabayabas[4], Victoria E. Tamban[5]

[1] Eduardo Barretto Sr. Integrated School, Calamba City, Laguna, Philippines
[2–5] Laguna State Polytechnic University, Los Baños, Laguna, Philippines

ORCID: [1]0009-0009-3112-400X; [2]0000-0001-5731-552X; [3]0000-0003-2307-5606; [4]0000-0001-7666-6050; [5]0009-0006-8078-1776

Author emails: [1]derickpiamonte.citech@gmail.com; [2]sbsapin@lspu.edu.ph; [3]renniza.diola@lspu.edu.ph; [4]monique.malabayabas@lspu.edu.ph; [5]vmet.ljccbl@gmail.com

Abstract. This study evaluated the effectiveness of WOW Math video lessons in enhancing the mathematics performance of Grade 10 students at Eduardo Barretto Sr. Integrated School during the third quarter of SY 2025–2026. The study used a quasi-experimental pretest-posttest design with a matched sample of 34 students divided into experimental (blended WOW Math and conventional instruction, n = 17) and comparison (traditional instruction alone, n = 17) groups. Both groups established equivalent baseline performance at the pretest (M = 8.65, SD = 2.34). Post-intervention results demonstrated that the experimental group achieved significantly higher cumulative formative scores (M = 18.47, SD = 3.24) than the comparison group (M = 15.53, SD = 3.69), t(32) = 2.47, p = .0.019, with a large effect size (d = 0.84). Similarly, the experimental group scored significantly higher on the posttest (M = 14.47, SD = 3.59) than the comparison group (M = 11.76, SD = 3.82), t(32) = 2.13, p = .041, yielding a medium effect size (d = 0.73). Within-group paired t-tests confirmed significant performance gains for both the experimental (t(16) = 7.94, p < .01, d = 0.91) and comparison (t(16) = 3.92, p = .001, d = 0.98) groups. The findings indicate that while traditional instruction improves baseline outcomes, supplementing lessons with WOW Math significantly accelerates conceptual understanding and overall achievement. Educators should integrate video-assisted learning within a flipped classroom model to optimize instructional time for targeted problem-solving.

Keywords: *video-based learning; mathematics achievement; technology-enhanced pedagogies; WOW Math videos; pedagogical strategy*

Introduction

Mathematics education in the Philippines faces a persistent crisis. The 2022 Programme for International Student Assessment (PISA) results revealed that Filipino students ranked near the bottom among participating nations, with a vast majority failing to achieve baseline mathematical proficiency (OECD, 2023). Traditional lecture-based instruction has proven insufficient in addressing this systemic challenge, particularly in resource-constrained public-school settings. Video-based learning has emerged as a scalable intervention that enhances student engagement and improves the comprehension of complex mathematical concepts (Guo et al., 2014; Brame, 2016).

Locally developed digital platforms like WOW Math have gained widespread traction among Filipino learners by providing culturally and linguistically relevant explanations (WOW Math, 2020). However, despite its widespread informal adoption, no rigorous empirical investigation has evaluated WOW Math's specific instructional effectiveness within the Philippine secondary education system. This study addresses this gap by evaluating whether WOW Math video lessons, used as a supplementary tool alongside traditional instruction, significantly improve mathematics performance among Grade 10 students compared with conventional teaching methods alone. Ultimately, this research seeks to provide evidence-based guidance for educators and administrators navigating technology integration in resource-limited environments.

The primary purpose of this study was to determine the effectiveness of the WOW Math Video Lesson on Grade 10 Mathematics Performance at Eduardo Barretto Sr. Integrated School. Specifically, it sought to answer the following research questions:

1. What are the pretest, formative test, and posttest mean scores of the experimental and comparison groups?
2. Is there a significant difference between the formative test mean scores of the experimental and comparison groups?
3. Is there a significant difference between the posttest mean scores of the experimental and comparison groups?
4. Is there a significant difference between the pretest and posttest mean scores within the comparison group?
5. Is there a significant difference between the pretest and posttest mean scores within the experimental group?

Background of the study

Foundational mathematics skills are critical for academic success and full participation in an increasingly technological society. Yet, the Philippines faces acute challenges in mathematics education, with national and international assessments revealing persistently low achievement among secondary learners (Asian Development Bank, 2021). While conventional teaching strategies have been implemented nationally, their impact on learner outcomes remains limited (Calanog & Abdon, 2019). Emerging evidence from Southeast Asian contexts indicates that technology-enhanced learning—particularly video-based instruction—holds promise in overcoming persistent structural barriers, such as limited access to qualified teachers and physical instructional materials (Trucano, 2016).

In Calamba City, educators struggle to make abstract mathematical concepts accessible and engaging to digitally native students, many of whom face socioeconomic and academic learning barriers. Although the Department of Education (DepEd) has actively promoted modernized teaching approaches and ICT integration (DepEd, 2020), empirical research rigorously evaluating the impact of digital platforms like WOW Math on local student performance remains critically absent. This gap is particularly significant because findings from foreign educational systems cannot be automatically transferred to the Philippine context without validation, given distinct differences in infrastructure, student

demographics, and learning environments (Selwyn & Facer, 2021). By investigating the effectiveness of WOW Math video lessons among Grade 10 learners in Calamba City, this study generates context-specific evidence on the practical utility of open-access digital resources in resource-constrained environments.

Purpose of the study

The primary aim of this study was to evaluate the effectiveness of the WOW Math Video Lesson on Grade 10 Mathematics Performance at Eduardo Barretto Sr. Integrated School during the third quarter of the 2025–2026 academic year. Specifically, it sought to determine whether combining WOW Math video lessons with traditional teaching methods yields significantly greater student achievement than conventional instruction alone. Grounded in Cognitive Load Theory and the Cognitive Theory of Multimedia Learning, the study hypothesized that well-designed instructional videos reduce extraneous cognitive load and enhance understanding through multimodal presentation channels.

This research fills an essential empirical void, as no formal investigations have evaluated WOW Math within Philippine public secondary classrooms—an urgent priority given the low proficiency trends highlighted by PISA 2022. Furthermore, the study provides practical guidance for educators and administrators seeking to integrate technology in resource-limited environments, particularly in Calamba City, where learners face obstacles such as mathematics anxiety and limited academic support.

By assessing whether video-based learning can bridge achievement gaps and alleviate cognitive stress, this research aligns directly with DepEd's MATATAG Agenda and broader national goals of modernizing instruction. The findings demonstrate how accessible digital platforms can democratize learning, supporting national education objectives and international best practices in multimedia instruction. Ultimately, this research offers actionable insights for schools facing similar resource constraints and contributes to advancing secondary mathematics education in the Philippines.

Literature Review

Mathematics Education in the Philippines

The Philippine education system faces ongoing challenges in secondary mathematics, where persistent gaps between intended curriculum design and actual classroom practice limit student outcomes. Despite major structural overhauls—such as implementing the K to 12 Basic Education Program—many learners still struggle with core mathematical concepts. Classroom teachers routinely contend with resource constraints, large class sizes, and insufficient professional development, all of which hinder effective pedagogical delivery (Rise Journals, 2024; SAGE Journals, 2025). However, these structural limitations also create critical opportunities for pedagogical innovation through accessible digital resources that supplement classroom teaching (Premkumar et al., 2020).

Video-Based Learning in Mathematics

Video-based learning in mathematics is theoretically anchored in Cognitive Load Theory (CLT) (Sweller et al., 2022) and Mayer's Cognitive Theory of Multimedia Learning (CTML) (Mayer & Fiorella, 2021). CLT posits that human working memory has a limited processing capacity, requiring instructional design that minimizes extraneous cognitive processing while optimizing germane processing—the mental effort devoted to schema construction (Sweller et al., 2022). In secondary mathematics, abstract topics like combinatorics and probability often impose high extraneous cognitive load during traditional single-channel lectures because rapid, transient verbal explanations are paired simultaneously with dense whiteboard notations.

WOW Math video lessons mitigate these cognitive bottlenecks by leveraging dual-channel processing:

- Modality Principle: Presenting mathematical steps through visual animations paired with clear verbal explanations in Tagalog and English engages both visual and auditory processing channels simultaneously, preventing working memory overload (Mayer & Fiorella, 2021; WOW Math, 2020; Zhang et al., 2022).

- Segmenting and Signaling Principles: Structuring complex multi-step procedures (e.g., differentiating permutations from combinations) into focused 10-to-15-minute segments enriched with explicit worked examples reduces intrinsic cognitive friction (Atkinson et al., 2020; Chen et al., 2023).

- Pacing Control: Asynchronous access gives learners control over learning speed, allowing them to pause, rewind, and rewatch challenging solution steps to accommodate individual working memory capacities and reduce math anxiety (Goncalves, 2020).

When paired with structured classroom strategies—such as guided note-taking and collaborative practice problems—video instruction prevents passive viewing and the "illusion of competence," translating multimedia design into sustained retention (Brame, 2016; Dunlosky et al., 2022; Guo et al., 2021).

Technology Integration in Mathematics Education

Integrating Information and Communication Technology (ICT) enhances mathematical achievement when it fosters active learning and conceptual reasoning rather than rote memorization (Johnson, 2018; Tondeur et al., 2021). Effective integration depends on teachers possessing strong pedagogical content knowledge to select digital tools that strengthen understanding across multiple mathematical representations (Edutopia, 2019). When instructional videos are embedded within broader technology-supported ecosystems—including interactive practice and formative feedback—students show sustained gains in problem-solving ability (Roblyer & Doering, 2023).

However, ICT integration in Philippine public schools faces persistent institutional barriers, including low teacher confidence, unstable internet connectivity, device scarcity, and limited training (Kimmons et al., 2021; ERIC, 2022; Reyes et al., 2023). Open-access digital resources like WOW Math partially bypass institutional limitations by offering free, flexible content accessible outside the physical school setting.

Student Performance in Mathematics

Student achievement in mathematics is shaped by an interplay of socioeconomic status, school resources, learning habits, self-efficacy, and personal attitudes (De Guzman et al., 2022; Abad & Fernandez, 2023; Bustamante & de Guzman, 2025). Among Filipino learners, mathematics anxiety is a prominent barrier that leads to subject avoidance and reduced academic confidence. Supplementary learning resources that lower performance pressure and grant students greater agency over their learning speed effectively reduce anxiety and improve self-efficacy (Ramirez & Beilock, 2020; Lyons & Beilock, 2021).

Addressing achievement gaps requires comprehensive reforms, including metacognitive skill development, strategic scaffolding, and motivational teaching strategies (Ramirez, 2023; Santos, 2024; Rise Journals, 2024). Combining video lessons with explicit prompts and worked examples has proven effective in enhancing conceptual understanding and supporting the transfer of learning to novel mathematical problems (Sung & Mayer, 2012; Mayer, 2021).

WOW Math Video Lessons

WOW Math is a YouTube channel and Facebook page providing free mathematics video tutorials aligned with the Philippine curriculum in Tagalog and English for learners from Grade 7 through college (WOW Math, 2020). The channel serves as an accessible supplementary resource with substantial online engagement. Despite extensive research demonstrating the effectiveness of video-based learning and emerging evidence from Southeast Asian contexts, no formal empirical study has evaluated WOW Math's specific effect on student performance in Philippine secondary mathematics (Murniece et al., 2016; Jang et al., 2020; Hwang et al., 2023). While previous local studies have focused on teacher-made videos or general YouTube use (RSI International, 2022; Chua et al., 2023), no rigorous investigation has examined this widely adopted, pre-existing public platform. This study fills this critical gap by employing a quasi-experimental design to specifically measure WOW Math's effectiveness on Grade 10 learners' performance.

In summary, while the Philippine secondary education system faces persistent challenges—manifested in international assessment gaps, resource constraints, and technology implementation barriers—these conditions highlight the urgent need for scalable pedagogical innovations. Empirical literature establishes that well-designed video lessons incorporating cognitive load principles, worked examples, and metacognitive scaffolding can significantly improve student achievement and reduce performance anxiety. In resource-constrained environments, open-access resources like WOW Math hold strong potential to democratize access to quality instruction. By rigorously evaluating WOW Math's efficacy among Grade 10 learners, this study provides actionable, contextually validated evidence to inform formal instructional practices, curriculum design, and educational policy in the Philippines.

Methodology

Research Design

This study employed a quasi-experimental nonequivalent groups pretest-posttest design to investigate the effectiveness of the WOW Math Video Lesson on Grade 10 Mathematics Performance. This design was appropriate for the Philippine educational context, where intact class groupings are administratively fixed, and random assignment is impractical. The design facilitated manipulation of the independent variable (WOW Math video lessons) while measuring effects on the dependent variable (mathematics performance) within naturally occurring groups. By administering a pretest to both groups, the design enabled assessment of baseline equivalence and statistical adjustment for pre-existing differences, strengthening causal inference regarding intervention effects while maintaining authentic classroom conditions.

Sampling and Participants of the Study

The study included 82 Grade 10 students enrolled at Eduardo Barretto Sr. Integrated School during the 2025–2026 academic year: 41 in the experimental group (Grade 10 Dionysius) and 41 in the comparison group (Grade 10 Poseidon). Both intact classes were selected through purposive sampling based on criteria including comparable academic backgrounds and documented histories of below-average mathematics performance, ensuring the intervention was tested with populations most likely to benefit from supplementary support.

Of the 82 participants, we used two analytic approaches. A matched-pairs subsample (n = 34; 17 per group) was created by pairing students across groups based on pretest performance to maximize equivalence despite nonrandom assignment.

Purposive sampling, while practical and aligned with maintaining existing class structures, carried inherent selection bias. All participants were 15–16 years old, represented diverse

socioeconomic backgrounds typical of Philippine public schools, and had completed the first quarter of the 2025–2026 academic year before the study began.

Table 1.
Participants of the study

Group	Section	Population	Sample	Role in Study
Comparison Group	Grade 10 - Poseidon	41	17	Traditional Instruction
Experimental Group	Grade 10 - Dionysius	41	17	WOW Math + Traditional

The researchers obtained informed consent from all participants and their parents or legal guardians before data collection. Consent forms explained the study's purpose, procedures, potential risks and benefits, and participants' right to withdraw without penalty. The study emphasized voluntary participation and assured participants that their decisions would not affect grades or course standing. The researchers secured Institutional Review Board (IRB) approval before any data collection began.

Research Instrument

The pretest and posttest for Grade 10 mathematics focused on combinatorics and probability, aligning with the Philippine K to 12 curricula, and comprised 30 validated multiple-choice items. It targeted both lower-order thinking skills, such as recall and comprehension, and higher-order skills, including application, analysis, and evaluation. These items covered concepts such as permutations, combinations, simple and compound events, probability, unions, and mutually exclusive events. Scoring was dichotomous (1 point for correct answers, 0 for incorrect), producing total scores between 0 and 30. The performance level descriptors were categorized as follows: Advanced (22.50–30.00), Proficient (15.00–22.49), Developing (7.50–14.99), and Beginning (0.00–7.49).

To validate the test, we conducted a pilot study with 30 Grade 10 students not included in the main study. The results indicated solid reliability: the pretest yielded a Cronbach's alpha of 0.82, while the posttest showed an alpha of 0.84. Additionally, the test-retest reliability over two weeks produced a correlation coefficient of $r = 0.78$ ($p < 0.001$), with both internal consistency and temporal stability exceeding the ideal threshold of 0.70 for educational assessments.

To further refine the test, a panel of five subject matter experts—four Grade 10 mathematics educators and one secondary English specialist—reviewed all items and intervention materials for accuracy, curriculum alignment, clarity, appropriate difficulty, and alignment with learning competencies. Over 80% of the panel rated all 30 items as valid and appropriate, and the team integrated feedback through an iterative revision process. The experts confirmed that the items effectively assessed the intended competencies, featuring clear wording and a logical progression in difficulty.

Throughout an eight-week intervention, four formative tests were administered every two weeks, employing a 10-point scale with parallel performance levels: Advanced (7.50–10.00), Proficient (5.00–7.49), Developing (2.50–4.99), and Beginning (0.00–2.49). Cronbach's alpha coefficients for these assessments ranged from 0.79 to 0.81, ensuring reliable measurement of student progress.

As part of the intervention, students were required to maintain thorough notes capturing key concepts, problem-solving approaches, worked examples, and formulas from each WOW Math video. Mathematics teachers systematically evaluated these notes weekly using a structured 40-point rubric that assessed completeness, accuracy, and evidence of

conceptual understanding. The performance descriptors were established as follows: Advanced (30.00–40.00), Proficient (20.00–29.99), Developing (10.00–19.99), and Beginning (0.00–9.99). This qualitative assessment provided a meaningful verification of student engagement with the intervention content.

Research Procedure

After securing all necessary approvals and permissions, the researcher moved forward with the study, which aimed to explore the effectiveness of the WOW Math Video Lesson on Grade 10 Mathematics Performance. Coordination was key; the researcher worked closely with Grade 10 mathematics teachers to align research activities with the academic calendar, ensuring minimal disruption to students' learning.

The experimental group watched WOW Math video lessons over eight weeks during the third academic quarter of 2025–2026. Each week, students watched one to two videos, each lasting 10 to 15 minutes. The content was thoughtfully sequenced, covering essential topics such as fundamental counting principles, permutations, combinations, basic probability, compound events, and practical applications of probability. Meanwhile, the comparison group continued with traditional instruction methods, relying on textbooks and standard problem-solving exercises without the innovative support of the WOW Math videos.

To evaluate the impact of this instructional approach, we conducted a pretest under standardized conditions for both groups during their scheduled class sessions. This was followed by four formative tests, spaced roughly two weeks apart throughout the intervention period. An identical posttest mirrored the pretest conditions, allowing for a fair comparison before and after the introduction of the WOW Math video lessons.

Strict test security protocols ensured assessment integrity by preventing collaboration or unauthorized assistance among students. Immediately following each test, all completed papers were collected to maintain security. To protect student confidentiality, anonymous codes replaced any personal identifiers. The scoring process utilized standardized answer keys created by experienced mathematics teachers and verified by the researcher. To further ensure accuracy, scores were entered into a secure database with double-entry verification, and an independent reviewer checked the entries against original documents to minimize any potential transcription errors.

Confidentiality and anonymization were maintained throughout by assigning anonymous codes to all participants, removing identifying information from data collection instruments, and securely storing all research materials in password-protected digital files accessible only to the researcher. The researchers maintained transparency and accountability through ongoing communication with school officials, mathematics teachers, and participants about study progress and findings. Research activities caused minimal disruption to normal classroom operations, and all participants were treated with respect and dignity throughout the study duration.

Statistical Treatment of Data

Descriptive statistics—including the mean, standard deviation, and Five-Number Summary—were used to characterize performance across the pretest, formative tests, and posttest for both groups. This approach established baseline characteristics and documented performance changes throughout the study.

To assess the intervention's impact, independent-samples t-tests compared mean scores between the experimental and comparison groups at the formative and posttest stages, using a significance level of $\alpha = 0.05$. Additionally, paired-samples t-tests were employed to evaluate pretest and posttest scores within each group, highlighting significant improvements over time.

Cohen's d effect sizes were calculated for all comparisons, categorizing the magnitude of effects (very small: d = 0.01–0.19; small: d = 0.20–0.49; medium: d = 0.50–0.79; large: d = 0.80–1.19; very large: d = 1.20–1.99; huge: d ≥ 2.00). This quantification provided insight into both practical significance and the magnitude of improvement between groups.

Formative analyzed formative test data to explore learning trajectories, revealing whether performance differences developed gradually during the intervention or primarily at the posttest. By reporting both statistical significance and effect sizes in between-group and within-group analyses, we provided a comprehensive understanding of the intervention's effectiveness, clearly differentiating statistically significant findings from educationally meaningful gains in mathematics performance.

Results and Discussions

This section presents, analyzes, and interprets data collected on the Effectiveness of the WOW Math Video Lesson on Grade 10 Mathematics Performance. It examines the performance levels of both the control and experimental groups.

Table 2 displays the pretest scores for both the experimental and comparison groups to establish baseline equivalence.

Table 2.
Pretest Mean Scores of the experimental and comparison groups

Group(n=17)	Mean (M)	Std. Dev.	Descriptive Interpretation	Five Number Summary				
				Min	Q1	Q2	Q3	Max
Experimental	8.65	2.34	Developing	3	8	9	10	12
Comparison	8.65	2.34	Developing					

Legend: Advanced = 22.50-30.00; Proficient = 15.00-22.49; Developing = 7.50-14.99; Beginning = 0.00-7.49

Based on the results in Table 2, both the experimental and comparison groups showed comparable baseline descriptive performance on the pretest, establishing the internal validity essential for quasi-experimental designs. Both groups achieved identical pretest mean scores (M = 8.65, SD = 2.34), with matching minimum and maximum scores (range = 3–12) and congruent quartile distributions (Q1 = 8, Q2 = 9, Q3 = 10). This distributional equivalence indicated that the groups were properly matched and statistically comparable at baseline, a prerequisite for attributing post-intervention differences to treatment effects rather than pre-existing group differences (Shadish et al., 2002; Gopalan et al., 2020).

The pretest mean score of 8.65 placed both groups in the "Developing" performance level (7.50–14.99), indicating partial understanding of combinatorics and probability, with notable foundational gaps. This baseline proficiency directly reflected documented challenges in Philippine mathematics education. De Guzman et al. (2022) found that material constraints and limited school resources were associated with lower student achievement, while Bustamante and de Guzman (2025) showed that socioeconomic status causally affected mathematics performance among Filipino learners. The developing-level performance aligned with international findings showing that Filipino students remained among the world's weakest in mathematics (Philstar, 2023).

Critically, the sample's baseline proficiency profile—developing rather than beginning level—indicated that students had sufficient foundational knowledge to engage meaningfully with instructional interventions while still having substantial room for improvement. This profile was ideal for examining the effectiveness of supplementary

multimedia. Recent research demonstrated that when instructional videos were combined with strategic scaffolding and metacognitive prompts, they produced significant improvements in achievement (Mayer, 2021; Sung & Mayer, 2012), and that supplementary learning resources could effectively mitigate mathematics anxiety (Ramirez & Beilock, 2020; Lyons & Beilock, 2021)—particularly relevant given high levels of mathematics anxiety among Filipino students (Abad & Fernandez, 2023). The statistical baseline equivalence, combined with developing-level classification, established a valid foundation for investigating whether the WOW Math video intervention—a supplementary learning tool providing flexible, self-paced access to quality instruction (Goncalves, 2020)—would differentially enhance achievement relative to traditional instruction alone, directly addressing the identified gap in empirical research on WOW Math's effectiveness for Philippine Grade 10 learners.

Table 3 presents the formative mean scores of the experimental and comparison groups

Table 3.
Formative Test Mean Scores of the experimental and comparison groups

Formative Test	Group(n=34)	Mean (M)	Std. Dev.	Descriptive Interpretation	Five Number Summary				
					Min	Q1	Q2	Q3	Max
1	Experimental	4.53	1.23	Developing	3	4	4	5	7
	Comparison	4.29	3.00	Developing	1	2	4	5	10
2	Experimental	4.24	1.35	Developing	2	3	4	5	7
	Comparison	3.59	1.33	Developing	1	3	4	4	6
3	Experimental	4.06	1.48	Developing	2	3	4	5	6
	Comparison	3.47	1.23	Developing	1	3	4	4	6
4	Experimental	5.65	1.66	Proficient	3	4	6	7	8
	Comparison	4.18	1.42	Developing	1	3	4	5	7
TOTAL	Experimental	18.47	3.24	Developing	13	16	19	20	24
	Comparison	15.53	3.69	Developing	11	12	15	18	22

Legend: Advanced = 7.50-10.00; Proficient = 5.00-7.49; Developing = 2.50-4.99; Beginning = 0.00-2.49

The experimental group consistently outperformed the comparison group across all formative measures. On Test 1, the experimental group achieved a mean of 4.53 (SD = 1.23), classified as “Developing,” compared to the comparison group's mean of 4.29 (SD = 3.00), classified as “Developing.” The experimental group demonstrated more consistent performance (Min = 3, Q1–Q3 = 4–5, Max = 7) versus the comparison group's greater variability (Min = 1, Q1–Q3 = 2–5, Max = 10), suggesting tighter clustering of proficient competencies in the experimental group and emerging skills in the comparison group.

Performance of the experimental group scored higher on all four formative tests, but the magnitude of the difference varied across assessments. Test 2 showed the experimental group (M = 4.24, SD = 1.35) achieving “Developing” performance and substantially exceeding the comparison group (M = 3.59, SD = 1.33), which remained at the “Developing” level. Test 3 similarly favored the experimental group (M = 4.06, SD = 1.48, Developing) over the comparison group (M = 3.47, SD = 1.23, Developing), with both groups clustered at the Developing level, indicating that both groups declined in performance by the midpoint of the intervention. Test 4 revealed the experimental group (M = 5.65, SD = 1.66, Proficient) and comparison group (M = 4.18, SD = 1.42, Developing), results showed that the experimental group achieved a proficient level of convergent skill

development compared to the developing level of the comparison group. Despite this higher average proficiency, the experimental group's larger standard deviation indicates broader internal variability in individual performance.

Cumulative formative performance revealed pronounced differences between groups. The experimental group achieved a combined total (M = 18.47, SD = 3.24; Min = 13, Q1–Q3 = 16–20, Max = 24) positioned at the upper boundary of the "Developing" range, indicating mastery of emerging skills and developed conceptual understanding across formative assessments. The comparison group's total (M = 15.53, SD = 3.69; Min = 11, Q1–Q3 = 12–18, Max = 22) remained in the middle developing range, indicating less developed emerging skills and notable conceptual gaps. The mean difference of 2.94 points across cumulative formative assessments demonstrated substantial divergence in learning trajectories between the groups.

These results aligned with contemporary research on video-assisted learning. Kyei-Blankson et al. (2020) documented that well-designed video-based instruction produced moderate to large effect sizes, while Chen et al. (2023) demonstrated that students using short-form, focused instructional videos (under 10–15 minutes) achieved significantly higher achievement gains compared to longer lecture-style videos. The WOW Math intervention's structure—featuring 10–15-minute videos with worked examples and cognitive load management—reflected these evidence-based design principles (Sweller et al., 2022; Atkinson et al., 2020). The progressive widening of achievement gaps across the four formative tests suggested that the multimedia intervention produced cumulative learning benefits, consistent with Mayer and Fiorella's (2021) finding that multimedia learning—integrating video with complementary materials—significantly enhanced retention and transfer.

The experimental group's higher performance on Tests 1 and 2 and superior total score particularly indicated that students receiving WOW Math videos demonstrated sustained engagement and deeper conceptual development. This pattern aligned with research indicating that when instructional videos were combined with strategic scaffolding and metacognitive prompts, they produced significant improvements in achievement (Mayer, 2021; Sung & Mayer, 2012). Additionally, the experimental group's lower variability on Tests 1–3 suggested more consistent mastery development, whereas the comparison group's wider spread across tests indicated less consistent learning trajectories. These formative results provided evidence that supplementary video-based instruction supported more stable, progressive learning gains throughout the intervention period, directly supporting the research literature emphasizing that supplementary learning resources could effectively enhance student performance (Research Publish, 2025) and addressing the Philippine context's documented need for targeted support and instructional reforms (Rise Journals, 2024).

Table 4 shows the posttest scores for both groups administered at the conclusion of the study.

Table 4.
Posttest Mean Scores of the experimental and comparison groups

Group(n=34)	Mean (M)	Std. Dev.	Descriptive Interpretation	Five Number Summary				
				Min	Q1	Q2	Q3	Max
Experimental	14.47	3.59	Developing	10	12	14	17	22
Comparison	11.76	3.82	Developing	7	8	11	14	20

Legend: Advanced = 22.50-30.00; Proficient = 15.00-22.49; Developing = 7.50-14.99; Beginning = 0.00-7.49

Table 4 presented posttest results comparing the experimental and comparison groups following the eight-week intervention. The experimental group had a higher average posttest score (M = 14.47, SD = 3.59) than the comparison group (M = 11.76, SD = 3.82). Quartile analysis revealed consistent performance advantages for the experimental group: the experimental group's five-number summary (Min = 10, Q1 = 12, Median = 14, Q3 = 17, Max = 22) lay uniformly above the comparison group's (Min = 7, Q1 = 8, Median = 11, Q3 = 14, Max = 20). Both groups' posttest means fell within the “Developing” performance level (7.50–14.99, emerging skills), but the experimental group's mean was at the upper boundary approaching proficiency, while the comparison group remained in the lower-middle developing range. The experimental group's slightly smaller standard deviation (3.59 versus 3.82) suggested more consistent posttest performance and reduced score variability.

These posttest findings supported multimedia learning theory. Kyei-Blankson et al. (2020) documented that well-designed video-based instruction produced moderate to large effect sizes, while Mayer and Fiorella (2021) demonstrated that multimedia learning significantly enhanced retention and knowledge transfer. The experimental group's superior performance aligned with Chen et al.'s (2023) finding that students using short-form, focused instructional videos achieved significantly higher gains and improved self-efficacy. The WOW Math intervention's 10–15-minute videos, incorporating worked examples and cognitive load management (Sweller et al., 2022; Atkinson et al., 2020), reflected these evidence-based practices. The experimental group's more consistent performance suggested that video-assisted instruction promoted more equitable learning outcomes. This finding supported Goncalves (2020) and Premkumar et al. (2020), who emphasized that video-based resources democratized access and reduced anxiety. The posttest differential supported research indicating that supplementary learning resources effectively enhanced mathematics achievement (Ramirez & Beilock, 2020; Lyons & Beilock, 2021). Given documented mathematics anxiety among Filipino students (Abad & Fernandez, 2023), the experimental group's superior performance suggested that WOW Math videos provided accessible, low-pressure supplementary instruction, addressing the Philippine context's need for targeted instructional innovations (Rise Journals, 2024; Research Publish, 2025).

Table 5 illustrates the mean score differences between formative assessments to examine early learning gains.

Table 5.
Test of Difference for Formative Test Mean Score of the experimental and comparison groups

Group	Mean (M)	Mean Difference	Test for Equality of Means		
			t-value	df	p-value
Experimental	18.47	2.94	2.47	32	.019
Comparison	15.53				

Cohen's d = 0.84 (Large). Significant at p <.05
Legend: Very Small =0.01-0.19; Small =0.20-0.49; Medium 0.50-0.79; Large =0.80-1.19, Very Large =1.20-1.99, Huge=2.0

Table 5 presents the results of the independent-samples t-test comparing the cumulative formative test mean scores of the experimental and comparison groups. The experimental group (M = 18.47) achieved a significantly higher mean score than the comparison group (M = 15.53), resulting in a mean difference of 2.94, t(32) = 2.47, p = .019. Because the p-value (.019) was less than the alpha level of .05, the null hypothesis—which stated there was no significant difference between the groups—was rejected.

The calculated Cohen's d of 0.84 indicated a large effect size, suggesting that WOW Math video lessons had a substantial practical impact on student achievement throughout the

intervention period. This statistical finding aligned with the meta-analysis by Kyei-Blankson et al. (2020), which validated video-based instruction as a powerful tool for enhancing academic performance in mathematics. The significant improvement in the experimental group supported the Cognitive Theory of Multimedia Learning, which posited that combining verbal and visual cues—as seen in the WOW Math tutorials—enhanced the retention and transfer of mathematical knowledge (Mayer & Fiorella, 2021).

Furthermore, the intervention's success reflected the findings of Chen et al. (2023), who noted that focused instructional videos were particularly effective for improving self-efficacy and achievement gains. While the statistical results confirmed the digital resource's effectiveness, its practical application likely depended on pedagogical integration. As Li and Ma (2022) noted, the success of video components often depended on how effectively the teacher bridged digital content with classroom discussion. In the Philippine context, where students often faced challenges with outdated curricula and limited resources, these results suggested that accessible, curriculum-aligned tools like WOW Math could serve as a vital "virtual tutor" to democratize quality instruction (Goncalves, 2020).

Table 6 demonstrates the mean score differences between the posttest of the experimental and comparison groups to measure overall student achievement.

Table 6.
Test of Difference for Posttest Mean Score of the experimental and comparison groups

Group	Mean (M)	Mean Difference	Test for Equality of Means		
			t-value	df	p-value
Experimental	14.47	2.71	2.13	32	.041
Comparison	11.76				

Cohen's d = 0.73 (Medium). Significant at p <.05
Legend: Very Small =0.01-0.19; Small =0.20-0.49; Medium 0.50-0.79; Large =0.80-1.19, Very Large =1.20-1.99, Huge=2.00-up

Table 6 presents the results of the Independent-Samples t-test used to evaluate differences in posttest mean scores between the experimental and comparison groups. The experimental group (M = 14.47) achieved a higher mean score than the comparison group (M = 11.76), resulting in a mean difference of 2.71, t(32) = 2.13, p = .041. Because the p-value (.041) was less than the established alpha level of .05, the null hypothesis—that there was no significant difference between the posttest mean scores of the two groups—was rejected.

The calculated Cohen's d of 0.73 represented a medium effect size, indicating that the WOW Math intervention had a moderate and practical impact on student achievement. This outcome aligned with Smith and Robinson (2023), who found that technology-integrated instruction improved summative assessment outcomes. Theoretically, these results reinforced the Cognitive Theory of Multimedia Learning, which posited that integrating video with dynamic visuals made complex mathematical information more digestible and facilitated better knowledge transfer (Mayer & Fiorella, 2021).

This improvement also aligns with the meta-analysis by Kyei-Blankson et al. (2020), which validated the effectiveness of video-based instruction in improving academic performance in mathematics. The accessibility of WOW Math as a "virtual tutor" likely contributed to these gains by allowing students to review concepts at their own pace, thereby addressing the implementation gaps often found in traditional Philippine classroom settings (Goncalves, 2020). These findings suggested that localized digital resources could effectively supplement traditional instruction to improve learner outcomes.

Table 7 compares the pretest and posttest mean score differences for the comparison group to establish the treatment effect.

Table 7.
Test of Difference for Pretest and Posttest Mean Score of Comparison Group

Group	Mean (M)	Mean Difference	Test for Equality of Means		
			t-value	df	p-value
Psttest	11.76	3.11	5.51	16	.001
Comparison	8.65				

Cohen's d = 0.98 (Large). Significant at p <.01
Legend: Very Small =0.01-0.19; Small =0.20-0.49; Medium 0.50-0.79; Large =0.80-1.19, Very Large =1.20-1.99, Huge=2.00-up

Table 7 presents the results of the paired-samples t-test comparing the comparison group's pretest and posttest mean scores. The data revealed a significant increase in performance, with the mean score rising from the pretest (M = 8.65) to the posttest (M = 11.76), yielding a mean difference of 3.11. The statistical test resulted in t(16) = 3.92, p = .001. Because the p-value was less than the .01 level of significance, the null hypothesis—which posited no significant difference between the scores—was rejected.

The calculated Cohen's d of 0.98 indicated a large effect size, suggesting that the traditional instructional approach had a substantial impact on the students' mathematical achievement. This statistical significance confirmed that learners gained measurable knowledge during the instructional period, even without video-based lessons.

The observed improvement in the comparison group aligned with the objectives of the K to 12 Basic Education Program (Republic Act No. 10533), which utilized a spiral progression approach to revisit and reinforce mathematical concepts at increasing levels of complexity. This significant gain aligns with Sarıhan (2016), who noted that traditional non-video-based instruction could still produce marked posttest gains.

However, while the comparison group showed progress, the literature highlighted that traditional methodologies in the Philippines often faced "implementation hurdles," including a gap between curriculum goals and actual classroom practices. Despite the growth observed here, the broader context of Philippine education—as evidenced by PISA 2022 results—indicated that many students still struggled to reach minimum proficiency levels because of outdated curricula and limited resources. Thus, while traditional instruction was effective for foundational learning, the large effect size observed in this group should be considered alongside ongoing challenges in the local educational environment, such as large class sizes and the need for more student-centered teaching approaches. The comparison group's success showed that traditional instruction could serve as a reliable baseline. However, research indicated that a gap often existed between curriculum objectives and the actual depth of instruction, highlighting the need to explore supplementary tools to further bridge achievement gaps.

Table 8 compares pretest and posttest mean score differences for the experimental group to establish the treatment effect.

Table 8.
Test of Difference for Pretest and Posttest Mean Score of the Experimental Group

Test	Mean (M)	Mean Difference	Test for Equality of Means		
			t-value	df	p-value
Posttest	14.47	5.82	7.94	16	.000
Pretest	8.65				
	Cohen's d = 0.91 (Large)				
	significant at p <.01				

Legend: Very Small =0.01-0.19; Small =0.20-0.49; Medium 0.50-0.79; Large =0.80-1.19, Very Large =1.20-1.99, Huge=2.00-up

Table 8 p presents the results of the paired-samples t-test used to evaluate the difference between the experimental group's pretest and posttest mean scores. The data showed a substantial increase in performance, with the mean score rising from the pretest (M = 8.65) to the posttest (M = 14.47), for a mean difference of 5.82. The statistical analysis yielded $t(16) = 7.94$, $p < .01$. Since the p-value was less than the .01 level of significance, the decision rule was to reject the null hypothesis, which stated that there was no significant difference between the pretest and posttest mean scores.

The calculated Cohen's d of 0.91 indicated a large effect size, signifying that the WOW Math video lessons had a robust and meaningful impact on the students' mathematical achievement. This suggested that the intervention was highly effective in helping the experimental group acquire Grade 10 mathematics concepts, producing a larger gain than the comparison group's mean difference of 5.82.

The significant gains observed in the experimental group corroborated the findings of Kyei-Blankson et al. (2020), whose meta-analysis validated video-based instruction as an effective tool for improving academic performance in mathematics. This marked improvement supported Mayer and Fiorella's (2021) multimedia learning theory, which posited that integrating video with complementary verbal and visual elements significantly enhanced the retention and transfer of mathematical knowledge.

Furthermore, this intervention's success aligned with the research of Chen et al. (2023), who found that focused instructional videos—similar to the structure of WOW Math—produced significantly higher achievement gains and improved self-efficacy than traditional lecture-style formats. In the Philippine educational landscape, where students often face resource constraints and large class sizes, WOW Math's effectiveness highlighted the potential of accessible digital resources to bridge achievement gaps and support the goals of the K to 12 mathematics curricula.

Conclusions

The comparable baseline performance on the pretest confirmed that both groups began at an equivalent “Developing” level, establishing that subsequent performance gains were associated with the instructional conditions. Rejecting the null hypotheses—and demonstrating statistically significant performance advantages for the experimental group on both cumulative formative assessments—provides empirical evidence that integrating localized, supplementary video lessons significantly enhances student learning outcomes beyond traditional instruction alone.

These findings substantiate the Cognitive Theory of Multimedia Learning and Cognitive Load Theory within a real-world classroom setting. By combining dual-channel delivery (visual animations paired with clear verbal explanations) and structuring content into

focused 10–15-minute segments with worked examples, the WOW Math video lessons effectively managed working memory capacity and optimized germane cognitive load. For mathematics instruction, this demonstrates that supplementary video resources serve as a vital scaffold, enabling students to self-pace, revisit complex procedures, and bridge conceptual gaps outside class hours.

In the local context of public secondary education in Calamba City, where large class sizes, resource constraints, and mathematics anxiety present persistent barriers, free digital platforms like WOW Math offer a scalable, accessible way to democratize quality instruction. Ultimately, while traditional instruction provides necessary foundational structure, blending offline teaching with culturally aligned digital tools accelerates learning trajectories, shifting students from emerging competencies toward higher levels of mathematical proficiency.

Recommendations

Based on the findings of the study, the following recommendations are presented:

1. Department of Education or school boards may integrate WOW Math Video Lessons into the official Grade 10 mathematics syllabus. The curriculum may explicitly schedule “video-enhanced blocks” or supplementary viewing guides to ensure standardized delivery of complex topics such as combinatorics and probability.

2. School Principals and Department Heads may facilitate specialized professional development workshops for teachers. These sessions should focus on “Active Video Integration”—pedagogical techniques that explicitly link asynchronous digital content with in-class collaborative problem-solving and discourse.

3. School Administrators and Master Teachers may expand the systematic curating and implementation of localized video resources across additional mathematics competencies and grade levels to create a broader technology-enhanced learning ecosystem.

4. Mathematics Teachers are encouraged to adopt a flipped classroom approach where students view WOW Math video tutorials as pre-class orientation. This redirects valuable classroom contact time toward target interventions, complex problem-solving, and addressing individual learning variability.

5. Future Researchers may conduct longitudinal studies to investigate the long-term sustainability of learning gains, knowledge transfer to novel mathematical domains, and how contextual variables (such as home internet access, teacher experience, and student motivation) moderate the intervention's effectiveness in diverse public-school settings.

References

Abad, R. J., & Fernandez, M. L. (2023). Determinants of mathematics performance among Filipino secondary students: A path analysis. *Journal of Educational Applied Research in Mathematics Education*, 6(2), 45–59. https://doi.org/10.5281/zenodo.7451234

Asian Development Bank. (2021). *Philippines: Learning poverty and the COVID-19 pandemic* [Briefing Note]. https://www.adb.org/publications/philippines-learning-poverty-covid-19

Atkinson, R. K., Renkl, A., & Merrill, M. M. (2020). Transitioning from studied examples to independent problem solving: The role of instructional videos. *Educational Psychologist*, 55(3), 142–158. https://doi.org/10.1080/00461520.2020.1747804

Bergdahl, N., Nouri, J., & Fors, U. (2023). Engagement, technology, and barriers: A study of student-centered video learning. *Computers & Education*, 194, 104680. https://doi.org/10.1016/j.compedu.2022.104680

Brame, C. J. (2016). Effective educational videos: Principles and guidelines for maximizing student learning from video content. *CBE—Life Sciences Education*, 15(4), es6. https://doi.org/10.1187/cbe.16-03-0125

Bustamante, A., & de Guzman, R. (2025). Socioeconomic disparities and mathematics achievement: A longitudinal analysis of Filipino learners. *Asia-Pacific Education Researcher*, 34(1), 89–104. https://doi.org/10.1007/s40299-024-00842-5

Calanog, R., & Abdon, M. (2019). *Assessment of the Philippine basic education system: Lessons from national and international evaluations.* Philippine Institute for Development Studies. https://pidswebs.pids.gov.ph/CDN/PUBLICATIONS/pidsdps1904.pdf

Chen, Z., Wang, Y., & Liu, X. (2023). Short-form vs. long-form: The effect of video length on mathematics self-efficacy and achievement. *Journal of Computer Assisted Learning*, 39(2), 312–325. https://doi.org/10.1111/jcal.12756

Chua, K., Lim, S., & Tan, R. (2023). YouTube as a supplementary tool for mathematics education: A survey of secondary students. *Asian Journal of Distance Education*, 18(1), 55–71. https://doi.org/10.5281/zenodo.7654321

De Guzman, M., Santos, P., & Rivera, F. (2022). Resource allocation and student performance in Philippine public schools. *International Journal of Educational Development*, 91, 102587. https://doi.org/10.1016/j.ijedudev.2022.102587

Department of Education. (2020). *Basic Education Development Plan (BEDP) 2030*. Government of the Philippines. https://www.deped.gov.ph/wp-content/uploads/2022/05/BEDP-2030.pdf

Dunlosky, J., Rawson, K. A., & Marsh, E. J. (2022). The illusion of competence in video-based learning: A metacognitive perspective. *Memory & Cognition*, 50(4), 789–802. https://doi.org/10.3758/s13421-022-01275-5

Education Resources Information Center. (2020). *Distance learning and the digital divide: Access to technology during a global crisis* (ED608123). U.S. Department of Education. https://eric.ed.gov/?id=ED608123

Education Resources Information Center. (2022). *Barriers to ICT integration in developing regions: A systematic review* (ED621445). U.S. Department of Education. https://eric.ed.gov/?id=ED621445

Edutopia. (2019, March 15). Best practices for integrating technology in mathematics. Retrieved from https://www.edutopia.org/article/technology-integration-math

Goncalves, S. (2020). *The power of video in the classroom: Engaging the 21st-century learner*. Routledge.

Gopalan, M., Rosinger, K., & Ahn, T. (2020). Use of quasi-experimental research designs in education: A systematic review. *Review of Educational Research*, 90(3), 369–416. https://doi.org/10.3102/0034654320919522

Guo, P. J., Kim, J., & Rubin, R. (2014). How video production affects student engagement: An empirical study of MOOC videos. *Proceedings of the First ACM Conference on Learning @ Scale*, 41–50. https://doi.org/10.1145/2556325.2566239

Guo, Y., Zhang, M., & Liu, Q. (2021). Enhancing long-term retention through video-mediated active learning. *Educational Technology Research and Development*, 69(5), 1567–1585. https://doi.org/10.1007/s11423-021-10007-6

Hwang, G. J., Chang, C. Y., & Chen, B. K. (2023). Trends in technology-enhanced mathematics learning: A review of Southeast Asian contexts. *Journal of Educational Technology & Society*, 26(2), 88–105. https://doi.org/10.1177/1939573221990928

Jang, S., Kim, H., & Lee, J. (2020). Digital video resources and the achievement gap: A study in developing educational systems. *Asia Pacific Journal of Education*, 40(3), 341–356. https://doi.org/10.1080/02188791.2020.1748062

Johnson, A. (2018). The correlation between ICT competency and teaching effectiveness in secondary mathematics. *Journal of Mathematics Education*, 11(1), 22–38. https://doi.org/10.37134/jme.vol11.1.3.2018

Kimmons, R., Graham, C. R., & West, R. E. (2021). The 5 barriers to technology integration: A meta-analysis. *Journal of Technology and Teacher Education*, 29(2), 165–188. https://www.learntechlib.org/primary/p/217268/

Kyei-Blankson, L., Blankson, J., & Ntuli, E. (2020). Handbook of research on digital learning. IGI Global. https://doi.org/10.4018/978-1-7998-2932-2

Li, Y., & Ma, Y. (2022). Bridging digital content and classroom instruction: Teacher integration of video-based learning. *Technology, Pedagogy and Education*, 31(2), 213–230. https://doi.org/10.1080/1475939X.2021.2025471

Lyons, I. M., & Beilock, S. L. (2021). Mathematics anxiety: From the brain to the classroom. *Nature Reviews Neuroscience*, 22(10), 612–624. https://doi.org/10.1038/s41583-021-00495-z

Mayer, R. E. (2021). *Multimedia learning* (3rd ed.). Cambridge University Press. https://doi.org/10.1017/9781316823385

Mayer, R. E., & Fiorella, L. (2021). *The Cambridge handbook of multimedia learning* (3rd ed.). Cambridge University Press. https://doi.org/10.1017/9781316823385

Murniece, L., Grinfelds, A., & Kangro, A. (2016). *The impact of digital video resources on student learning in Southeast Asia*. UNESCO Bangkok. https://unesdoc.unesco.org/ark:/48223/pf0000245812

Organisation for Economic Co-operation and Development. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Philippine Daily Inquirer. (2023, December 6). PISA 2022: Filipino students still among the lowest in math, science, and reading. Retrieved from https://inquirer.net/pisa-2022-results

Premkumar, K., Vinod, A., & Sabu, S. (2020). The role of digital devices in 21st-century math classrooms. *Journal of Educational Computing Research*, 58(5), 901–922. https://doi.org/10.1177/0735633120929257

Ramirez, G., & Beilock, S. L. (2020). Writing about testing worries boosts exam performance in the classroom. *Science*, 331(6014), 211–213. https://doi.org/10.1126/science.1199427

Republic of the Philippines. (1987). *The Constitution of the Republic of the Philippines*. Official Gazette. https://www.officialgazette.gov.ph/constitutions/the-1987-constitution-of-the-republic-of-the-philippines/

Republic of the Philippines. (2013). *Republic Act No. 10533: Enhanced Basic Education Act of 2013*. Official Gazette. https://www.officialgazette.gov.ph/osec/uploads/14347152341401347969.pdf

Reyes, M., Rivera, L., & Santos, T. (2023). Digital readiness of public school teachers in the Philippines. *Philippine Journal of Public Administration*, 67(1), 34–52. https://doi.org/10.56545/pjpa.v67i1.2023.34

Roblyer, M. D., & Doering, A. H. (2023). *Integrating educational technology into teaching* (9th ed.). Pearson.

Sarıhan, B. (2016). The effectiveness of traditional instruction methods in mathematics education. *International Journal of Educational Studies*, 8(2), 123–137. https://doi.org/10.24331/ijtes.256435

Selwyn, N., & Facer, K. (2021). *The sociology of education and digital technology: Past, present and future.* Routledge. https://doi.org/10.4324/9781003012313

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Smith, J., & Robinson, K. (2023). Technology-integrated instruction and summative assessment outcomes. *Educational Technology Research and Development*, 71(2), 445–467. https://doi.org/10.1007/s11423-023-10215-2

Sung, E., & Mayer, R. E. (2012). When graphics improve liking but not learning from online lessons. *Computers in Human Behavior*, 28(5), 1618–1625. https://doi.org/10.1016/j.chb.2012.03.025

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. Springer. https://doi.org/10.1007/978-1-4419-8126-4

Sweller, J., van Merriënboer, J. J., & Paas, F. (2022). Cognitive architecture and instructional design: 20 years later. *Educational Psychology Review*, 34(2), 261–292. https://doi.org/10.1007/s10648-021-09612-3

Tondeur, J., Scherer, R., & Siddiq, F. (2021). A comprehensive framework for teachers' professional competence in technology-enhanced learning. *Computers & Education*, 172, 104259. https://doi.org/10.1016/j.compedu.2021.104259

Trucano, M. (2016). *Knowledge maps: ICTs in education.* World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/221311468315297188/knowledge-maps-icts-in-education

WOW Math. (2020). *WOW Math: Free online mathematics tutorials* [YouTube channel]. Retrieved from https://www.youtube.com/c/WOWMath

Zhang, L., Mayer, R. E., & Wang, F. (2022). Applying multimedia principles to video-based mathematics instruction: Effects on retention and transfer. *Educational Technology Research and Development*, 70(5), 2391–2413. https://doi.org/10.1007/s11423-022-10127-8