


Research Article

YouTube Tutorials Videos and Student Achievement in Mathematics: A Case in Bosomtwe Girls' STEM School

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<https://doi.org/10.59652/823dgi68>

Abstract: The increasing integration of digital technologies in education has created new opportunities to enhance Mathematics teaching and learning. Among these technologies, YouTube tutorial videos have become a widely used instructional resource that supports the teaching and learning of abstract mathematical concepts. This study examined how this video resources influenced students' achievement when blended with the traditional classroom instruction. The study employed quasi-experimental study, grounded in multimedia learning theory. Purposive sampling was used to select grade 10 students at the Bosomtwe STEM Girls' High school. The students' performance was assessed using a 10-item circle theorem achievement test, administered as both a pre-test and a post-test. Data were analysed using one-way ANOVA to determine whether there were statistically significant differences in students' achievement scores among the groups. Where significant differences were found, Tukey's HSD post-hoc test was conducted to identify the specific groups between which the difference occurred. There were no statistically significant differences among the groups in the pretest, indicating comparable baseline knowledge. However, post-test analysis revealed a statistically significant difference in achievement among the groups, $F(2, 87) = 3.865, p = 0.025$. Post-hoc analysis using Tukey's HSD further revealed that the difference was attributable to the blended group, rather than to the YouTube-only instruction or the traditional method-only instruction ($p = 0.026$; mean difference = 1.1 points). The study concludes that integrating YouTube tutorials findings revealed that the blended method group demonstrated significantly higher achievement than those who were taught through YouTube only and the traditional method only. This study offers valuable implications for Secondary Mathematics teaching, indicating that educators should strategically adopt blended strategies rather than relying solely on either traditional or digital methods. Implications for practice and future research are discussed.

Keywords: YouTube tutorials; videos; student achievement; Mathematics; quasi-experimental

Received: January 11, 2026

Accepted: March 25, 2026

Published: March 30, 2026



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1. Introduction

As the 21st-century world becomes increasingly connected and dependent on digital innovation, the role of technology in education has fundamentally changed. This development is now a vital driver of transformative learning experiences (Kalyani, 2024). Technology in education has made most Mathematics topics that were previously abstract appear more real or concrete to learners (Mbatha, 2024). Mathematics plays a crucial role in a nation's development. The importance of Mathematics in the development of most countries has led them to include it in their curriculum as a core or compulsory subject.

This aligns with the conclusion of Borsato and Llerena (2025), who state that Mathematics plays a foundational role in contemporary society, serving as a key driver of the knowledge-based economy. It underpins much of the scientific and industrial innovation that shapes modern development. As technological systems become increasingly complex, a mathematical lens is essential for analysing, designing, and managing their operations. Teachers play a significant role in making Mathematics more engaging and accessible to learners.

Despite the importance of the teacher, there is a concerning trend of declining academic achievement in Mathematics among students over time, highlighting the need to prioritise

students' achievement in Mathematics education. Since achievement is viewed as the result of conceptual mastery, Fullan (2001) highlights that adopting an innovation can be a complex and demanding process, as it requires transformation across several aspects such as instructional materials, pedagogical strategies, and underlying belief systems. Since the advancement of technology, there have been other platforms supporting learning. As Pagau and Mytra (2023) observe, digital platforms and learning applications offer flexible, on-demand access to educational content, enabling learners to engage beyond traditional classroom constraints and even independently of direct teacher facilitation.

One notable trend in digital education is the growing reliance on video tutorials to deepen student comprehension and foster engagement. With digital resources becoming increasingly accessible, many educators now integrate these tutorials as complementary tools alongside conventional classroom methods (Turbanada et al., 2025). This helps learners who learn through visuals. Zapata et al. (2025) also found that engaging pictures and text can make learning an enjoyable adventure. This aligns with multimedia theory, which says that Students learn better from words and pictures than from words alone (Mayer, 2002). This may address the diverse needs of learners (Turbanada et al., 2025).

Despite the trend to integrate technology into teaching and learning, the integration process has not yet been effectively accomplished in classroom practice. Although classrooms have more technology, there is little evidence that these technologies are effectively integrated into the teaching and learning process (Ramorola, 2013). Cirneanu and Moldoveanu (2024) point out that transitioning traditional whiteboard-style teaching to digital formats poses challenges, especially when it comes to effectively representing mathematical notation.

In contrast, Bright et al. (2024) emphasise that the integration of technological tools in Mathematics instruction can substantially improve student learning outcomes. Additionally, teaching through creativity also boosts the interest of students in Mathematics (Pound & Lee, 2021). Students' interest in a subject also influences their performance. (Abrantes et al., 2007). These observations highlight the importance of thoughtfully choosing digital tools that can effectively support and enrich online Mathematics instruction. Equally vital is ensuring that educators possess the conceptual understanding necessary to navigate and teach within these technologically enhanced learning environments (Balanquit & Nobis, 2025). The significance of videos in education cannot be overlooked because, during the recent pandemic, platforms like YouTube, Zoom, and others were used for teaching and learning Mathematics (Videla et al., 2022). When videos learning utilised as a multimedia tool that combines spoken and visual cues with non-verbal elements, video-based instruction promotes logical thinking and increases learner engagement (Lange & Costley, 2020).

Today, most students spend more time learning online and interacting with their friends. According to a study by Selevičienė and Burkšaitienė (2015), most students reported spending 3-5 hours online daily. Their findings showed 64.4% of students spend 3-5 hours online per day, 23.2% spend 0-2 hours, 8.1% spend 6-9 hours, and 3.0% spend 10 hours or more. While this 2015 study highlights the quantity of time students spend online, more recent research has begun to examine the purpose and outcomes of that engagement. For example, Balanquit & Nobis (2025) highlighted that learners actively utilise multiple online tools, such as virtual classroom platforms and messaging applications, to support their studies. The authors found that this active use of technology is directly correlated with students developing stronger work habits, improved time management, and increased confidence.

Szabo et al. (2020) advised educators to integrate technology into Mathematics education not as a novelty, but as a strategic tool for developing 21st-century skills, such as problem-solving, creativity, collaboration, and critical thinking. They recommended using platforms like GeoGebra to enhance visualisation. (Damayanti et al., 2025) suggest that YouTube functions as an instructional tool that combines visual and auditory features, which can effectively help students overcome difficulties in learning Mathematics. Its extensive range of visual resources, tutorials, and demonstrations offers an alternative learning approach, improving understanding and clarifying abstract concepts.

Yaacob et al. (2021) found that younger learners grasp concepts more effectively when lessons are delivered through platforms like YouTube and video podcasts. Building on this insight, the present studies investigate YouTube as the primary channel for teacher-created content, providing digital native students with the flexibility and ease they are accustomed to in their everyday digital interactions.

In line with this view, Asanre et al. (2024) noted a significant improvement in the mathematical performance of senior secondary students when YouTube was used as a teaching tool. Their findings support the incorporation of YouTube into classroom teaching,

advising teachers to combine it with other multimedia resources, ensure content aligns with curriculum goals, and base lessons on real-life, practical contexts. (Turbanada et al., 2025; Asanre et al., 2024) results showed that both groups (controlled and experimental groups) initially had a limited understanding of the topic used for the study, with no significant difference in pre-test scores. After the intervention, both improved: the control group reached a “fair” level, while the experimental group achieved a “good” level.

However, statistical analysis found no significant difference in post-test scores, suggesting that YouTube video tutorials did not significantly outperform traditional instruction in improving learning outcomes. After their study, they concluded that video-based learning complements traditional methods and recommended further research to examine performance when YouTube is integrated into traditional teaching. To date, there have been limited studies on the use of both traditional and video-based teaching methods simultaneously. It is on this gap that this study seeks to assess YouTube influence on student outcomes in Mathematics.

This research sought to answer the following research questions:

- (1) What are the secondary high school students’ achievements in the pre-test?
- (2) What are the students’ achievements in the post-test?

The hypothesis is formulated around these considerations:

H₀: There will be no statistically significant difference in the mean post-test achievement scores on the circle theorem achievement test (CTAT) among students taught using the blended method (traditional + YouTube), the traditional-only method, and the YouTube-only method, after controlling for their pre-test scores.

H₁: There will be a statistically significant difference in the mean post-test achievement scores on the CTAT among the three groups, after controlling for their pre-test scores.

2. Materials and Methods

This section outlines the methodology used in the study. It presents the research design, study participants, sampling technique, research instrument, data collection procedure, and methods for data analysis.

2.1. Research Design

The study employed a quasi-experimental, pre-test-post-test research design. This approach is suitable because the classes were already existing (Cohen et al., 2017). The design involved one experimental group and two distinct control groups to evaluate the effectiveness of three different instructional approaches.

Experimental group (EG): This group received traditional classroom instruction complemented by curated YouTube tutorial videos. This blended approach aimed to enhance learning by combining digital resources (YouTube videos) with conventional teaching methods. Control group 1 (CG1): This group acted as the baseline and received instruction solely through traditional methods, such as lectures and standard textbook exercises. Control group 2 (CG2): This group studied circle theorems only through a selected playlist of YouTube tutorial videos, without traditional classroom instruction. This method assessed the potential of YouTube as a tool for self-directed learning. The effectiveness of each method was measured by analysing the difference between pre-test and post-test scores to evaluate improvements in students’ problem-solving skills.

2.2. Participants of the Study

The population for this study comprised all 180 Form Two students at the Bosomtwe STEM Girls’ High School in the 2023/2024 academic year. This group was selected as the target population because they have foundational knowledge in plane geometry.

The study employed purposive sampling. This method was used to deliberately select three intact Form Two classes rather than a random sample. This choice was purposeful because these classes were available and accessible (Creswell, 2014). Using intact classes allowed for the phenomenon to be studied in a natural, real-world setting, which was crucial for the study’s validity. The average class size is 30 students. The use of intact or complete classes is a common practice in educational settings is to minimise disruption (Asanre et al., 2024). These three classes were randomly assigned to the experimental group, control group 1, or control group 2.

2.3. Research Instrument

A 10-item CTAT was used to evaluate student performance. The instrument featured standardised questions developed based on the content of the government-approved secondary high school 2 Mathematics textbook, Chapter 13, to ensure curriculum alignment (Turbanada et al., 2025). The test assessed students' knowledge and problem-solving abilities related to circle theorems and their applications. To maintain consistency, the same test was administered for both the pre-test and the post-test. To ensure the instrument's quality, it underwent a validation process. Face and content validity were established through review by experienced Mathematics teachers, a method supported by previous research (Asanre et al., 2024). A reliability index was also computed, aiming for a score comparable to the 0.70 index reported in a related study (Cheung et al., 2024)

2.4. Data Collection

The instrument for data collection was a pen-and-paper achievement test developed by the researchers, as we did not find an existing instrument that covered all the sub-topics and concepts of the circle theorem. A pretest was administered before the intervention to evaluate students' initial understanding, followed by a period during which the experimental group used YouTube Videos and traditional methods as an intervention. In contrast, the control group 1 utilised the traditional instructional methods, and the control group 2 utilised the YouTube tutorial videos only. The same test was used as a post-test to measure improvements in student performance. There was no time limit for the test to prevent undue stress on learners and reduce the likelihood of mistakes caused by time pressure; this approach ensured that learners could perform at their best.

2.5. Data Analysis

Data analysis was conducted using IBM SPSS Statistics version 20, with statistical significance evaluated at the $\alpha = 0.05$ level. Descriptive statistics, including means, standard deviations, and confidence intervals, were computed for both pre-test and post-test scores within each instructional group to facilitate interpretation of the inferential results and provide a comprehensive overview of student performance patterns.

2.6. Ethical Considerations

Adherence to strict ethical principles was paramount throughout this study to ensure the protection and well-being of all student participants (Lincoln et al., 1984). Formal approval was first secured from the relevant educational authorities and the school's administration. Following this, informed consent was obtained from the students' parents or guardians, as well as their assent. The consent forms provided a clear and comprehensive overview of the study's purpose, the procedures for each of the three instructional groups, and the expected duration of participation.

Confidentiality and anonymity were guaranteed to all participants. Data collected from pre-tests and post-tests were coded to remove any personally identifiable information, ensuring that student privacy was maintained in the analysis and reporting of the findings. Furthermore, all participants were informed that their involvement was completely voluntary. It was made clear that they had the right to withdraw from the study at any time, for any reason, without facing any academic penalty or negative consequences.

The study was designed to integrate seamlessly into the existing curriculum, thereby avoiding disruptions to the educational schedule. All instructional materials, including the traditional lesson plans and the selected YouTube videos, were directly aligned with the Ghana Education Service learning objectives for the topic. This ensured that every student, regardless of their assigned group, received a complete and valuable educational experience. Upon completion of the data collection, a summary of the findings was shared with the school administration, and the researcher was available to debrief participants and address any questions they may have.

3. Results

3.1. Significant Difference

To examine whether significant differences exist among the instructional groups, a one-way analysis of variance (ANOVA) was done. Table 1 shows the summary of the ANOVA results. Table 1 shows the significance difference among groups.

Table 1. Significant differences among groups based on ANOVA results.

| | Sum of | df | Mean | F | Sig. |
|--|--------|----|------|---|------|
|--|--------|----|------|---|------|

| | squares | | square | | |
|----------------|---------|----|--------|-------|------|
| Between groups | 20.156 | 2 | 10.078 | 3.865 | .025 |
| Within groups | 226.833 | 87 | 2.607 | | |
| Total | 246.989 | 89 | | | |

Source: Own authors' development.

A one-way ANOVA was performed to compare the effect of three different teaching techniques on exam scores. The results, shown in table 1, indicate a statistically significant difference in the mean post-test scores among the groups. The analysis produced an F-value of 3.865 with (2, 87) degrees of freedom. The corresponding p-value (Sig.) was .025, which is less than the 0.05 alpha level. This finding suggests that the choice of instructional method had a statistically significant effect on students' academic achievement.

3.2. Performance during Pre-Test

Table 2 presents the level of students' performance during the pre-test for both the control groups and the experimental group. The results show the mean scores and the standard deviations for the different learning groups. The table also provides the significance values and the 95% confidence intervals, which help to determine whether there were meaningful differences in the performance among the groups before intervention.

Table 2. Pre-test performance comparisons among control and experimental groups.

| (I) Groups | (J) Groups | Mean Difference (I-J) | Std. Error | Sig. | 95% CI | |
|-------------------------|-------------------------|-----------------------|------------|------|--------|-------|
| | | | | | LB | UB |
| Traditional method only | YouTube tutorial only | -.0667 | .4936 | .990 | -1.244 | 1.110 |
| | Blended method only | -.4667 | .4936 | .613 | -1.644 | .710 |
| YouTube tutorial only | Traditional method only | .0667 | .4936 | .990 | -1.110 | 1.244 |
| | Blended method only | -.4000 | .4936 | .698 | -1.577 | .777 |
| Blended method only | Traditional method only | .4667 | .4936 | .613 | -.710 | 1.644 |
| | YouTube tutorial only | .4000 | .4936 | .698 | -.777 | 1.577 |

Source: Own authors' development.

A one-way ANOVA with post-hoc pairwise comparisons was conducted to examine baseline differences in Mathematics test scores across the three instructional groups (traditional, YouTube tutorial, and blended method) prior to the intervention.

The analysis revealed no statistically significant differences among the three groups at pre-test. The traditional group, compared to the YouTube tutorial group, showed a negligible mean difference of -0.0667 points ($p = 0.990$, 95% CI [-1.244, 1.110]). Similarly, the traditional group compared to the blended method group yielded a mean difference of -0.4667 points ($p = 0.613$, 95% CI [-1.644, 0.710]). The comparison between the YouTube tutorial and blended method groups demonstrated a mean difference of -0.4000 points ($p = 0.706$, 95% CI [-1.5]). All pairwise comparisons yielded p-values greater than the conventional alpha level of 0.05, with a standard error of 0.4936 across all comparisons. These findings establish baseline equivalence among the three groups, satisfying a critical assumption for subsequent post-test comparisons.

3.3. Post-Test Performance

Following the instructional intervention, a one-way ANOVA with Tukey's HSD post-hoc test was conducted to evaluate differences in Mathematics achievement across the three instructional conditions. Table 3 presents the pairwise comparisons of post-test performance among the traditional method, YouTube tutorial, and blended method groups.

The analysis revealed one statistically significant difference among the pairwise comparisons. The comparison between the YouTube tutorial and blended method groups yielded a mean difference of -1.1000 points ($p = 0.026$, 95% CI [-2.094, -0.106]), indicating that students in the blended method group significantly outperformed those receiving

YouTube tutorials alone. The traditional method, compared to YouTube tutorial groups, showed a minimal mean difference of 0.2333 points ($p = 0.842$, 95% CI [-0.761, 1.227]), suggesting comparable performance between these two approaches. The traditional method versus blended method comparison demonstrated a mean difference of -0.8667 points ($p=0.100$, 95% CI [-1.861, 0.127]).

Table 3. Performance during Tukey’s HSD post-test.

| (I) Groups | (J) Groups | Mean Difference (I-J) | Std. Error | Sig. | 95% CI | |
|----------------------------|----------------------------|-----------------------------|------------|------|--------|-------|
| | | | | | LB | UB |
| Traditional method only | YouTube tutorial only | .2333 | .4169 | .842 | -.761 | 1.227 |
| | Blended method only | -.8667 | .4169 | .100 | -1.861 | .127 |
| YouTube tutorial only | Traditional method only | -.2333 | .4169 | .842 | -1.227 | .761 |
| | Blended method only | -1.1000* | .4169 | .026 | -2.094 | -.106 |
| Blended method only | Traditional method only | .8667 | .4169 | .100 | -.127 | 1.861 |
| | YouTube tutorial only | 1.1000* | .4169 | .026 | .106 | 2.094 |

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

Source: Authors’ own development.

Therefore, the results demonstrate that while no significant differences existed among the groups at the pre-test stage, confirming baseline equivalence, statistically significant differences emerged following the instructional intervention. The ANOVA results indicate that the type of instructional method significantly influenced students’ academic achievement. In particular, the blended learning approach proved to be more effective than the use of YouTube tutorials alone, as evidenced by the significant post-test difference between these groups. Overall, these findings suggest that integrating multiple instructional strategies enhances learning outcomes more effectively than relying on a single method.

4. Discussion

The findings revealed that significant difference among the pairwise comparisons. The comparison between the YouTube tutorial and blended method groups yielded a mean difference of -1.1000 points ($p = 0.026$, 95% CI [-2.094, -0.106]), indicating that students in the blended method group significantly outperformed those receiving YouTube tutorials alone. The traditional method, compared to YouTube tutorial groups, showed a minimal mean difference of 0.2333 points ($p = 0.842$, 95% CI [-0.761, 1.227]), suggesting comparable performance between these two approaches. The traditional method versus blended method comparison demonstrated a mean difference of -0.8667 points ($p=0.100$, 95% CI [-1.861, 0.127]). This shows that integrating YouTube tutorials with traditional classroom instruction creates a cooperative learning environment that capitalises on the strengths of both pedagogical approaches.

According to multimedia learning theory, students learn more effectively from combinations of words and pictures than from words alone (Bright et al., 2024). The audiovisual nature of YouTube tutorials, when combined with teacher-facilitated instruction, enhances conceptual understanding and retention of abstract geometric concepts such as circle theorems. This aligns with findings from Asanre et al. (2024), who reported that integrating YouTube as a teaching tool significantly impacted senior secondary school students’ mathematical achievement.

The absence of a significant difference between the traditional-only and YouTube-only methods is especially notable. Although YouTube tutorials offer visual and auditory learning opportunities, their effectiveness as a standalone instructional tool seems limited without teacher guidance and scaffolding. This conclusion is supported by research indicating that self-directed digital learning, while useful as a supplement, may not sufficiently replace structured teacher-student interactions, particularly for complex abstract concepts (Turbanada et al., 2025).

The findings from the study are consistent with prior research on the pedagogical effectiveness of YouTube by Hadji Jamil et al. (2022) who found a significant relationship between the use of YouTube tutorial videos and Mathematics performance among STEM students, concluding that frequent use of YouTube tutorials correlated with proficient Mathematics achievement. Similarly, Insorio and Macandog (2022) highlighted video lessons as practical supplementary tools that reinforce mathematical concepts alongside module-based learning.

However, the findings from Turbanada et al. (2025) are contradictory from this study. Their investigation revealed no significant difference between traditional instruction and YouTube video tutorials when teaching unit conversion to Grade 7 students ($p = 0.593$). The discrepancy likely reflects differences in mathematical complexity: circle theorems represent abstract geometric concepts requiring spatial reasoning and visualisation, whereas unit conversion involves procedural skills.

The present study's inclusion of a blended approach provided nuanced insights into how instructional combinations affect learning outcomes differently across mathematical domains. These results support contemporary research emphasising the effectiveness of technology-enhanced learning. According to Cirneanu and Moldoveanu (2024), challenges exist in digitising traditional Mathematics instruction, particularly regarding the presentation of mathematical notation. However, Boadu and Boateng (2024) argue that integrating technology into Mathematics teaching can significantly improve student performance when implemented effectively.

The findings highlight the vital role of teacher mediation in learning enhanced by technology. Digital platforms such as YouTube offer unprecedented access to educational content even though their effectiveness hinges on pedagogical integration (Thaqi & Atanasoska, 2025). Teachers play crucial roles, curating suitable content, providing context, facilitating discussions, and ensuring curriculum alignment that purely self-directed digital learning cannot fulfil (Avci et al., 2020).

These findings have significant implications for Mathematics instruction in STEM-focused schools. Educators should adopt blended instructional approaches strategically, utilising YouTube videos as supplementary resources that reinforce classroom instruction, provide alternative explanations, and offer visual demonstrations of abstract concepts (Çavuş & Deniz, 2022). Teacher professional development should emphasise both technical competencies and pedagogical strategies for effective technology integration. This is because other studies have shown that most teachers struggle with multimedia integration in Mathematics classroom (Arhin et al., 2024; Thurm & Barzel, 2020)

The findings also revealed the blended method students perform high thereby its integration requiring sufficient technological infrastructure, reliable internet connectivity, projection equipment, and student device access to support blended learning initiatives. But other research has shown that lack of instructional materials hinders multimedia integration (Nyarko et al., 2021). Curriculum guidelines should explicitly incorporate recommendations for multimedia resource integration, providing teachers with implementation frameworks (Lazou & Tsinakos, 2025). Moreover, teachers should develop competencies in evaluating and curating YouTube content, as not all available videos are pedagogically sound or curriculum-aligned (Moreno et al., 2020).

This study had the following limitations. First, the quasi-experimental design, which uses intact classes instead of random student allocation, may introduce selection bias, despite established baseline equivalence. Second, the relatively small sample size (30 students per group) and single-school setting restrict generalisability to other contexts, including mixed-gender schools, rural areas, or different grade levels. Finally, the study employed solely quantitative achievement measures, without exploring qualitative dimensions such as student engagement, attitudes toward Mathematics, self-efficacy, or metacognitive development factors, which are important for a comprehensive understanding of instructional effectiveness.

5. Conclusions

This study investigated whether the blended instructional approach (traditional classroom teaching with YouTube-based tutorials) significantly enhances students' achievement in Mathematics compared to using either the traditional method alone or YouTube-based instruction alone. The findings reveal that, when traditional teaching and YouTube-supported learning yielded no significant difference in students' performance,

students achieved notably better learning outcomes when these two methods were integrated.

The results of this study highlight the importance of strategically leveraging digital technologies within the teaching and learning process. YouTube tutorials offer visual explanations, step-by-step demonstrations, and opportunities for repeated viewing, which can reinforce students' understanding of complex mathematical concepts. At the same time, traditional classroom instruction provides structured guidance, immediate feedback, and interactive engagement with the teacher. The combination of these strengths creates a more comprehensive learning environment that supports deeper conceptual understanding and improves student performance in Mathematics.

Furthermore, the findings highlight the continued relevance of teacher-guided instruction in the digital era. While digital platforms such as YouTube offer valuable educational resources, they are most effective when integrated with structured classroom teaching that enables teachers to guide discussions, clarify misconceptions, and adapt instruction to meet students' learning needs. This suggests that technology should be viewed as a complementary tool rather than a replacement for traditional teaching practices. In the context of the increasing digital transformation in education, the key challenge for educators and policymakers is not choosing between traditional and digital instructional methods, but rather designing effective strategies that successfully integrate both approaches. Thoughtful integration of technology with conventional teaching can create richer, more flexible, and more engaging learning environments that accommodate diverse learning styles and promote deeper understanding of mathematical concepts.

Future research should explore the lasting effects of blended instruction on Mathematics achievement over long periods, including the retention and transfer of learning to new problems. Studies should elucidate the mechanisms underlying the effectiveness of blended learning, whether benefits arise from increased instructional time, multiple representations, student autonomy, or other factors. Investigations should examine how student characteristics (prior achievement, learning styles, and digital literacy) moderate the effectiveness of instructional approaches, enabling personalised pedagogical strategies.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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