



Technology-Enhanced Transformative Teaching Strategies and Students' Critical Thinking Skills

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Abstract

This study examined technology-enhanced transformative teaching strategies and students' critical thinking skills. The objectives were to determine differences in critical thinking skills among students taught using flipped classroom via video-based learning, collaborative online learning, and teacher-led video-supported instruction, and to examine gender differences in critical thinking under collaborative online learning and teacher-led video-supported instruction. Two research questions guided the study, while two hypotheses were tested at a 0.05 level of significance. A quasi-experimental design involving a non-equivalent pretest-posttest control group was adopted. The sample comprised 240 undergraduate students from three universities in Rivers State, selected using intact classes. The Critical Thinking Skills Test (CTST) with a reliability coefficient of 0.81 (KR-21) was used for data collection. Data were analysed using mean and standard deviation, while ANCOVA was used for hypothesis testing. Findings showed that all instructional strategies improved students' critical thinking skills. However, flipped classroom via video learning recorded the highest mean gain, followed by collaborative online learning, and teacher-led video-supported instruction. ANCOVA results revealed a significant difference among instructional strategies. Gender analysis also showed a significant difference with male students slightly outperforming female students in mean gain scores. The study concludes that technology-enhanced transformative teaching strategies significantly enhance students' critical thinking skills, with learner-centred approaches being more effective than teacher-led instruction. It recommends increased adoption of flipped classroom and collaborative online learning strategies in higher education to strengthen critical thinking development.

Keywords: Technology, Learning, Teaching Strategies, Critical Thinking Skills, Flipped Classroom

Introduction

The integration of technology-enhanced transformative teaching strategies provides a solid foundation for developing students' critical thinking skills, conceptualized as the ability to analyze, evaluate, and synthesize information in order to make sound judgments. This perspective is rooted in Constructivist Learning Theory, which explains that learners build knowledge actively through interaction, inquiry, and meaningful engagement rather than simply receiving information (Schunk, 2020). In response to current educational demands, there is a clear shift from traditional teacher-centered instruction toward more learner-centered and transformative approaches (Darminto et al., 2025). Digital tools such as simulations, learning platforms, and Learning Management Systems (LMS) are increasingly used to create more engaging and interactive learning environments. These tools encourage students to think critically, solve problems, and construct knowledge collaboratively rather than memorizing content. However, when learning is technology-driven, adequate guidance remains important, as limited structure may overwhelm learners and reduce learning effectiveness (King, 2021).

Transformative Learning Theory further explains how these strategies support critical thinking by emphasizing reflection and changes in perspective. It suggests that meaningful learning happens when students critically examine

their prior assumptions and rethink their understanding through reflection and dialogue (Kitchenham, 2008). In this sense, critical thinking involves more than reasoning; it includes the ability to question ideas, evaluate evidence, and make informed decisions (Cömert, 2025). Alharbi et al. (2022) further describe it as a process involving identifying problems, analyzing information, and selecting appropriate solutions. Technology-supported tools such as online discussions, reflective writing activities, and multimedia resources give students opportunities to reflect deeply and engage in meaningful academic dialogue. Through these processes, learners are encouraged to challenge their viewpoints and strengthen their reasoning abilities. As a result, learning becomes more reflective, interactive, and intellectually engaging, ultimately enhancing critical thinking skills. In this study, critical thinking is understood as the ability to think beyond memorisation by analysing information, drawing conclusions, evaluating ideas, and interpreting meaning. It also involves reflecting carefully and using evidence to make sound judgments (Facione, 1990; Ennis, 2018). This view aligns with modern educational goals, which emphasize deep understanding and the ability to solve problems in complex learning situations.

Among the prominent technology-enhanced transformative strategies, the flipped classroom has shifted teaching and learning from where teachers are the main source of knowledge and control of the classroom to where students take an active role in their learning. The flipped classroom reverses traditional instruction by enabling students to engage with learning materials independently through digital media before class, while classroom time is dedicated to interactive activities such as discussions, problem-solving, and analysis (Sun et al., 2025; Chukwuemeka et al., 2021). This approach allows students to assimilate foundational knowledge at their own pace and apply it in collaborative settings, thereby enhancing critical thinking and problem-solving skills (Dominic et al., 2025).

In video-based flipped classrooms, teachers provide instructional videos for pre-class learning, while in-class sessions focus on guided practice and deeper cognitive engagement (Bello & Bala, 2025; Anyigor-Ogah, 2025). Empirical studies support the effectiveness of this approach; for instance, Widyaningrum (2020) and Ay and Daghan (2023) found that flipped learning improves interaction, feedback, and critical thinking. Similarly, Utami et al. (2025) and Aneshie-Otakpa et al. (2021) reported significant improvements in students' critical thinking skills, while Alpat (2024) demonstrated its effectiveness in enhancing critical thinking in language learning contexts. Another important strategy is online collaborative learning, which emphasizes the social construction of knowledge through digital interaction. This approach involves learners working together via networked platforms to achieve shared learning goals (Gaad, 2022; Alharbi et al., 2022). It promotes critical thinking by allowing learners to reflect, discuss, and refine their ideas collaboratively. Studies by Li and Shukor (2023) and Al-Yafaei and Mudhsh (2023) highlight that asynchronous discussions provide learners with time for deeper reflection, leading to improved reasoning and argumentation skills. Furthermore, collaborative environments encourage learners to justify their perspectives and negotiate meaning, thereby strengthening critical thinking. Despite these benefits, variations in outcomes have been observed, particularly regarding gender differences. While Zhao et al. (2024) and Sugara et al. (2026) report differences in critical thinking development between male and female students, Marni et al. (2020) found no significant variation, indicating inconsistencies in the literature.

Collectively, the reviewed studies highlight the significant potential of technology-enhanced transformative teaching strategies in promoting critical thinking. However, much of the existing research focuses on single instructional approaches in isolation, with limited comparative analysis of strategies such as flipped classroom, online collaborative learning, and teacher-led video-supported instruction within the same context. Additionally, many studies emphasize academic achievement rather than critical thinking as a distinct outcome. This creates a gap in understanding the relative effectiveness of different technology-enhanced strategies in shaping students' critical thinking skills. Therefore, this study addresses this gap by providing a direct comparative analysis of these instructional approaches to determine their relative effectiveness in promoting critical thinking among undergraduate students.

University classrooms are increasingly shaped by diverse ways of using digital tools to cause change in learners' behavior. In many cases, lecturers now integrate video lessons, online platforms, and interactive discussions into their conventional teaching. For example, students may be asked to watch instructional videos before coming to class and then use class time to discuss ideas and solve problems together. In other situations, the same video content is delivered during the lesson, with the lecturer explaining and guiding students step by step. There are also cases where students work in online groups, sharing ideas and completing tasks through digital platforms. While these approaches are becoming more common, there is still no clear understanding of how much they actually help students develop deeper thinking skills, such as critical thinking.

What makes this situation more uncertain is that most available studies tend to look at flipped classrooms and collaborative online learning on their own, without comparing them directly with teacher-led video-supported instruction in the same learning environment. Because of this, findings are often mixed, making it difficult to clearly identify which approach best supports higher-order thinking skills. It is also not fully clear whether these newer, technology-based methods truly lead to better critical thinking outcomes than more structured, teacher-guided video instruction. This lack of clear evidence creates a need for a careful investigation into how these technology-enhanced transformative teaching strategies influence students' critical thinking skills.

The aim of this study is to investigate technology-enhanced transformative teaching strategies and students' critical thinking skills. Specifically, the study sought to;

1. Determine the difference in critical thinking skills among students taught using flipped classroom via video-based learning, collaborative online learning, and teacher-led video-supported instruction.
2. evaluate the critical thinking skills of male and female students taught using collaborative online learning and those taught using teacher-led video-supported instruction.

Research Questions

The following research questions guide the study

1. What is the difference in critical thinking skills among students taught using flipped classroom via video-based learning, those taught using collaborative online learning and those taught using teacher-led video-supported instruction?
2. What is the difference in critical thinking skills between male and female students taught using collaborative online learning and those taught using teacher-led video-supported instruction?

Hypotheses

The following null hypotheses were tested at the 0.05 significance level to guide the study.

1. There is no significant difference between the critical thinking skills of students taught using flipped classroom via video-based learning, collaborative online learning, and teacher-led video-supported instruction.
2. There is no significant difference in the critical thinking skills of male and female students taught using collaborative online learning and those taught using teacher-led video-supported instruction.

Methodology

This study adopted quasi-experimental design, specifically a non-equivalent pre-test and post-test control group structure, to evaluate the effectiveness of a technology-enhanced flipped classroom approach. The design is considered appropriate because it allows for a systematic investigation of how different technology-enhanced instructional strategies influence students' critical thinking skills (Creswell & Creswell, 2018). Specifically, the study compared the effects of the flipped classroom through video-based learning, collaborative online learning, and teacher-led video-supported instruction on students' critical thinking skills. The population comprised all universities in Rivers State. The study involved undergraduate students drawn from the Department of Curriculum Studies and Educational/Instructional Technology from three universities. These departments were purposively selected because they offer courses that integrate digital learning tools and instructional design approaches relevant to the study. A total sample of 240 undergraduate students participated in the study. Intact classes across different levels of study were used to ensure natural classroom settings were maintained. The selected departments from each of the universities (Rivers State Universities, University of Port Harcourt and Ignatius Ajuru University of Education) were randomly assigned to three instructional groups: flipped classroom via video-based learning, collaborative online learning, and teacher-led video-supported instruction. Each group reflected students' normal learning environment without disrupting academic schedules. Data were collected using a Critical Thinking Skills Test (CTST), consisting of multiple-choice items designed to assess students' ability to analyze, evaluate, and interpret information. The instrument was subjected to content and face validity to ensure the clarity, relevance, and measure students' critical thinking skills. Reliability was established through pilot testing with a group of undergraduate students who had the same characteristics as the students for the study. Kuder-Richardson 21 was used to obtain a reliability coefficient of 0.81.

Table 1: Sample Distribution of Students by University and Gender

University	Transformative teaching Strategies	Male	Female	Total
Ignatius Ajuru University of Education	Flipped classroom via video-based learning	25	30	55
University of Port Harcourt	Collaborative online learning	45	55	100
Rivers State University	Teacher-led video-supported instruction	40	45	85

Data collection was carried out by administering a pretest to all groups to establish baseline critical thinking levels. The instructional treatments were then implemented over a specified period. Students in the flipped classroom group were engaged with video lessons before class and participated in interactive, problem-solving activities during class. Those in the collaborative online learning group were engaged in structured online discussions and group-based tasks, while the teacher-led video-supported group received instruction through videos presented and explained by the lecturer during class sessions. At the end of the treatment period, a post-test was administered to measure changes in students' critical thinking skills. The data collected were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was employed to test the hypotheses at a 0.05 level of significance with the aid of the Statistical Package for the Social Sciences (SPSS).

Results

Research Question 1: What is the difference in critical thinking skills among students taught using flipped classroom via video-based learning, those taught using collaborative online learning and those taught using teacher-led video-supported instruction?

Table 2: Mean and Standard Deviation of Critical Thinking Skills of students based on Technology-Enhanced Transformative Strategies.

Technology Enhanced Strategy				Pretest	Posttest	Mean Gain
Flipped Classroom via Video Learning			Mean	7.0545	12.5636	5.5091
			n	55	55	55
			SD	1.91889	3.95233	4.26386
Online Collaborative Learning			Mean	7.1700	11.2100	4.0400
			n	100	100	100
			SD	2.13227	3.46788	3.96938
Teacher-led video-supported instruction.			Mean	7.1059	9.5412	2.4353
			n	85	85	85
			SD	1.92739	3.50358	4.09252

Table 1 indicates that students exposed to flipped classroom via video learning ($n = 55$) improved from a pretest mean of 7.05 ($SD = 1.92$) to a posttest mean of 12.56 ($SD = 3.95$), with a mean gain of 5.51. Students in online collaborative learning ($n = 100$) improved from a pretest mean of 7.17 ($SD = 2.13$) to a posttest mean of 11.21 ($SD = 3.47$), with a mean gain of 4.04, while those taught using teacher-led video-supported instruction ($n = 85$) improved from 7.11 ($SD = 1.93$) to 9.54 ($SD = 3.50$), with a mean gain of 2.44. This shows that all strategies enhanced critical thinking skills, with flipped classroom via video learning producing the highest improvement.

Research Question 2: What is the difference in critical thinking skills between male and female students taught using collaborative online learning and those taught using teacher-led video-supported instruction?

Table 3: Mean and Standard Deviation of Critical Thinking Skills of students based on Gender

Gender		Pretest	Posttest	Mean Gain
Male	Mean	7.2294	11.7798	4.5505
	N	109	109	109
	SD	2.15438	4.01700	4.46900
Female	Mean	7.0305	10.2214	3.1908
	N	131	131	131
	SD	1.87674	3.39296	3.92843

Table 2 indicates that male students ($n = 109$) improved from a pretest mean of 7.23 ($SD = 2.15$) to a posttest mean of 11.78 ($SD = 4.02$), with a mean gain of 4.55, while female students ($n = 131$) improved from 7.03 ($SD = 1.88$) to 10.22 ($SD = 3.39$), with a mean gain of 3.19. This showed that both genders benefited from the instructional strategies, with male students showing slightly higher gains in critical thinking skills.

Testing of Hypotheses

Hypothesis 1: There is no significant difference between the critical thinking skills of students taught using flipped classroom via video-based learning, collaborative online learning, and teacher-led video-supported instruction.

Table 4: ANCOVA Analysis of the difference in the Critical Thinking Skills of students based on Strategies Tests of Between-Subjects Effects

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Squared	Eta
Corrected Model	320.145 ^a	3	106.715	8.220	.000	.095	
Intercept	2051.294	1	2051.294	158.016	.000	.401	
Pretest	1.572	1	1.572	.121	.728	.001	
Technology Enhanced Strategy	318.793	2	159.396	12.279	.000	.094	
Error	3063.651	236	12.982				
Total	32051.000	240					
Corrected Total	3383.796	239					

a. R Squared = .095 (Adjusted R Squared = .083)

Table 4 reveals a value of $F(2, 236) = 12.279$, $p < .001$ for the effect of technology-enhanced strategies on students' posttest critical thinking skills after controlling for pretest scores. This result indicates a statistically significant difference in the critical thinking performance of students exposed to the different instructional strategies. The Partial Eta Squared value of .095 shows a moderate effect size, indicating that the instructional strategy accounted for a meaningful proportion of the variance in students' critical thinking skills.

Hypothesis 2: There is no significant difference in the critical thinking skills of male and female students taught using collaborative online learning and those taught using teacher-led video-supported instruction.

Table 5: ANCOVA Analysis of the difference in the Critical Thinking Skills of students based on Gender Tests of Between-Subjects Effects

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Squared	Eta
Corrected Model	144.824 ^a	2	72.412	5.298	.006	.043	
Intercept	2065.408	1	2065.408	151.129	.000	.389	
Pretest	.324	1	.324	.024	.878	.000	
Gender	143.472	1	143.472	10.498	.001	.042	
Error	3238.972	237	13.667				
Total	32051.000	240					
Corrected Total	3383.796	239					

a. R Squared = .043 (Adjusted R Squared = .035)

Table 4 reveals a value of $F(1, 237) = 10.498$, $p = .001$ ($p < .05$) for the effect of gender on students' posttest critical thinking skills after controlling for pretest scores. This result indicates a statistically significant difference in the critical thinking performance of male and female students. The Partial Eta Squared value of .042 shows a small to moderate effect size, indicating that gender accounted for a modest proportion of the variance in students' critical thinking skills.

Discussion

The findings of this study reveal that all technology-enhanced instructional strategies improved students' critical thinking skills, although to varying degrees. Specifically, students exposed to the flipped classroom via video learning recorded the highest mean gain, followed by those in online collaborative learning, while teacher-led video-supported instruction produced the least improvement. This pattern suggests that more student-centered and interactive approaches are more effective in enhancing critical thinking. Furthermore, the ANCOVA result confirmed that these differences were statistically significant, indicating that the type of instructional strategy had a meaningful effect on students' critical thinking performance even after controlling for pretest scores.

These findings are consistent with existing literature that emphasizes the effectiveness of learner-centered digital pedagogies. For instance, Widyaningrum (2020) and Ay and Dağhan (2023) reported that flipped learning enhances interaction, feedback, and critical thinking by allowing students to engage more actively with learning content. Similarly, Utami et al. (2025) and Aneshie-Otakpa et al. (2021) found that flipped classroom models significantly improve students' critical thinking outcomes across different learning areas, reinforcing the present result that flipped learning yields strong cognitive benefits. In the same vein, Li and Shukor (2023) and Al-Yafaei and Mudhsh (2023) observed that collaborative online learning promotes deeper reflection and reasoning through asynchronous discussions, which aligns with the moderate gains observed in this study for online collaborative learning. However, the present findings also extend the literature by providing a direct comparison of multiple instructional strategies within a single study context. While previous studies often examined flipped learning or collaborative learning in isolation, this study demonstrates their relative effectiveness alongside teacher-led video-supported instruction. The lower performance of the teacher-led approach supports the argument that overly instructor-centered models may limit opportunities for active reasoning and learner autonomy. This contrasts with earlier assumptions that structured teacher guidance alone is sufficient for developing higher-order thinking skills, suggesting instead that learner engagement plays a more critical role.

These findings contribute to addressing the identified research problem by clarifying how different technology-enhanced transformative teaching strategies influence critical thinking development. The results emphasize that instructional approaches that promote interaction, reflection, and learner autonomy are more effective in fostering critical thinking than traditional teacher-led methods. This contributes to educational practice by providing evidence-based guidance for selecting instructional strategies that better support cognitive development in contemporary learning environments. The findings on gender differences show that both male and female students experienced improvement in critical thinking skills following exposure to the instructional strategies. However, male students recorded a higher mean gain compared to female students. This suggests that while the interventions were beneficial for both groups, the extent of improvement varied slightly by gender. The ANCOVA result further confirmed a statistically significant difference between male and female students' posttest scores after controlling for pretest performance, although the effect size was relatively small, indicating that gender contributed only a modest influence on critical thinking outcomes.

These findings are partially consistent with Zhao et al. (2024) and Sugara et al. (2026) who reported observable gender differences in critical thinking development, which aligns with the present finding that male students demonstrated slightly higher gains. However, these results contrast with the study by Marni et al. (2020), which found no significant gender-based differences in critical thinking performance, suggesting that gender may not always be a determining factor in cognitive development. The variation across studies may be attributed to differences in instructional context, sample characteristics, and exposure to technology-enhanced learning environments. The present findings contribute to the ongoing debate by providing evidence that gender differences in critical thinking exist but are not strongly pronounced. This implies that while gender may influence learning outcomes to some extent, instructional strategies remain a more dominant factor in shaping students' critical thinking skills. Consequently, the results reinforce the

importance of focusing on pedagogical design rather than gender-based assumptions when implementing technology-enhanced transformative teaching strategies.

Conclusion

The study concluded that technology-enhanced transformative teaching strategies have a significant positive effect on students' critical thinking skills. All the instructional approaches examined, flipped classroom via video learning, online collaborative learning, and teacher-led video-supported instruction contributed to improvements in students' critical thinking, although at different levels. The flipped classroom approach emerged as the most effective strategy, followed by online collaborative learning, while teacher-led video-supported instruction showed the least improvement. This indicates that learner-centered and interactive instructional models are more effective in promoting higher-order thinking skills than more traditional teacher-led approaches. The study also revealed that gender has a statistically significant influence on students' critical thinking skills, although the effect is relatively small. Male students demonstrated slightly higher gains than female students, suggesting minor variations in how students benefit from instructional strategies.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Educators should adopt learner-centered technology-enhanced instructional strategies, particularly the flipped classroom model, as it demonstrated the highest improvement in students' critical thinking skills.
2. Schools and institutions should support the integration of video-based learning resources and structured pre-class activities to enhance students' engagement and promote deeper cognitive processing.
3. Online collaborative learning should be strengthened through well-structured group tasks, guided discussions, and active monitoring to ensure meaningful participation and improve learners' reasoning abilities.
4. Teacher-led video-supported instruction should be redesigned to include more interactive and student-centered activities rather than relying predominantly on direct instruction.

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