The Impact of HyFlex Flipped Classroom in University-level Video Production Training

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***Abstract*—As flexible, technology-supported instructional modes become increasingly prevalent in higher education, empirical validation of their effectiveness in practice-oriented courses is critical. This study examines the impact of the HyFlex Flipped Classroom (HFFC), which combines flipped and blended learning by offering face-to-face, synchronous online, and asynchronous participation options, on students' cognitive outcomes. A 2×2 quasi-experimental design was implemented with 150 undergraduate media students enrolled in a video production course, assigned to either the HFFC group (n = 80) or the Conventional Flipped Classroom (CFC) group (n = 70). Data analysis employed descriptive statistics and Analysis of Covariance (ANCOVA), with gender as a moderating variable. Results show that HFFC significantly enhanced students' cognitive outcomes compared to CFC. Although gender was not a significant predictor, HFFC contributed to reducing gender-related disparities. These findings suggest that HFFC supports higher-order learning and promotes a more equitable learning environment, providing empirical support for its adoption in practice-based higher education.**

***Keywords*—cognitive level, HyFlex, flipped classroom, video production, higher education**

I. Introduction

In 2020, COVID-19 spread over the world, posing significant obstacles to schooling in every nation. The pandemic has changed the higher education landscape, according to the EDUCAUSE Horizon Reports from 2022, which also highlight the importance of hybrid course types in the post-pandemic period. As one of their tactics, higher education institutions offer training in instructional design and online learning pedagogy [1]. Effective instructional design can encourage and benefit students to choose online learning [2]. During this period, the pupils' cognitive performance decreased, and the workload rose [3, 4]. Therefore, there is an urgent need to develop a new teaching mode to address these issues [5], and the HyFlex mode has shown a clear growth trend since 2019 due to the emergence and influence of the pandemic [6]. However, the remaining key issue is that the adoption of such flexible modes merely covers hidden flaws and still substantially enhances the quality of learning. Explicitly measuring cognitive level is crucial to determine whether these new modes genuinely foster the deeper understanding and application of knowledge that higher education aims to deliver.

Due to the quick development of digital technology worldwide, flipped classrooms have become a cutting-edge teaching strategy in higher education institutions [7]. As an alternative to in-person instruction, the majority of college students favor flipped learning [8]. Flipped classrooms are thought to offer better student learning results than other learning approaches [9]. As technology advances, blended online learning might become more viable after the pandemic [10]. More interaction between participants is possible with HyFlex flipped classrooms. Before class, the teacher sends out the agenda so everyone is familiar with the class topics. In class, students actively share information and engage in discussions with classmates by forming small groups, fostering a sense of community and personal connections. After class, students can review and reinforce their learning or engage in group practical exercises as needed. In addition, it can serve as a transition between online and offline instructional modes and respond to emergencies, such as course restrictions, at any time.

The HyFlex Flipped Classroom (HFFC) integrates the structured approach of the flipped classroom with the flexible participation options of the HyFlex model. In this model, students engage with core content before class, while the HyFlex component enables participation in activities in person, synchronously online, or asynchronously. This approach broadens the reach of active learning across multiple instructional formats in the post-pandemic context. Anderson and Krathwohl's cognitive taxonomy, which builds upon Bloom's taxonomy, conceptualizes cognitive processes as progressing from basic to advanced skills, including remembering, understanding, applying, analyzing, evaluating, and creating. This revised framework is particularly suitable for video production courses, which require students to recall information, comprehend concepts, solve problems, make creative decisions, and apply knowledge in practical contexts.

The variety of mental skills that pupils use to process information, learn, and solve issues is included in their cognitive level [11]. These abilities are essential for both general intellectual growth and academic performance. The present study evaluates students' cognitive level using Anderson and Krathwohl's cognitive taxonomy, progressing from lower-order to higher-order skills. Cognitive performance is operationalized through the structured scoring of students' learning tasks and assessments associated with video production. Exams, quizzes, and assignments are commonly used in Flipped Classrooms (FC) to evaluate students' cognitive level. This method demonstrates how the flipped classroom can improve students' understanding of the material by fostering active engagement and lively debate. Numerous studies show that both flipped classrooms and HyFlex environments can greatly improve students' cognitive level. Although there is limited research on flipped classrooms and the HyFlex model, investigating a new instructional method requires a careful assessment of students' cognitive abilities.

Gender inequality is a major factor in online settings [12]. A lot of research claims that males are more engaged in the flipped classroom style, while females' academic performance, motivation, self-efficacy, and personal confidence are exceptional when compared to boys in the same group [13–15]. While numerous studies have examined the HyFlex mode and flipped classroom across various genders in terms of grades, performance, course choices, etc., the question of how gender influences students' effectiveness in HFFC contexts remains unresolved. By precisely evaluating how gender differences affect cognitive level within the HFFC mode, an area that previous research has mostly ignored, our study immediately fills this gap.

Video production has become a key tool for entertainment, education, and communication across many industries worldwide [16]. Because of this, film and media production courses increasingly need to include real-world tasks such as group projects, portfolio building, and problem-solving to help students prepare for their future careers [17]. These activities often require students to practice repeatedly, work together, and combine theory with hands-on production skills. This approach brings both teaching opportunities and practical challenges in traditional classrooms. A video creation course blends theory and practice, teaching both the technical skills valued in STEM fields and the core theoretical knowledge found in the arts. These combined demands make video production a good fit for the HyFlex Flipped Classroom (HFFC) model. With HFFC, students can learn theoretical concepts, technical steps, and analytical methods before class, so class time can focus on working together, discussing, and solving problems. Since the course is highly interdisciplinary, it provides valuable lessons for both science and liberal arts students and serves as a strong example. The HFFC model also helps solve common group project issues, such as limited access to equipment, scheduling problems, and different learning speeds. It lets students keep working on projects and collaborating with classmates outside of class, whether they join in person, online at the same time, or on their own schedule.

In context, this study aids in defining not only the functions of the HyFlex flipped classroom during the pandemic but also the opening up of new learning opportunities in video production for both men and women, especially in terms of making the most of online instructional technology to give students more options for raising their cognitive level. This study intends to close a major gap in the literature and go beyond a discussion of flexibility to an empirical investigation of the potential of the HFFC mode to support significant cognitive advancement and for which student subgroups.

A. Research Questions

The flipped classroom model and HyFlex model promotes active learning and cognitive development in higher education. Since the pandemic, demand for instructional flexibility has grown. This study examines whether the HyFlex Flipped Classroom (HFFC) provide flexibility leads to greater cognitive acquisition than Conventional Flipped Classroom (CFC).

(1) Is there any significant difference on university students' cognitive acquisition between the HFFC and the CFC?
(2) Is there any significant difference on university students' cognitive level between male and female students in the HFFC mode?
(3) Is there any significant difference on university students' cognitive level in male students across the two instruction modes (HFFC vs. CFC)?
(4) Is there any significant difference on university students' cognitive level in female students across the two instruction modes (HFFC vs. CFC)?
(5) Is there any interaction effect between instruction modes (HFFC vs. CFC) and gender (male vs. female) on university students' cognitive level?

B. Research Hypotheses

(1) There is no statistically significant difference on university students' cognitive level between the HFFC and the CFC.
(2) There is no statistically significant difference on university students' cognitive level between male and female students in the HFFC mode.
(3) There is no statistically significant difference on university students' cognitive level in male students across the two instruction modes (HFFC vs. CFC).
(4) There is no statistically significant difference on university students' cognitive level in female students across the two instruction modes (HFFC vs. CFC).
(5) There is no interaction effect between instruction modes (HFFC vs. CFC) and gender (male vs. female) on university students' cognitive level.

II. Literature Review

A. Flipped Classroom

The flipped classroom, as defined by Bishop and Verleger [18], consists of pre-class computer-based individual instruction and in-class interactive group activities. This approach differs significantly from traditional teaching methods [8] and is central to blended learning. Students engage with instructional materials, such as online videos, before and after face-to-face sessions [19, 20]. In-person classes focus on collaborative group work led by instructors, setting the flipped classroom apart from conventional lectures [21, 22]. This model is especially relevant for video production courses because it enables students to learn foundational theory and technical skills before class. In-class time is then used for collaborative production, peer feedback, and problem-solving. Compared with face-to-face, e-learning, and blended learning methods, the flipped classroom is associated with higher student outcomes [9]. Studies show that the Flipped Classroom (FC) improves student performance and receives more positive feedback than passive lecture-based instruction [23, 24]. In Chinese art design education, the flipped classroom has proven more effective than standard classroom approaches [25]. Research also indicates that flipped classroom models enhance cognitive and attitudinal outcomes, with positive effects on student confidence, participation, and motivation [26–29]. However, most studies have focused on knowledge-based subjects, leaving the effectiveness of the flipped classroom in practice-based disciplines underexplored. In practice-oriented courses like video production, where learning depends on applying theory to real-world tasks, the effectiveness of the conventional flipped classroom remains insufficiently examined. This gap underscores the need for further research. Most existing literature examines the Flipped Classroom (FC) in its conventional form, which emphasizes pre-class individual learning and in-class interactive activities. For clarity, this model is referred to as the Conventional Flipped Classroom (CFC) to ensure consistency in subsequent comparisons.

B. HyFlex Model

HyFlex is well-suited for higher education. It provides greater access, convenience, and flexibility [30]. The design of HyFlex derives from two key concepts: "Hybrid" and "Flexible". "Hybrid" involves a blend of online and in-person teaching and learning, and "Flexible" enables students to learn in a self-directed environment [31]. In the HyFlex model, teachers provide structure, content, and learning activities for each course or topic. Students have the flexibility to choose the attendance mode: face-to-face classes, online classes, or accessing recorded content, based on their preferences [32, 33]. In addition, if a student misses an in-person or online session, they can catch up by watching the recorded class video [34]. HyFlex permits both blended and flexible learning [35] by combining the ideas of blended learning with flexible delivery [36]. While the logistical advantages of blended learning have been well documented, those of the HyFlex model are well established. Prior research indicates that excessive flexibility can undermine students' sense of learning community and decrease sustained peer interaction when learners pursue divergent participation pathways. Integrating flipped classroom principles, specifically structured pre-class individual preparation and in-class collaborative activities, has been proposed as a pedagogical strategy to support shared learning goals and collective engagement in flexible learning environments. Therefore, combining HyFlex with the flipped classroom in the HFFC model is conceptually designed to balance flexibility with pedagogical structure, addressing concerns regarding reduced community cohesion in standard HyFlex implementations.

C. HyFlex Flipped Classroom

Currently, there is no established concept of a HyFlex flipped classroom in education. Ongoing studies are examining the efficacy and flexibility of the HyFlex model [33, 35–38], as well as student satisfaction [33, 37] and teachers' perceptions of this adaptable environment [39, 40]. The HyFlex flipped classroom merges two instructional approaches into a three-phase structure. During the pre-class phase, students work independently on instructor-provided materials. In the in-class phase, they can participate flexibly, either face-to-face or online, with access to recordings. Finally, the post-class phase includes homework assignments and review sessions. This model could address the limitations of the individual approaches. However, its integration remains largely theoretical, with limited empirical research on its impact—especially regarding cognitive outcomes in skill-based courses and differences across demographic groups, such as gender.

D. Theoretical Framework

The instructional design theory adopted Lo and Hew's FC Model [41]and Beatty's HyFlex Model [31] as tools to design instructional materials in a flipped classroom environment. Lorin Anderson & David Krathwohl's taxonomy of the cognitive domain was supported as a learning theory, as shown in Fig. 1. In addition, previous studies suggest that gender can influence students' cognitive engagement and learning outcomes in technology-based and hands-on learning settings. Research on flipped classrooms and digital learning has found gender differences in learning strategies, participation, and responses to group and independent activities. Since the HFFC model involves flexible participation and challenging tasks, considering gender as a variable helps us better understand how different students experience and benefit from this approach.

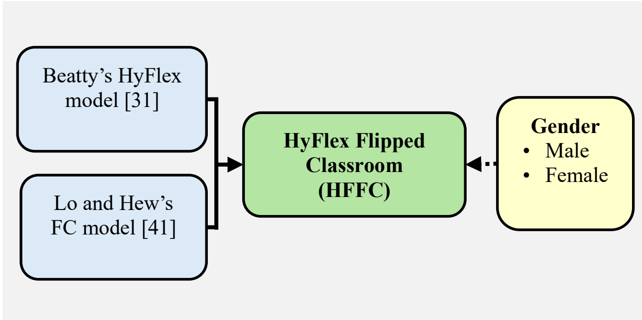

Fig. 1. Theoretical framework.

E. Previous Studies

This section critically synthesizes the recent five years of research at the nexus of flexible and HyFlex models, contextualizing the present study within the most recent scholarly discourse.

Recent research has examined teaching models and techniques in the post-pandemic era, with a predominant focus on student satisfaction regarding flexibility [24, 40, 42, 43]. However, a detailed analysis exposes notable contradictions. Some researchers found that asynchronous learners in a HyFlex course reported a lower sense of community, suggesting that adaptability does not necessarily correlate with effective instructional strategies [44]. The complexity rises when these models are integrated. While the hybrid flipped classroom prototype achieved high satisfaction level, it produced inconclusive results regarding higher-order cognitive outcomes [45]. This underscores a persistent issue in the literature: the tendency to conflate student satisfaction with demonstrable deep learning. Additional studies have explored the combination of the HyFlex model and the flipped classroom, yet have emphasized attitudinal outcomes over rigorous evaluation of cognitive development, particularly in practice-based disciplines [45–48].

This study implements a targeted intervention and applies rigorous quantitative research, rather than common satisfaction measures, to assess students' cognitive level in video production within a hierarchical framework. It also examines gender equity and the understudied mediating role of demographics.

III. Materials and Methods

A. Research Design

This study used a quasi-experimental 2×2 design to investigate the impact of the HyFlex Flipped Classroom

(HFFC) on undergraduate students' cognitive level, with gender as a moderating variable in higher education. The research was conducted over a six-week period within a video production course. This design was adopted to test cognitive level in an authentic, intact classroom context, prioritizing ecological validity over strict experimental control. Consequently, the findings are interpreted as evidence of association within the specific instructional context.

B. Research Participants

A purposive sample of 150 second-year undergraduates from a media program participated in this study. Of these 150 students, 47 were male and 103 were female, a ratio that reflects the typical gender distribution in media studies in Shandong Province and thus enhances the reproducibility of the results. The application of this cohort was deliberate, as the practice-based nature of video production education, which demands the integration of theory and hands-on application, provides a critical test case for evaluating the efficacy of the HFFC mode. Participants reported a spectrum of prior video production experience, from novice to intermediate, as measured by a pre-intervention demographic survey. For the experimental phase, the students were randomly assigned to two groups: HFFC (80 students) and CFC (70 students).

C. Research Procedure

The experiment included four phases: introduction, pre-test, intervention, and post-test. The study team assigned participants to the HyFlex Flipped Classroom (HFFC) or the Conventional Flipped Classroom (CFC). Both groups took a pre-test to assess baseline knowledge. The study used a flipped classroom model during the six-week intervention, structuring activities before, during, and after class. For pre-class preparation, participants accessed 15-minute instructional videos and readings distributed via DingTalk by the instructors. The materials clarified key concepts and outlined practical procedures. During class, HFFC participants attended in person or online, synchronously or asynchronously, while CFC participants attended only in person. All groups followed identical lesson plans, objectives, and tasks to ensure equivalence, though the modes of participation and interaction varied. Instructors facilitated interaction through live discussions, demonstrations, and platform-based feedback. Monitors tracked participation across all formats. After each lesson, quizzes and group tasks reinforced learning and provided formative feedback. At the end, instructors administered post-tests to assess learning outcomes.

D. Research Instruments

levelThis research developed an instrument based on Lorin Anderson and David Krathwohl's taxonomy of cognitive domains to measure the cognitive level in the flipped classroom environment. The instrument used for both the pretest and posttest in this study is the quiz. The questionnaire was designed using the actual learning sequence and process of current video production courses for Chinese college students. Its content aligns with the Chinese teachers' teaching syllabus. Experts in related majors have reviewed and evaluated the questionnaire. The instrument has 42 questions and three demographic questions, divided into seven sections: (A) Video production process, (B) Scriptwriting, (C) Storyboard, (D) Composition and Shooting, (E) Lighting arrangements, (F) Audio recording, and (G) Editing. Each section includes 6 level: remember (level 1), understand (level 2), apply (level 3), analyze (level 4), evaluate (level 5), and create (level 6). All 42 questions are dichotomous.

E. Data Collection and Analysis

This research uses IBM Statistical Packages for Social Sciences (SPSS) Statistics to analyze data to validate assumptions and draw accurate conclusions. The data analysis employs both descriptive and inferential statistical methods. In this research, ANCOVA will be utilized to investigate the research questions of the effect of the HyFlex flipped classroom mode on the students' cognitive level.

F. Validity and Reliability

Three university lecturers in media, each with over 20 years of teaching experience, tested the cognitive level instruments. Because participants were Chinese students, two translators with level 2 CATTI certification conducted back-translations to ensure the validity and reliability of the English-Chinese translations. Reliability tests for both pretest and posttest instruments were conducted on a sample of 10 second-year undergraduates. The Kuder-Richardson 20 (KR-20) was used to assess internal consistency reliability. The pre-test instruments in the HyFlex flipped classroom showed internal consistency of 0.89; post-test instruments showed solid consistency of 0.85.

IV. Result and Discussion

ANCOVA was the most suitable method for testing the hypothesis regarding students' cognitive level in the HyFlex Flipped Classroom (HFFC) and Conventional Flipped Classroom (CFC) video production training. Before this analysis, the mean and standard deviation for both groups were calculated. Table 1 presents descriptive statistics for cognitive level by instructional mode.

Table 1. Descriptive statistics for cognitive level by instructional mode

Group	N	Mean	Std. D	Std. Error
HFFC	80	68.33	10.890	1.218
CFC	70	67.04	8.970	1.072
Total	150	67.73	10.028	0.819

Table 2 illustrates the distribution of students' cognitive level under the HFFC and CFC instructional modes by gender. In the HFFC mode, females' average cognitive level ($M = 69.62$) was 3.96 points higher than males' ($M = 65.66$), while in the CFC mode, females' ($M = 67.78$) cognitive level was 2.47 points higher than males' ($M = 65.31$). The overall trend shows that, regardless of instructional mode, females outperformed males in cognitive level. However, the magnitude of the gender difference was larger in the HFFC mode than in the CFC mode, providing preliminary evidence for subsequent testing of the main gender effect and the interaction effect.

The Levene test for variance homogeneity of post-test cognitive level data was not statistically significant ($F = 2.284$, $p = 0.081$). Skewness was 0.131, and kurtosis was −0.629, both within commonly accepted ranges.

Table 2. Descriptive Statistics for cognitive level by gender

Group	Gender	N	Mean	Std. D
HFFC	Male	26	65.66	11.049
	Female	54	69.62	10.677
	Total	80	68.33	10.890
CFC	Male	21	65.31	8.267
	Female	49	67.78	9.235
	Total	70	67.04	8.970
Total	Male	47	65.50	9.803
	Female	103	68.75	10.011
	Total	150	67.73	10.028

Table 3 indicates that the instructional mode main effect was significant (F = 18.262, p < 0.001), with a partial η^2 of 0.111. This effect size is moderately large, indicating that the instructional modes account for a considerable proportion of the variance in students' cognitive level. This result suggests that, aside from differences in students' initial cognitive level, the HFFC mode has a significant advantage over the CFC mode in improving cognitive level. It is worth noting that the significant F-value not only reflects differences in group means but also indicates that the instructional modes, as a core independent variable, have a stable and substantial impact on cognitive learning outcomes. The main effect of the instructional modes reached statistical significance (p < 0.05), and the null hypothesis $H_0$1was rejected. This indicates significant differences in cognitive level among university students across different instructional modes.

Table 3. ANCOVA results for cognitive level by instructional mode

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14328.821[a]	2	7164.410	1608.902	<0.001	0.956
Intercept	60.879	1	60.879	13.672	<0.001	0.085
Pre-test	14266.452	1	14266.452	3203.798	<0.001	0.956
Group	81.318	1	81.318	18.262	<0.001	0.111
Error	654.588	147	4.453			
Total	703089.569	150				
Corrected Total	14983.409	149				

a. R Squared = 0.956 (Adjusted R Squared = 0.956)

Table 4 presents an analysis of cognitive level differences between male and female students across the HFFC instructional modes. The results indicate that the main effect of gender was not statistically significant (F = 2.071, p = 0.154), with a partial η^2 of 0.026, a small effect size. While descriptive statistics suggest that female students exhibit slightly higher cognitive level than male students, this difference does not reach statistical significance after controlling for pre-test scores. These findings demonstrate the effectiveness and inclusivity of the HFFC instructional design, as it supports cognitive development equally across genders and minimizes potential gender disparities. Additionally, the small effect size indicates that any observed gender differences have limited explanatory power. As the main effect of gender did not achieve statistical significance (p > 0.05), the null hypothesis H_{0}.2 was not rejected, confirming the absence of significant differences.

Table 4. ANCOVA results for cognitive level by gender in HFFC

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9014.689[a]	2	4507.344	977.854	<0.001	0.962
Intercept	47.590	1	47.590	10.324	0.002	0.118
Pre-test	8739.272	1	8739.272	1895.957	<0.001	0.961
Group	9.546	1	9.546	2.071	0.154	0.026
Error	354.926	77	4.609			
Total	382,925.170	80				
Corrected Total	9369.615	79				

a. R Squared = 0.962 (Adjusted R Squared = 0.961)

Table 5 compares the cognitive performance of male students under the HFFC and CFC modes. The results showed that the main effect of instructional mode was not significant (F = 1.324, p = 0.256), with a corresponding partial η^2 of 0.029, which falls within the small effect range. This suggests that the influence of different instructional modes on cognitive processes did not differ significantly across the male group. This result implies that the positive impact of instructional modes on cognitive level is extremely limited in the male population, and that variations in learning engagement techniques or strategies may mitigate these effects. Since the main effect of instructional mode was not significant in the male sample (p > 0.05), the null hypothesis H_{0}.3 was not rejected, indicating that the instructional modes did not differ significantly in cognitive level among males.

Table 5. ANCOVA results for male students' cognitive level by instructional mode

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4283.902[a]	2	2141.951	690.854	<0.001	0.969
Intercept	69.462	1	69.462	22.404	<0.001	0.337
Pre-test	4282.453	1	4282.453	1381.241	<0.001	0.969
Group	4.105	1	4.105	1.324	0.256	0.029
Error	136.419	44	3.100			
Total	206,071.429	47				
Corrected Total	4420.321	46				

a. R Squared = 0.969 (Adjusted R Squared = 0.968)

In contrast to the male sample, Table 6 shows that, in the female population, instructional mode had a significant main effect (F = 18.687, p < 0.001) with a relatively large partial η^2 of 0.157. This indicates that the HFFC mode improves cognitive level in females more than the CFC mode. The effect size shows that instructional mode accounts for considerable variation in female cognitive level. This finding is statistically significant and provides data support for the differentiated effects of instructional modes across gender groups. The null hypothesis $H_0.4$ was rejected. The results show that the HFFC mode is significantly superior to the CFC mode for improving female cognitive level.

Table 6. ANCOVA results for female students' cognitive level by instructional mode

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9739.589[a]	2	4869.794	1007.122	<0.001	0.953
Intercept	13.808	1	13.808	2.856	0.094	0.028
Pre-test	9652.941	1	9652.941	1996.323	<0.001	0.952
Group	90.357	1	90.357	18.687	<0.001	0.157
Error	483.536	100	4.835			
Total	497,018.141	103				
Corrected Total	10,223.125	102				

a. R Squared = 0.953 (Adjusted R Squared = 0.952)

Table 7 analyzes the effects of instructional modes, gender, and their interaction on cognitive level. The main effect of instructional modes was significant (F = 11.156, p = 0.001, partial η^2 = 0.071), while the main effect of gender was not (F = 0.104, p = 0.748). The interaction between instructional modes and gender was not statistically significant (F = 2.902, p = 0.091, partial η^2 = 0.020). Although this p-value approached significance and the effect size was small, the findings suggest only a potential trend in the differential impact of instructional modes on cognitive level by gender. This trend does not suffice as evidence for a statistically significant interaction. Thus, the null hypothesis H0.5 was not rejected, indicating no significant interaction effect between instructional modes and gender on cognitive level.

Table 7. ANCOVA results for effects of mode, gender and their interaction on cognitive level score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14,342.628[a]	4	3585.657	811.386	<0.001	0.957
Intercept	62.573	1	62.573	14.159	<0.001	0.089
Pre-test	13,914.568	1	13914.568	3148.679	<0.001	0.956
Group	49.299	1	49.299	11.156	0.001	0.071
Error	0.458	1	0.458	0.104	0.748	0.001
Total	12.826	1	12.826	2.902	0.091	0.020
Corrected Total	640.781	145	4.419			

a. R Squared = 0.957 (Adjusted R Squared = 0.956)

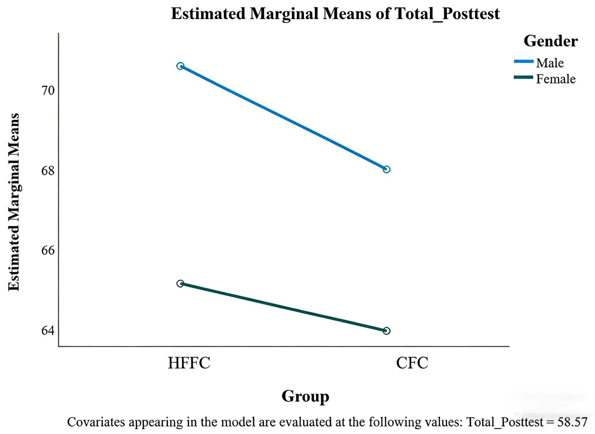

Fig. 2. Interaction effect between gender and instructional modes.

Fig. 2 shows the interaction between gender and instructional modes in relation to cognitive level. In the HFFC mode, females demonstrate a significantly higher cognitive level than males, while the gender difference in the CFC mode is minor. The non-parallel trend lines suggest a possible interaction, but the changes in slope are minimal. This is consistent with the ANCOVA analysis, which found the interaction effect was not statistically significant. Although a trend in gender differences exists, the magnitude does not reach statistical significance for an interaction effect.

A. Discussion

ANCOVA results demonstrated that, after controlling for pre-test cognitive level, instructional mode exerted a significant main effect on post-test performance. Specifically, the HFFC group outperformed the CFC group, with a statistically significant difference (p < 0.05) and a moderate effect size, indicating substantial educational value. In addition, students in the HFFC group showed more consistent improvement across several cognitive dimensions of video production, including production processes, script logic, storyboard design, and editing principles.

Higher-order cognition develops through iterative knowledge processing, contextual application, and reflective reconstruction from a cognitive learning perspective [49]. The Hybrid Flexible Flipped Classroom (HFFC) structure facilitates this development by moving lower-order knowledge acquisition to pre-class activities and allocating structured learning time to higher-order analysis and application. Furthermore, the synchronous and asynchronous flexibility of HFFC enables repeated engagement with learning materials, thereby supporting deeper conceptual reorganization [50]. These opportunities to revisit and restructure knowledge may explain students' improved integration of theory and practice in video production tasks [51]. The cyclical process of understanding, application, and refinement promoted by HFFC corresponds with pathways associated with higher-order cognitive development [52]. Although the Conventional Flipped Classroom (CFC) also combines pre-class preparation with in-class activities, its fixed temporal structure may restrict individualized pacing and cognitive processing. In contrast, HFFC offers an advantage by redistributing control over learning, allowing students to regulate their engagement according to their cognitive needs [51]. This shift from externally paced learning to increased autonomy is consistent with research linking learning autonomy to deeper cognitive processing [53, 54].

The results indicated that the main effect of gender on cognitive level was not significant, suggesting that gender alone does not account for cognitive differences. However, the interaction between gender and instructional mode revealed a more complex pattern, supporting the view that gender effects are context-dependent and shaped by learning environments rather than inherent characteristics [55]. In both male and female groups, students in the HFFC mode outperformed those in the CFC mode. Among males, HFFC was linked to a significant cognitive advantage, which may reflect an alignment between flexible learning pathways and task-oriented learning tendencies in technology-related contexts [56, 57]. For females, the cognitive gain under HFFC was even more pronounced. Previous research indicates that females may be more sensitive to time pressure and immediate evaluation in complex tasks [58, 59]. By reducing temporal constraints and performance pressure, HFFC may provide a more supportive environment for reflective knowledge construction. The asynchronous components also support independent regulation and deeper cognitive processing [60]. Although the interaction analysis demonstrated a non-significant moderating effect of instructional mode on gender differences, the findings suggest that the HFFC mode did not intensify gender disparities, indicating its potential to provide a relatively equitable learning environment. These results suggest that HFFC not only enhances overall cognitive performance but also reduces structural disparities between groups. This finding is consistent with the inclusive principles emphasized in university design for learning [61], indicating that flexible instructional design may promote greater educational equity.

V. Conclusion

The current study shows quantifiable cognitive gains for both male and female students, providing quantitative evidence for the educational efficacy of the HyFlex flipped classroom in a practice-oriented media course. Given the observed gender-related performance patterns, future studies should explore how gender and other individual or social factors interact with HFFC to enhance inclusivity and educational equity. This finding challenges the conventional wisdom that the HyFlex mode is always advantageous and highlights the need to view "flexibility" as a pedagogical variable rather than an inherent advantage. There is little information on cross-disciplinary transfer, institutional scalability, and long-term knowledge retention due to the study's brief duration and single-course restriction. Therefore, generalizability of findings of future research should be tested across disciplines, educational level, and longer time spans through longitudinal designs to assess sustained learning outcomes. Additionally, as HFFC relies heavily on digital tools, students' technology acceptance and proficiency may influence outcomes and warrant further investigation.

The cognitive benefits identified in this study indicate that the HyFlex flipped classroom serves as an effective pedagogical strategy for enhancing both conceptual understanding and practical skill development in media courses. Permitting students to alternate between in-person and online participation mitigates the social isolation associated with fully online formats while maintaining the autonomy increasingly expected by students. The provision of recorded sessions serves not only as a convenience but also as a means of enabling repeated engagement with disciplinary techniques, which may account for the sustained cognitive improvements observed in post-test results. These findings underscore the importance for educational institutions, particularly those considering curriculum reform in video creation, to establish integrated resource ecosystems that encompass platforms, instructional materials, and assessment methods alongside hybrid scheduling. Overall, the study underscores the necessity of ongoing investment in practice-oriented digital platforms capable of supporting large-scale, hybrid, and multimodal learning environments.

Ethical Approval and Informed Consent

Ethical Approval: This study was approved by the Universiti Sains Malaysia Ethics Committee (Approval No. USM/JEPeM/PP/24100935).

Informed Consent: Informed consent was obtained from all individual participants included in the study.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

The authors confirm contribution to the paper as follows: Study conception and design: Wang Ting, Wan Ahmad Jaafar Wan Yahaya; Paper writing: Wang Ting; data collection and analysis: Wang Ting; All authors reviewed the results and approved the final version of the manuscript.

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