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The Effectiveness of the Flipped Learning Model on Cognitive Engagement and Critical Thinking in Upper Elementary School Students with Attention-Deficit/Hyperactivity Disorder

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A B S T R A C T

The present study aimed to determine the effectiveness of the flipped learning model on cognitive engagement and critical thinking among upper elementary school students with attention-deficit/hyperactivity disorder (ADHD). This study employed a quasi-experimental pretest–posttest design with a control group and a follow-up assessment. The statistical population consisted of sixth-grade female students diagnosed with attention-deficit/hyperactivity disorder who were referred to the Counseling Center of the Alborz Province Department of Education during the first six months of 1404 SH. Of these students, 24 were selected through purposive sampling and randomly assigned to experimental and control groups. The research instruments included the Cognitive Processing Questionnaire developed by Kember et al. (2004) and the Critical Thinking Questionnaire developed by Ricketts (2003). The experimental group received eight sessions of flipped learning instruction, whereas the control group received conventional classroom instruction. The data were analyzed using analysis of covariance and the Bonferroni post hoc test. The results indicated that flipped learning had a significant positive effect on cognitive engagement and critical thinking ($p<.001$). Accordingly, flipped learning can be recommended as an effective and sustainable instructional approach for enhancing cognitive engagement and strengthening critical thinking among elementary school students with attention-deficit/hyperactivity disorder.

Keywords: *attention-deficit/hyperactivity disorder, critical thinking, cognitive engagement, flipped learning.*

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental condition that can substantially affect children's educational, behavioral, cognitive, and social functioning. Difficulties in maintaining attention, regulating impulses, organizing goal-directed behavior, and sustaining effort are particularly consequential within school environments, where students are expected to follow instructions, process increasingly complex information, regulate their learning behavior, and participate effectively in structured classroom activities. Contemporary clinical research increasingly emphasizes the heterogeneity of ADHD, suggesting that children presenting with attentional

and hyperactivity-related symptoms may differ substantially in their cognitive profiles and developmental trajectories. Developmental patterns involving hyperactivity, irritability, and related psychological characteristics further demonstrate that childhood behavioral difficulties cannot be understood as a uniform phenomenon (Dugré & Potvin, 2022). Similarly, neuropsychological evidence has questioned simple functional distinctions among conventional ADHD subtypes, indicating that the cognitive characteristics of children with ADHD may be considerably more complex than categorical descriptions alone suggest (Díaz-Moreno et al., 2025). Recent work distinguishing cognitive disengagement syndrome from ADHD presentations also highlights the importance of carefully considering attentional and cognitive characteristics when examining educational functioning in children and adolescents (Burns et al., 2025).

The educational consequences of ADHD are particularly important during the elementary school years because students are gradually required to move beyond the acquisition of basic information toward more complex forms of reasoning, independent learning, cognitive control, and problem solving. Children with ADHD may experience difficulties in sustained and selective attention, working memory, inhibition, and the flexible allocation of cognitive resources, all of which are central to successful classroom learning. Experimental and intervention research has consequently examined methods of strengthening attention and related cognitive processes among these students. For example, percussion-based exercises have been investigated as a means of improving different forms of attention and theory of mind in children with attention difficulties (Hatemzadeh & Rezaei, 2025), while self-regulation strategy training has been shown to be relevant to attention deficits, social adjustment, and perceived competence among children with ADHD (Shahi et al., 2024). Working-memory training has likewise been studied in relation to attentional problems and adaptive and maladaptive cognitive-emotional regulation in children with ADHD, illustrating the close connection between cognitive control and broader psychological functioning (Zhao & Zhang, 2024). Such findings reinforce the need to consider instructional approaches that do not merely transmit curriculum content but also provide conditions that support students' executive and self-regulatory capacities.

Neuroscientific findings further support the importance of educational environments that are responsive to the cognitive characteristics of children with ADHD. Changes in cognitive demands require dynamic reorganization of functional brain networks, and research involving children with ADHD has demonstrated differences in how these networks are configured under changing cognitive conditions (Michael et al., 2024). Such findings suggest that classroom tasks imposing high simultaneous demands on attention, working memory, response control, and information processing may be particularly challenging for these students. At the same time, ADHD-related characteristics do not imply a uniform deficit across every form of higher-order cognition. Recent research has indicated that the magnitude of ADHD symptoms can be associated with different patterns of creative problem solving and with reliance on insight-based versus analytical solution processes (Maisano et al., 2026). Accordingly, educational interventions for children with ADHD should not be limited to deficit compensation; they should also provide structured opportunities through which students can engage cognitively, explore alternative solutions, regulate their thinking, and actively construct understanding.

One construct that is especially relevant in this context is cognitive engagement. Cognitive engagement refers broadly to the quality and intensity of the mental effort that students devote to learning and includes the use of meaningful processing strategies, self-regulation, persistence, monitoring, elaboration, and deeper interaction with academic content. Within self-regulated learning, cognitive engagement represents more than observable classroom participation because a student may appear behaviorally involved while engaging only superficially with instructional material. Effective learning requires learners to strategically allocate cognitive resources, monitor their understanding, connect new information with prior knowledge, and adapt their learning strategies when difficulties arise (Li & Lajoie, 2022). Research on academic achievement has similarly treated cognitive engagement as closely connected to task value, achievement-related emotions, and academic self-regulation, suggesting that it occupies an important position within the broader motivational and cognitive architecture of learning (Shivandi Chalicheh, 2015). For students who experience attention-regulation difficulties, creating conditions that facilitate this form of sustained mental participation is therefore especially important.

Cognitive engagement is also influenced by the characteristics of the educational environment. Students are more likely to invest sustained mental effort when they perceive learning tasks as manageable, purposeful,

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interactive, and responsive to their individual needs. Evidence from students with learning difficulties indicates that perceived teacher expectations are related to cognitive engagement and academic self-efficacy, highlighting the importance of instructional relationships and learning environments in shaping students' cognitive participation (Mortezapour et al., 2024). More recent educational research has likewise shown that instructional designs emphasizing active participation can improve cognitive engagement. Flipped instruction has been associated with greater cognitive engagement and active classroom participation (Paydar et al., 2025), while comparisons of flipped classroom and microlearning approaches among elementary school students have highlighted changes across cognitive, emotional, and behavioral dimensions of engagement (Esnavandi et al., 2025). Emerging pedagogical research involving primary students also demonstrates that instructional structures requiring active construction, self-regulation, and engagement with complex tasks can meaningfully influence students' cognitive engagement (Ma et al., 2026). These findings make cognitive engagement an important outcome when evaluating instructional models intended for students with ADHD.

Alongside cognitive engagement, critical thinking is a major educational outcome because successful learning increasingly requires students to evaluate information rather than merely remember it. Critical thinking involves a disposition and capacity to question assumptions, analyze evidence, compare alternatives, evaluate claims, draw reasoned conclusions, and regulate one's judgments. The Ricketts critical thinking framework has been psychometrically examined among school students, with evidence supporting the assessment of dimensions such as innovativeness, cognitive maturity, and engagement or commitment in thinking (Pakmehr et al., 2013). These dispositions are particularly relevant during late childhood and early adolescence, when students encounter increasingly complex curricular tasks and become more capable of reflecting on alternative explanations and evaluating the validity of information. Educational research has demonstrated that explicit thinking-oriented interventions, including philosophy-for-children programs, can promote critical thinking alongside academic self-efficacy and other developmental outcomes among children in this age range (Salemi et al., 2024). Similarly, critical thinking skills training has been associated with improvements in educationally relevant outcomes such as academic creativity and satisfaction with learning (Yousefizadeh & Aghaei Moghadam, 2023).

The development of critical thinking may present particular challenges for students with ADHD. Analytical reasoning often requires students to inhibit an immediate response, retain multiple pieces of information in working memory, examine relationships among competing claims, and persist long enough to evaluate possible solutions. Difficulties in attention regulation or impulsive responding can therefore interfere with the deliberate cognitive processes necessary for careful judgment. At the same time, these skills are amenable to educational intervention when students are given structured opportunities to practice reasoning in an active learning environment. Programs explicitly designed to stimulate alternative perspectives and organized thinking, such as De Bono's Six Thinking Hats approach, have demonstrated effectiveness in strengthening critical thinking among children and adolescents (Hashempour et al., 2025). These findings indicate that critical thinking should not be viewed simply as a stable individual characteristic but as an educationally modifiable capacity or disposition that can be cultivated through appropriately structured classroom experiences.

Traditional teacher-centered instruction may be insufficient for promoting such higher-order learning outcomes, particularly when students have difficulty maintaining sustained attention during prolonged verbal explanations. Conventional classroom structures typically allocate substantial class time to the transmission of new content, leaving students to complete exercises and consolidate learning independently afterward. This arrangement can place simultaneous demands on listening, working memory, note-taking, comprehension, and response regulation. Research comparing traditional and blended instructional approaches from the perspective of cognitive load theory suggests that alternative instructional arrangements can produce different educational consequences by changing how and when students encounter learning material (Shiralinejad et al., 2022). For learners with ADHD, reducing unnecessary cognitive demands and providing opportunities to revisit content may be particularly advantageous because information does not have to be completely processed during a single teacher-led presentation. This need has encouraged growing interest in flexible instructional approaches that combine digital preparation with active classroom learning.

Flipped learning represents one of the most prominent of these approaches. The model reverses the traditional

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sequence of instruction by moving initial exposure to instructional content outside the classroom and reserving face-to-face instructional time for active application, discussion, problem solving, feedback, collaboration, and clarification. Early descriptions of the inverted classroom emphasized this redistribution of instructional activities as a way of creating more classroom time for higher-level engagement with learning materials (Morin et al., 2013). Rather than positioning the learner primarily as the recipient of teacher-delivered information, flipped learning encourages students to encounter foundational content before class and then use classroom time to interact with concepts more actively. Meta-analytic evidence has indicated that flipped learning can positively affect a range of educational indicators (Sahebyar & Mesrabadi, 2021), and broader reviews have emphasized its relationships with cognitive styles, learning processes, and academic performance (Somaa, 2024). More recent bibliometric and thematic analyses indicate that flipped learning has developed into a substantial international research domain concerned with active learning, technology integration, student-centered pedagogy, engagement, and educational outcomes (Yüksel, 2026).

The characteristics of flipped learning may be especially relevant to students with ADHD. Pre-class videos or multimedia resources can generally be paused, replayed, and reviewed at a personally manageable pace, providing students with repeated opportunities to process information that might otherwise be missed during a single classroom explanation. Classroom time can then be devoted to shorter, varied, interactive activities that may be better suited to students who experience difficulty sustaining attention during extended lectures. Furthermore, teacher feedback can be delivered while students are actively completing exercises, allowing misconceptions to be addressed before they become consolidated. Flipped learning may also provide opportunities for self-directed learning and a greater sense of learner agency. Research with sixth-grade female students has shown that flipped learning can positively affect self-directed learning and academic achievement (Allahgholipour & Fathollahi, 2025), while studies in other educational populations have reported improvements in self-directed learning and self-efficacy following flipped instruction (Zahedian & Nami, 2024). These characteristics suggest a plausible instructional fit between flipped learning and the needs of students who require repetition, flexible pacing, immediate feedback, and structured participation.

Importantly, the potential benefits of flipped learning extend beyond academic achievement to the higher-order cognitive outcomes central to the present study. A flipped classroom creates a pedagogical sequence in which basic exposure to information occurs before class, allowing classroom activities to emphasize analysis, application, comparison, evaluation, and problem solving. This structure provides a direct pathway through which both cognitive engagement and critical thinking may be strengthened. Research in the Thinking and Research curriculum has shown that flipped learning can improve students' critical thinking (Ahmadvand Kahrizi et al., 2025). Flipped learning has also been reported to enhance critical thinking and academic engagement in educational settings where students are required to work actively with scientific content (Shafiei & Iranizadeh, 2025). International evidence similarly indicates that combining problem-based learning with a flipped classroom can improve critical thinking alongside digital literacy among junior high school students (Antara et al., 2026). These findings are particularly relevant because they suggest that the mechanism of flipped learning is not restricted to convenience of content delivery; rather, its effectiveness may derive from reallocating instructional time toward cognitively demanding activity.

Flipped learning may further promote higher-order thinking through collaboration and creative problem solving. When students arrive in class with preliminary familiarity with lesson content, the teacher can organize peer discussion, collaborative tasks, reasoning activities, and problem-solving exercises that require students to explain their ideas and evaluate alternative perspectives. A creative problem-solving-based flipped learning strategy has been shown to facilitate students' creativity-related performance, thinking tendencies, skills, and collaboration (Hsia et al., 2021). Such interactive learning processes are potentially valuable for students with ADHD because they replace extended passive listening with structured participation and provide multiple external cues for maintaining involvement. The combination of advance exposure to content, classroom interaction, teacher scaffolding, and peer exchange may therefore reduce some barriers to engagement while simultaneously increasing the opportunities available for analytical and reflective thought.

Nevertheless, the application of flipped learning to students with ADHD also raises important questions. The model requires a degree of independent preparation outside the classroom, and students with attention and self-regulation difficulties may not consistently complete pre-

class activities without appropriate structure and supervision. The effectiveness of flipped learning in this population may therefore depend on adaptation of the model, including brief instructional materials, clear assignments, parental monitoring when appropriate, accessible technological platforms, and systematic teacher feedback. Contemporary psychiatric practice more generally emphasizes evidence-based and structured approaches to assessment and intervention rather than assuming that a strategy effective for one clinical population or context will necessarily generalize to another (American Psychiatric, 2024). In education, the same principle supports direct empirical evaluation of instructional models among students with specific developmental and psychological characteristics rather than extrapolating findings exclusively from typically developing learners.

Despite the rapid expansion of flipped learning research, an important gap therefore remains. Existing studies provide evidence for its effects on academic engagement, cognitive engagement, self-directed learning, academic achievement, creativity, collaboration, and critical thinking in different student populations (Ahmadvand Kahrizi et al., 2025; Allahgholipour & Fathollahi, 2025; Esnavandi et al., 2025; Paydar et al., 2025; Shafiei & Iranizadeh, 2025). Reviews and broader syntheses also indicate that the model has become an established subject of educational inquiry (Somaa, 2024; Yüksel, 2026). However, substantially less is known about whether these advantages extend to elementary school students with ADHD, whose attentional, executive, and self-regulatory characteristics may alter how they respond to both the pre-class and classroom components of flipped instruction. This gap is theoretically important because the same features that make flipped learning promising for ADHD—repetition, pacing flexibility, active classroom work, and immediate feedback—may also place demands on independent preparation and self-management. Empirical evaluation in this population is therefore necessary to determine whether the model can effectively strengthen higher-order cognitive outcomes rather than assuming that findings obtained from general student populations will automatically generalize to students with ADHD.

Accordingly, the aim of the present study was to determine the effectiveness of the flipped learning model in improving cognitive engagement and critical thinking among upper elementary school students with attention-deficit/hyperactivity disorder.

2. Methods and Materials

2.1. Study Design and Participants

The present study was applied in terms of purpose and employed a quasi-experimental pretest–posttest control-group design with a one-month follow-up assessment. The study population consisted of sixth-grade female elementary school students aged 11–13 years who had been diagnosed with attention-deficit/hyperactivity disorder (ADHD) and were referred to the Counseling Center of the Alborz Province Department of Education during the first six months of 2025. Because of the specific clinical characteristics of the target population, the inclusion criteria, and limitations related to accessibility, participants were recruited through purposive sampling. Based on Cohen's statistical power recommendations, with a significance level of $\alpha = .05$, a large anticipated effect size of $d = .80$, and statistical power of .80, a sample size of 12 participants per group was considered adequate. To allow for possible attrition, 30 students were initially screened. Following the application of the eligibility criteria, 24 students were identified as eligible and were randomly assigned, using a random-number table, to an experimental group receiving flipped learning instruction and a control group receiving conventional instruction, with 12 participants in each group. Eligibility required the student's willingness to participate, written informed consent from a parent, enrollment in the sixth grade, an age between 11 and 13 years, no simultaneous participation in another educational or therapeutic intervention, receipt of a red-flag indicator on the ADHD component of the NAMAD screening system, a score above 34 on the parent version of the Conners Attention-Deficit/Hyperactivity Disorder Scale, and a definitive diagnosis of ADHD by the psychologists and psychiatrist of the counseling center. Students were excluded if they discontinued cooperation during the intervention, simultaneously received another therapeutic or educational intervention, used medication considered capable of interfering with the intervention process, or were absent from more than two intervention sessions. After ethical approval was obtained from the relevant university authorities under the code IR.IAU.SEMNAN.REC.1405.006 and coordination was established with the Counseling Center of the Alborz Province Department of Education, eligible students referred from elementary schools throughout the province were reassessed according to the study criteria. Both groups completed the outcome measures before the intervention,

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immediately after the intervention, and again one month later. To minimize the possible influence of participants' regular classroom teachers, the intervention was implemented during the summer after completion of the formal school year.

2.2. Measures

The Revised Two-Factor Learning Process Questionnaire (R-LPQ-2F), developed by Kember, Biggs, and Leung in 2004, was used to assess students' approaches to cognitive processing and served as the measure of cognitive engagement in the present study. The questionnaire contains 22 items organized into two principal dimensions, namely the deep approach and the surface approach. The deep approach is assessed by Items 1–11, whereas the surface approach is assessed by Items 12–22. All items are rated on a five-point Likert scale ranging from 1, indicating strongly disagree, to 5, indicating strongly agree. Higher scores on a given dimension indicate a greater tendency to employ the corresponding learning and cognitive-processing approach, whereas lower scores reflect less frequent use of that approach. In the original psychometric evaluation, Kember et al. reported satisfactory factorial validity based on confirmatory factor analysis and strong internal consistency, with a Cronbach's alpha coefficient of .96. The Iranian version of the instrument was evaluated by Shivandi in 2015, who reported satisfactory confirmatory factorial validity and Cronbach's alpha coefficients of .91 for the total questionnaire, .82 for the deep approach, and .71 for the surface approach. In the present study, the internal consistency of the questionnaire was reassessed using Cronbach's alpha, yielding a coefficient of .88 for the total scale, which indicated satisfactory reliability.

The Ricketts Critical Thinking Disposition Inventory (CTDI), developed by Ricketts in 2003, was administered to assess participants' disposition toward critical thinking. The instrument consists of 33 items distributed across three dimensions: creativity or innovativeness, assessed by Items 1–11; cognitive maturity, assessed by Items 12–20; and mental engagement or commitment, assessed by Items 21–33. Responses are provided on a five-point Likert scale ranging from 1, strongly disagree, to 5, strongly agree. Accordingly, the total score may range from 33 to 165, with lower scores indicating a weaker disposition toward critical thinking and higher scores indicating a stronger critical thinking disposition. Psychometric evaluation of the original instrument demonstrated satisfactory content, construct, and factorial validity, together with adequate internal consistency and split-half reliability; the reported Cronbach's alpha coefficient for the overall scale was .90. In Iran, Pakmehr et al. examined the psychometric properties of the instrument in 2013 and reported satisfactory factorial validity and acceptable model fit based on confirmatory factor analysis. They also reported a Cronbach's alpha coefficient of .89 for the total scale and coefficients greater than .70 for its subscales, in addition to satisfactory split-half reliability. For the present sample, internal consistency was again evaluated using Cronbach's alpha, and a coefficient of .85 was obtained for the total critical thinking scale, demonstrating acceptable reliability.

2.3. Intervention

The experimental group participated in eight weekly instructional sessions based on the flipped learning model proposed by Morin et al. (2013), with the educational content drawn from the sixth-grade Thinking and Research textbook, whereas the control group received the same general curriculum content through conventional textbook-based, lecture-oriented instruction. Before the beginning of the intervention, instructional objectives were determined and appropriate videos, worksheets, handouts, and supplementary learning activities were prepared. The flipped learning process consisted of determining the primary and secondary objectives of each lesson, providing short instructional videos before class, assigning preparatory activities that students completed before attending each session, using classroom time for interactive and cognitively demanding activities, and assigning post-class reflection and preparation for the subsequent lesson. Materials were distributed to students in the experimental group through the SHAD educational messaging platform. Students were expected to watch the videos before attending class, complete associated worksheets or assignments, prepare for classroom discussion, and submit questions online whenever they encountered unclear material. The instructor reviewed students' preliminary work before each session and provided appropriate feedback. Because all participants had ADHD, parents were also asked to supervise the completion of pre-class activities and encourage active participation. During classroom sessions, time was primarily allocated to group discussion, collaborative problem solving, correction of misconceptions, application of learned concepts, and activities requiring higher levels of cognitive processing rather than direct presentation of basic content. Post-class

activities required students to evaluate and summarize the completed work and prepare for the following session. The first session addressed "Random Words," in which students watched a five-minute video on establishing connections among unrelated words, collaboratively constructed a story from three unrelated words, and subsequently summarized the procedure and selected three new words. The second session, "Sights of My Homeland," involved viewing material on Iran's natural and historical attractions, discussing the importance of protecting historical sites, and preparing a report on a local tourist attraction. The third session, "The Trustworthy Orange-Clad Worker," used a short story about saving and trustworthiness, followed by role-play and analysis of ethical situations and a written reflection on a personal experience of trustworthiness. The fourth session, "The Fragrance of Medina," incorporated a video about the Prophet's kindness, guided discussion and behavioral comparison, and preparation of a poster or drawing on kindness. The fifth session, "Aq Kand," used a paused video depicting a pristine natural environment, after which students collaboratively continued the story, engaged in peer critique, and rewrote the story with a different ending. The sixth session, "The Moon and the Fox," involved viewing an animation, analyzing why the fox was deceived, generating strategies for avoiding deception, and identifying relevant proverbs. The seventh session, "The Snake Catcher and the Dragon," included an introduction to mythical creatures, a simulated dialogue aimed at developing a peaceful solution, and preparation of a letter from the dragon to human beings. The eighth session focused on "Methods of Collecting Information," in which students viewed a video illustrating a simple research project, collaboratively designed a five-item questionnaire concerning interest in reading, and conducted and reported an interview with a family member. The same instructor, who had received specialized training in flipped learning and instructional skills, taught both the experimental and control groups in order to reduce instructor-related variability. Immediately after completion of the eight-session intervention, both groups completed the posttest measures, and the same instruments were administered again one month later to evaluate the maintenance of intervention effects.

2.4. Data Analysis

Data were analyzed using IBM SPSS Statistics version 25. Descriptive statistics, including means and standard deviations, were first calculated to summarize participants' scores on cognitive engagement, including the deep and surface approaches, and critical thinking across the pretest, posttest, and follow-up assessments. Before conducting the inferential analyses, the assumptions required for covariance-based procedures were examined. The normality of the distributions was evaluated using the Shapiro–Wilk and Kolmogorov–Smirnov tests, homogeneity of variances was examined using Levene's test, homogeneity of the variance–covariance matrices was assessed using Box's M test, and the homogeneity of regression slopes was also evaluated. After confirming that the statistical assumptions were adequately satisfied, multivariate analysis of covariance was used to examine the overall effect of group membership on the combination of dependent variables while controlling for baseline scores, followed by univariate analyses of covariance to determine intervention effects separately for the deep approach, surface approach, and critical thinking. Bonferroni-adjusted post hoc comparisons were additionally conducted to examine changes between the pretest, posttest, and one-month follow-up assessments and to determine whether the observed intervention effects were maintained over time. Statistical significance was evaluated at the .05 level.

3. Findings and Results

Due to incomplete or invalid responses on some questionnaires and the dropout of one participant from the experimental group, data from the two groups of 12 participants were analyzed. Demographic data indicated that the groups were homogeneous in terms of age. The mean age and standard deviation were 12.01 ± 1.14 years in the flipped learning group and 12.10 ± 1.16 years in the control group. The descriptive statistics are presented in Table 1.

Table 1

Descriptive Statistics of the Study Variables by Assessment Stage and Group

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Variable	Component	Group	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Follow-Up Mean	Follow-Up SD
Cognitive Engagement	Deep Approach	Experimental Group	26.2	8.4	33.1	7.1	34.19	7.1
		Control Group	27.06	8.9	29.92	8.8	29.00	8.3
	Surface Approach	Experimental Group	29.3	8.4	37.2	8.97	36.26	8.2
		Control Group	30.1	8.14	33.13	8.14	33.0	10.2
Critical Thinking	Critical Thinking	Experimental Group	97.7	13.6	120.4	13.4	119.7	13.2
		Control Group	95.6	13.3	100.5	13.2	99.9	13.8

As shown in Table 1, the mean posttest scores of the experimental group receiving the flipped learning instructional model were higher than those of the control group receiving traditional instruction for both components of cognitive engagement (deep and surface approaches) and for critical thinking. However, no substantial changes were observed from posttest to follow-up. Examination of the assumptions of multivariate analysis of covariance showed that, according to the Shapiro–Wilk and Kolmogorov–Smirnov tests, the distributions of cognitive engagement and critical thinking were normal within each group ($p > .05$). Levene's test also indicated homogeneity of variances across the pretest, posttest, and follow-up stages for the study variables ($p > .05$). Box's M test further indicated that the assumption of homogeneity of the variance–covariance matrices was satisfied ($M = 7.72$, $F = 6.73$, $p > .05$). The assumption of homogeneity of regression slopes was also met ($p > .05$). Examination of the linear relationship between the covariate and dependent variables showed significant differences based on pretest scores ($p < .001$). Given that the assumptions were satisfied, multivariate analysis of covariance was subsequently conducted. Wilks' lambda indicated a significant difference between the groups in the linear combination of the dependent variables (Wilks' Lambda = .84, $F = 6.87$, $p < .001$, $\eta^2 = .92$). The results of the univariate analyses are presented in Table 2.

Table 2

Summary of Analysis of Covariance for Between-Group Effects on the Study Variables

Variable	Source of Variation	Sum of Squares	df	Mean Square	F	p	Eta Squared
Deep Approach	Pretest	486.06	1	486.06	51.12	< .001	.78
	Group	420.50	1	420.50	44.25	< .001	.67
	Error	209.14	22	9.51	—	—	—
	Total	9568.00	24	—	—	—	—
Surface Approach	Pretest	412.30	1	412.30	38.75	< .001	.64
	Group	305.80	1	305.80	28.74	< .001	.57
	Error	234.10	22	10.64	—	—	—
	Total	9320.00	24	—	—	—	—
Critical Thinking	Pretest	40.17	1	40.17	4.52	.045	.17
	Group	184.43	1	184.43	20.76	< .001	.49
	Error	195.40	22	8.88	—	—	—
	Total	9679.00	24	—	—	—	—

As shown in Table 2, after controlling for the effect of the pretest, significant between-group differences were observed in the posttest mean scores for the deep approach ($F = 44.25$, $p < .001$, $\eta^2 = .67$), the surface approach ($F = 28.74$, $p < .001$, $\eta^2 = .57$), and critical thinking ($F = 20.76$, $p < .001$, $\eta^2 = .49$). Specifically, the mean posttest scores of the experimental group were significantly higher than those of the control group on these variables. In other words, the flipped learning instructional model significantly increased cognitive engagement and critical thinking scores in the experimental group at posttest compared with the control group. Although increases in the study variables were observed in both the experimental and control groups at posttest, the magnitude of improvement was substantially greater in the experimental group. The results of the Bonferroni post hoc test comparing mean scores across assessment stages are presented in Table 3.

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Table 3

Bonferroni Post Hoc Test for Comparing Mean Scores Across Assessment Stages by Group

Variable	Group	Pretest–Posttest Mean Difference	*p*	Pretest–Follow-Up Mean Difference	*p*	Posttest–Follow-Up Mean Difference	*p*
Deep Approach	Experimental Group	−6.9	< .001	−7.99	< .001	−1.09	.50
	Control Group	−2.86	< .001	−1.94	< .001	.92	.50
Surface Approach	Experimental Group	−7.9	< .001	−6.96	< .001	.94	.60
	Control Group	−3.03	< .001	−2.9	< .001	.13	.70
Critical Thinking	Experimental Group	−22.7	< .001	−22.0	< .001	.7	.50
	Control Group	−4.9	< .001	−4.3	< .001	.6	.50

The results presented in Table 3 indicate that significant increases in cognitive engagement, including both the deep and surface approaches, and critical thinking were observed from pretest to posttest and from pretest to follow-up in both groups ($p < .05$). In contrast, the differences between posttest and follow-up were not statistically significant for any of the variables ($p > .05$), indicating that the effects were maintained during the follow-up period.

Furthermore, the magnitude of improvement was greater in the experimental group. These findings indicate that the flipped learning instructional model was more effective than traditional instruction in enhancing the dimensions of cognitive engagement and critical thinking among students with attention-deficit/hyperactivity disorder.

4. Discussion

The present study examined the effectiveness of the flipped learning model in improving cognitive engagement and critical thinking among upper elementary school students with attention-deficit/hyperactivity disorder (ADHD). The findings demonstrated that, after controlling for pretest scores, students who received flipped learning instruction obtained significantly higher posttest scores than those who received conventional classroom instruction on both components of cognitive engagement, namely the deep approach and surface approach, as well as on critical thinking. The between-group effects were statistically significant for the deep approach, ($F = 44.25$, $p < .001$, \eta^2 = .67), the surface approach, ($F = 28.74$, $p < .001$, \eta^2 = .57), and critical thinking, ($F = 20.76$, $p < .001$, \eta^2 = .49). Moreover, the Bonferroni comparisons indicated significant improvements from pretest to posttest and from pretest to the one-month follow-up assessment, whereas differences between posttest and follow-up were not statistically significant. Thus, the improvements observed after flipped learning were maintained during the follow-up period. Collectively, these findings indicate that restructuring instruction through pre-class exposure to content and active classroom participation can produce meaningful and relatively stable improvements in cognitive engagement and critical thinking among students with ADHD.

The finding concerning improved cognitive engagement is consistent with previous research demonstrating that flipped and active instructional approaches can increase students' mental involvement in learning. Paydar et al. reported that flipped instruction was effective in improving cognitive engagement and active participation, supporting the view that replacing passive content reception with structured pre-class preparation and active classroom work increases the degree to which students invest cognitive effort in learning (Paydar et al., 2025). Similarly, Esnavandi et al. found favorable effects of flipped classroom instruction on cognitive, emotional, and behavioral engagement among elementary school students (Esnavandi et al., 2025). The current results also correspond with research emphasizing that cognitive engagement is closely connected with self-regulation, strategic processing, and purposeful investment of cognitive resources during learning (Li & Lajoie, 2022). In the present intervention, students were not merely asked to listen to explanations; instead, they encountered instructional materials before class and subsequently worked with those materials through discussion, problem solving, storytelling, comparison, role-play, questioning, and other cognitively demanding activities. Such a structure appears

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capable of increasing the depth and continuity of students' interaction with instructional content.

One explanation for the improvement in cognitive engagement is that flipped learning alters the temporal distribution of cognitive demands. In a traditional classroom, students are frequently expected to attend to new information, maintain it in working memory, organize it, interpret the teacher's explanation, and sometimes respond immediately. These simultaneous demands may be especially difficult for children with ADHD because attentional control and executive functioning are frequently compromised. Research has demonstrated that children with ADHD show neuropsychological difficulties that cannot be reduced to simple diagnostic subtypes and that their cognitive functioning is characterized by considerable heterogeneity (Díaz-Moreno et al., 2025). Neuroimaging evidence has likewise shown differences in the reconfiguration of functional brain networks under changing cognitive demands among children with ADHD (Michael et al., 2024). By permitting students to watch short videos at home, pause them, replay sections, and process material at a more individualized pace, flipped learning may reduce the immediate processing burden and allow cognitive resources to be allocated more effectively during subsequent classroom activities.

This explanation is also supported by studies emphasizing the role of cognitive and self-regulatory difficulties in ADHD. Zhao and Zhang showed that interventions targeting working memory can influence attention and cognitive-emotional regulation in children with ADHD (Zhao & Zhang, 2024). Shahi et al. similarly demonstrated that self-regulation strategy training can improve attention-related difficulties and other adaptive outcomes among children with ADHD (Shahi et al., 2024). The flipped learning intervention used in the present study incorporated several features that may indirectly support these capacities. Students were given clearly structured pre-class materials, specific assignments, repeated opportunities to review instructional videos, parental supervision of preparation, and teacher feedback before and during classroom activities. This combination may have functioned as an external scaffold for attention and self-regulation. Rather than requiring students to independently regulate every stage of learning, the intervention distributed regulatory support across the student, parent, instructional platform, and teacher. Such scaffolding may be particularly important for students with ADHD, who may benefit from structured environments that reduce avoidable distractions and provide frequent guidance.

The maintenance of cognitive engagement improvements at follow-up is also noteworthy. The lack of a significant decline from posttest to the one-month follow-up suggests that the intervention may have influenced more than temporary classroom participation. The repeated use of pre-class preparation, active problem solving, reflection, collaboration, and post-class summarization may have encouraged students to adopt more persistent approaches to processing information. This interpretation is compatible with research indicating that cognitive engagement is embedded within self-regulated learning processes rather than representing a momentary behavioral response (Li & Lajoie, 2022). It is also aligned with findings showing that instructional approaches emphasizing learner autonomy and active participation can improve self-directed learning and academic functioning (Allahgholipour & Fathollahi, 2025; Zahedian & Nami, 2024). When students repeatedly experience themselves as active participants capable of preparing, discussing, questioning, and solving problems, they may begin to internalize some of these learning behaviors, helping explain the persistence of intervention effects beyond the immediate instructional period.

The positive finding regarding critical thinking is also consistent with previous research. Ahmadvand Kahrizi et al. found that flipped learning improved students' critical thinking in the Thinking and Research course, which closely parallels both the instructional context and outcome examined in the present study (Ahmadvand Kahrizi et al., 2025). Shafiei and Iranizadeh likewise reported that flipped learning instruction increased critical thinking as well as academic engagement (Shafiei & Iranizadeh, 2025). Internationally, Antara et al. demonstrated that a problem-based flipped classroom model improved critical thinking skills among junior high school students (Antara et al., 2026). These convergent findings suggest that one of the major educational strengths of the flipped model lies in freeing classroom time for activities requiring analysis, judgment, comparison, explanation, and evaluation rather than using most classroom time for one-way transmission of factual information.

The development of critical thinking in the present study can be explained through the nature of the classroom tasks used during the intervention. Students were required to construct stories from unrelated concepts, discuss reasons for protecting historical sites, evaluate ethical situations, compare their own conduct with exemplary behavior,

generate alternative endings for narratives, analyze why a character was deceived, propose strategies to prevent deception, resolve conflict through simulated dialogue, design questionnaires, and conduct interviews. These activities required more than recall. They involved interpretation, comparison, generation of alternatives, judgment, reasoning, perspective taking, and evaluation of possible responses. Previous evidence suggests that structured thinking interventions can enhance critical thinking in children and adolescents. Hashempour et al., for example, demonstrated the effectiveness of De Bono's Six Thinking Hats program for strengthening critical thinking (Hashempour et al., 2025), while Salemi et al. found that a philosophy-for-children intervention improved critical thinking among female students aged 10–13 years (Salemi et al., 2024). Yousefizadeh and Aghaei Moghadam similarly reported favorable educational effects following explicit critical thinking skills training (Yousefizadeh & Aghaei Moghadam, 2023). The present results extend this line of evidence by suggesting that critical thinking can also be strengthened through an instructional design in which opportunities for higher-order thinking are integrated into regular curriculum activities.

Another possible mechanism involves the separation of initial content acquisition from classroom reasoning. In conventional instruction, the learner may be asked to understand new information and immediately analyze or respond to it. For children with ADHD, this sequence can be problematic because impulsivity may encourage premature responding before sufficient information has been considered. Flipped learning introduces a temporal interval between first exposure and classroom discussion. Students can encounter the basic material before class and then return to it later in a socially supported environment. This additional processing opportunity may facilitate more deliberate responses and reduce the pressure to formulate judgments immediately. The importance of response style in ADHD is consistent with recent evidence showing that ADHD symptom magnitude is associated with differences in creative problem solving and reliance on insight-based versus analytical solution modes (Maisano et al., 2026). By giving students multiple opportunities to process information and defend their views, flipped instruction may support a shift from impulsive responding toward more reflective evaluation.

Collaboration may represent another important explanation for the improvement in critical thinking. The experimental sessions incorporated group discussion, peer critique, role-play, cooperative problem solving, and opportunities to justify responses. Such activities expose students to perspectives that differ from their own and require them to clarify the reasoning behind their conclusions. Hsia et al. showed that a creative problem-solving-based flipped learning strategy promoted creative thinking tendencies and collaboration, suggesting that flipped environments can support both cognitive and interpersonal dimensions of complex problem solving (Hsia et al., 2021). When students are required to listen to another interpretation, identify points of disagreement, explain why they support a particular solution, and revise their views following feedback, critical thinking becomes part of the social learning process. This may have been especially valuable for students with ADHD because the interactive structure provided continuous behavioral and cognitive stimulation, reducing reliance on prolonged passive attention.

The observed results can additionally be interpreted in relation to cognitive load. Shiralinejad et al. found that blended instruction based on cognitive load theory differed from traditional instruction in its effects on students, emphasizing the importance of how educational information is organized and delivered (Shiralinejad et al., 2022). Flipped learning may reduce extraneous cognitive load by allowing basic content to be reviewed before class and at an individualized pace. Classroom cognitive resources can then be devoted to applying and evaluating information rather than simultaneously receiving and processing entirely new content. This feature is especially relevant to students with ADHD, for whom working-memory limitations and fluctuations in sustained attention may make uninterrupted teacher-centered instruction difficult. Therefore, the effectiveness of the present intervention may partly reflect better alignment between instructional demands and the cognitive processing characteristics of the participants.

The findings are also compatible with broader evidence concerning the effectiveness of flipped learning. Meta-analytic findings have supported positive effects of flipped learning across educational indicators (Sahebyar & Mesrabadi, 2021), while Somaa's review emphasized the relevance of flipped classroom approaches to cognitive styles and academic performance (Somaa, 2024). More recently, Yüksel's analysis of global flipped learning research showed that this instructional model has become increasingly connected with active learning, learner-centered education, engagement, and technology-supported pedagogy (Yüksel, 2026). Research with primary students

has also shown that active pedagogical structures can influence cognitive engagement and self-regulated learning (Ma et al., 2026). The present study contributes to this literature by examining a population that has received considerably less attention in flipped learning research: elementary school students with ADHD. The significant effects across both cognitive engagement and critical thinking suggest that flipped instruction may remain beneficial even when students experience attentional and executive-function challenges, provided that the model is appropriately structured and supported.

5. Conclusion

Overall, the present findings suggest that the effectiveness of flipped learning for students with ADHD may depend on its implementation rather than merely on the use of digital videos. The intervention included brief pre-class content, clearly defined objectives, worksheets, teacher feedback, parental supervision, active classroom tasks, and post-class reflection. These elements worked together as a coherent instructional system. The findings should therefore not be interpreted as evidence that simply providing videos before class is sufficient to improve cognitive outcomes. Rather, the likely mechanism involves the combination of flexible pre-class exposure with scaffolded, interactive, higher-order classroom activity. This interpretation is consistent with research showing that effective flipped learning is associated with active participation, engagement, self-directed learning, and structured opportunities for applying knowledge (Allahgholipour & Fathollahi, 2025; Paydar et al., 2025). The results therefore support a view of flipped learning as an integrated pedagogical design rather than merely a technological modification of traditional homework.

Several limitations should be considered when interpreting the findings. First, the sample was relatively small and consisted exclusively of sixth-grade female students with ADHD who had been referred to a single provincial counseling center, which limits the generalizability of the results to male students, other age groups, students from different geographical or socioeconomic backgrounds, and children with different ADHD presentations or levels of symptom severity. Second, purposive sampling was used before random group assignment, and therefore the sample may not fully represent the broader population of elementary school students with ADHD. Third, the follow-up period was limited to one month, which does not establish whether improvements in cognitive engagement and critical thinking persist over longer periods. Fourth, the primary outcomes were assessed through questionnaire-based measures and may therefore have been influenced by response tendencies, students' understanding of the items, or social desirability. Finally, parental supervision was incorporated into the flipped learning condition, making it difficult to completely separate the effects of the instructional model from the additional structure and support provided at home.

Future studies should replicate the present investigation with larger and more heterogeneous samples drawn from multiple schools, counseling centers, cities, and educational regions. Including both female and male students and examining different age groups would help determine the extent to which the effects are developmentally and demographically generalizable. Longer follow-up periods of three, six, or twelve months are recommended to evaluate the durability of intervention effects. Future research should also combine self-report measures with teacher ratings, classroom observations, performance-based critical thinking tasks, academic achievement measures, and objective indicators of attention or executive functioning. Studies comparing flipped learning with other active instructional approaches would clarify whether its effects are specific to the flipped structure or reflect the broader benefits of interactive teaching. Researchers could also investigate potential mediators and moderators, including ADHD symptom severity, working memory, self-regulation, academic motivation, parental involvement, technology access, and students' adherence to pre-class activities.

Schools, teachers, educational psychologists, and counseling centers may consider incorporating appropriately adapted flipped learning strategies into educational programs for students with ADHD. Instructional videos should be brief, clearly organized, developmentally appropriate, and available for repeated viewing, while pre-class tasks should be simple enough to prevent excessive demands on independent self-regulation. Classroom time should emphasize guided discussion, problem solving, role-play, peer interaction, questioning, and activities that require students to analyze and apply information rather than passively receive it. Teachers should provide frequent feedback and monitor completion of pre-class activities, while parents can be given concise guidance on how to support preparation without completing tasks for their children. Professional development programs may also be useful for training teachers to design flipped lessons that

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account for attentional variability, the need for movement and variety, and the executive-function difficulties commonly experienced by students with ADHD. When implemented as a structured and supportive instructional model, flipped learning may provide schools with a practical approach for simultaneously promoting active engagement and higher-order thinking in this population.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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