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Can Flipped Learning Drive Higher-Order Thinking in Sustainable Education? A Systematic Literature Review

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Abstract

Rapid global change and the demands of 21st-century education have created an urgent need to develop students' higher-order thinking skills (HOTS), critical, creative, and problem-solving abilities, yet evidence on how flipped learning (FL) supports these skills remains fragmented. This systematic literature review addresses that gap by synthesizing recent studies (2021–2025) on the impact of FL on HOTS across formal education levels and diverse cultural contexts, with particular attention to implications for sustainable education. Following PRISMA guidelines, 32 peer-reviewed empirical studies were identified from Scopus, ERIC, and ProQuest using predefined inclusion and exclusion criteria. Methodological quality was appraised using a simplified CASP checklist, and inductive thematic synthesis was employed to identify patterns in pedagogy, technology use, and HOTS outcomes. Findings indicate that FL can enhance cognitive engagement, learner autonomy, and performance when integrated with inquiry-based and collaborative strategies; critical thinking often improved through structured argumentation, creativity through project-based and digital tasks, and problem-solving through real-world, team-based learning. However, effects varied by discipline, education level, and contextual factors such as digital readiness and instructional design quality; several studies reported minimal gains in low-tech or weakly scaffolded settings. These results underscore FL's potential as a sustainable pedagogical framework that optimizes resources and fosters lifelong learning, but also highlight gaps: most studies were small-scale, quasi-experimental, and lacked longitudinal or cross-cultural comparison. Future research should adopt more rigorous, context-sensitive designs and explore how FL compares with other active learning models to inform curriculum and teacher training policies.

Keywords: Flipped Learning, Higher-Order Thinking Skills (HOTS), systematic literature review, critical thinking, creative thinking.

INTRODUCTION

The accelerating transformation of education in the 21st century underscores the urgency of developing lifelong learning capacities that enable learners to navigate complex and unpredictable challenges. Higher-order thinking skills (HOTS) are central to this goal,

which extend beyond basic knowledge recall to encompass the active manipulation, integration, and application of information in novel contexts. Drawing on the revised Bloom's taxonomy (Wilson, 2016), HOTS comprise three interrelated cognitive domains. Critical thinking involves the reasoned analysis and evaluation of information to form sound judgments and make informed decisions. Creative thinking emphasizes generating original and adaptive ideas, including refining or reconfiguring existing knowledge to meet emerging needs. Problem-solving focuses on identifying and framing complex issues, analyzing relevant data, and implementing contextually appropriate solutions (Kwangmuang et al., 2021; Lu et al., 2021; Pollarolo et al., 2023). These domains work synergistically: critical thinking enables logical appraisal, creativity fosters innovation, and problem-solving integrates both to generate effective action. To capture this multifaceted construct, HOTS are commonly assessed through a combination of quantitative and qualitative approaches, including structured performance tasks, analytical reasoning measures, reflective narratives, and collaborative inquiry-based activities (Y. M. Huang et al., 2022; Liu & Zhang, 2022; Zain et al., 2022). As such, HOTS serve as the cognitive foundation for adaptive expertise, equipping learners to engage critically, innovate responsibly, and respond constructively to the demands of a rapidly evolving world.

Cultivating higher-order thinking skills requires instructional approaches that move beyond rote memorization toward participatory and inquiry-driven learning. Flipped learning (FL) offers such an approach by shifting core content delivery to the pre-class phase, typically through videos or digital modules, so that class time can focus on active engagement through discussions, case analyses, problem-solving, and collaborative projects (Akçayır & Akçayır, 2018; Suad et al., 2022). Effective FL design incorporates three essential components: (1) structured pre-class exposure to key materials, (2) interactive and learner-centered activities during class, and (3) ongoing formative assessment with timely feedback (Bergmann & Sams, 2012; Zain et al., 2022). By reallocating classroom time to higher-level cognitive engagement, FL prepares learners to make informed decisions in complex, real-world contexts (Suad et al., 2022). Within sustainable education, mastery of HOTS is vital for equipping students to meet the demands of an increasingly competitive and dynamic global job market (Harso et al., 2024; Hsu & Wu, 2023). Thus, higher education institutions need to adopt dynamic, interactive pedagogies aligned with these objectives.

Empirical research supports FL as an effective innovation for fostering students' cognitive growth in higher education, with critical thinking frequently cited as the most enhanced dimension of HOTS (Andrini et al., 2019; Chang & Hwang, 2020; Chen & Hwang, 2020; H. Huang, 2020; Khlaisang et al., 2021; Tolbert, 2020). Its theoretical basis draws on constructivist learning theory, which highlights active engagement, collaboration, and reflection (Azizah & Sa'adah, 2021), and cognitive load theory posits that offloading basic content to pre-class learning allows face-to-face sessions to emphasize higher-order tasks. This structure reduces unnecessary cognitive load and enables students to engage more deeply in activities such as problem-solving, structured argumentation, collaborative projects, and reflective discussion (Araiza-Alba et al., 2021; Erden & Kaya, 2025; Samadi et al., 2024; Zamora-Polo et al., 2019). Consequently, FL fosters metacognitive awareness, strengthens conceptual understanding, and nurtures intellectual autonomy, core elements of HOTS (Almulla, 2023), while also enhancing collaboration and social competencies essential for success in modern knowledge-based societies (Supiandi et al., 2019).

Several studies have examined the relationship between flipped learning and the development of HOTS, yet findings remain inconclusive, particularly within the context of continuing education (Yusnadi et al., 2020). Research by Samadi et al. (2024) indicates that flipped classrooms can enhance self-regulated learning and HOTS among EFL students (Aljaraideh, 2019; Fan et al., 2024; Priyaadharshini & Vinayaga Sundaram, 2018). Other studies highlight flipped learning's positive effects on student motivation and peer interaction (Zheng et al., 2020). However, few explicitly investigate its impact on all three HOTS components: critical thinking, problem-solving, and creativity. These findings indicate the model's potential to transform students' learning processes and cognitive engagement. However, the literature also presents mixed or contrasting results. Jensen et al. (2015) argue that improvements in learning outcomes often stem from active learning strategies rather than the flipped model itself. McLaughlin et al. (2013) report that although students appreciate flipped learning, its effectiveness can be undermined when pre-class materials are misaligned with course content. Similarly, Nouri (2016) notes challenges in meeting diverse learners' needs; some students perceive flipped learning as unhelpful in supporting their learning. These variations suggest that the success of flipped learning is contingent upon multiple factors, including instructional design, teaching context, and learner characteristics.

Although flipped learning (FL) has gained attention as an innovative pedagogy, existing research presents mixed findings on its effectiveness in fostering higher-order thinking skills (HOTS), and limited attention has been given to its role within sustainable education. While some studies indicate that FL can enhance self-regulation, motivation, and aspects of HOTS, evidence remains inconsistent across disciplines, educational levels, and cultural contexts, and few investigations address all three key HOTS dimensions, critical thinking, creative thinking, and problem-solving. Moreover, the influence of contextual factors such as technological readiness, instructional design, and learner diversity on FL outcomes has not been systematically synthesized. To address these gaps, this study conducts a systematic literature review (SLR) to rigorously identify, evaluate, and synthesize empirical studies on the relationship between FL and HOTS in continuing education. The novelty of this review lies in its specific focus on the interaction between FL and the three cognitive domains of HOTS, examined across diverse cultural and pedagogical contexts, while highlighting technological implications and identifying underexplored patterns to inform instructional design and future research. Accordingly, this study seeks to answer five research questions: (1) How does flipped learning influence the development of HOTS in different contexts? (2) In what ways does flipped learning affect critical thinking? (3) How does flipped learning support creative thinking? (4) What is the impact of flipped learning on problem-solving? and (5) What are the implications of flipped learning for sustainable education?

METHOD

This study employs a systematic literature review (SLR) as its methodological framework. SLR provides a rigorous and transparent process for identifying, evaluating, and synthesizing relevant empirical studies, enabling researchers to detect trends, gaps, and patterns in a given field while minimizing bias (Siddaway et al., 2019; Dubé & Wen, 2021). To ensure methodological transparency and replicability, this review follows the Preferred

Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which structure the identification, screening, eligibility, and inclusion phases (Page et al., 2021).

Data for this review were gathered through a comprehensive search of three major academic databases: Scopus, ProQuest, and ERIC, which are widely used in systematic reviews for their broad disciplinary coverage and reliable indexing (Booth et al., 2021; Gusenbauer & Haddaway, 2020). The search strategy employed predefined keywords and Boolean combinations, including *"flipped learning"*, *"flipped classroom"*, *"higher-order thinking skills"*, *"critical thinking"*, *"creative thinking"*, *"problem-solving"*, *"sustainable education"*, and *"sustainability."* Search queries targeted terms in titles and abstracts to ensure relevance. The inclusion criteria were restricted to peer-reviewed empirical studies, meta-analyses, and systematic reviews published between 2021 and 2025 to capture current evidence. This initial search produced 2,578 records (1,554 from Scopus, 458 from ProQuest, and 566 from ERIC). After removing 1,930 duplicates, 648 unique articles remained for the screening phase.

Following identifying 648 unique records, a two-stage screening and eligibility process was conducted per PRISMA recommendations (Page et al., 2021). In the initial screening, titles and abstracts were reviewed against predefined inclusion criteria: studies had to explicitly relate to flipped learning and at least one of the three HOTS components (critical thinking, creative thinking, or problem-solving), be peer-reviewed and published in English between 2021 and 2025, and fall within the field of education. A total of 534 articles were excluded at this stage for failing to meet these criteria, leaving 114 studies for full-text screening. The subsequent eligibility phase applied stricter criteria, requiring articles to be original empirical research published in peer-reviewed journals with accessible full text. Each study was appraised for methodological clarity and potential bias during this phase, considering factors such as research design, instruments, sample size, and context (Booth et al., 2021; Higgins et al., 2019). Studies that addressed critical thinking as a teaching strategy rather than a student outcome or did not explicitly examine the effects of flipped learning on HOTS were excluded. After this full-text assessment, 32 articles met all criteria and were included in the final synthesis and analysis.

Articles were eligible for inclusion if they met several predefined criteria aligned with the aims of this review. Specifically, studies were considered when they examined flipped learning within sustainable or 21st-century education, explicitly measured or discussed higher-order thinking skills (HOTS), including critical thinking, creativity, or problem-solving, and addressed pedagogical implications relevant to formal education settings. Only peer-reviewed journal articles or conference papers published in English between 2021 and 2025 were included, while non-English publications, books, research reports, and in-press manuscripts were excluded. Additional exclusion criteria applied to studies focusing solely on learner perceptions without reporting cognitive outcomes, those lacking methodological rigor, and those unrelated to education or sustainable pedagogy (e.g., informal training or workplace-based programs). This screening ensured that the final set of articles offered both conceptual depth and empirical validity for meaningful synthesis. Following the PRISMA protocol, 32 studies met all inclusion criteria and were carried forward for reporting and analysis.

For the data analysis, this study applied qualitative content analysis and inductive thematic synthesis to identify recurring trends, methodological patterns, and gaps within the

reviewed literature. Thematic analysis was used to systematically examine and interpret study patterns, following established guidelines for identifying and organizing themes in qualitative data (Braun & Clarke, 2006; Thomas & Harden, 2008). An inductive approach allowed themes to emerge naturally rather than predetermined, focusing on key areas such as pedagogical design, digital tool integration, and HOTS outcomes. Manual coding was conducted to categorize findings related to instructional strategies, technology use, learner engagement, and assessment practices. To ensure methodological rigor, the quality of included studies was appraised using a simplified Critical Appraisal Skills Programme (CASP) checklist, with two independent coders assessing each study. Inter-coder reliability was addressed through code comparison, and discrepancies were resolved through discussion until consensus was reached (Higgins et al., 2019). This process enhanced auditability and minimized subjective bias. The analysis emphasized qualitative aspects most relevant to the development of HOTS, intentionally excluding unrelated quantitative descriptors (e.g., class sizes or geographic distribution) to maintain coherence with the SLR's objectives. Organizing the findings thematically enabled nuanced insights into how flipped learning influences critical thinking, creativity, and problem-solving.

FINDINGS AND DISCUSSION

This section presents the findings of the systematic literature review and discusses their implications for understanding the role of flipped learning (FL) in enhancing higher-order thinking skills (HOTS). The synthesis draws on 32 selected studies published between 2021 and 2025, covering diverse educational contexts, methodological approaches, and cultural settings. To ensure clarity, the discussion is structured thematically, with each subsection addressing a key dimension of HOTS: critical thinking, creative thinking, and problem-solving. These dimensions are further examined concerning contextual factors such as discipline, learner maturity, technological readiness, and instructional design quality. By integrating evidence across studies, the discussion highlights the consistencies and variations in FL outcomes, offering insights into its pedagogical potential, limitations, and implications for sustainable education.

Flipped Learning across Contexts

Six studies' analyses demonstrate that flipped learning (FL) exerts a generally positive influence on the development of higher-order thinking skills (HOTS), which include critical thinking, creativity, and problem-solving. As summarized in Table 1, FL consistently produced gains when paired with active and interactive strategies, though the strength of the outcomes varied depending on discipline, learner maturity, and instructional design.

Table 1. The flipped learning approach's impact on High Order Thinking Skills.

No	Author	School Level	Research Design	The Impact
1	Y. M. Huang et al. (2022)	Business university students	Quasi-experimental (quantitative & qualitative)	Business simulation games in FL boosted behavioral and cognitive engagement, improved academic performance, and enhanced problem-solving, critical thinking, and creativity.
2	Zain et al. (2022)	Postgraduate student teachers	Qualitative	Game-based FL fostered innovation, cooperative work, logical reasoning,

				and interpersonal communication; informed GBFL guideline development for meaningful learning.
3	Riza & Setyarini (2020)	11th-grade high school (Aceh)	Case study	FL through English-speaking simulations and discussions effectively developed students' advanced cognitive skills.
4	Liu & Zhang (2022)	University students	Quasi-experimental	FL was more effective than traditional instruction in fostering students' HOTS through active and reflective engagement.
5	Samadi et al. (2024)	EFL learners, two private institutes (Arak)	Quasi-experimental (quantitative)	FL greatly improved EFL learners' evaluation, analysis, and creative thinking engagement.
6	Hsu & Wu (2023)	University students (Zhejiang, China)	Quasi-experimental	Combining business simulation games with FL significantly enhanced problem-solving, critical thinking, and creativity.

The analysis of six studies indicates that flipped learning (FL) generally positively influences the development of higher-order thinking skills (HOTS), including critical thinking, creativity, and problem-solving. Across different contexts, FL was most effective when implemented alongside active learning strategies and robust instructional design. Studies consistently show that integrating FL with approaches such as business simulation games, project-based learning, and structured group collaboration significantly boosts student engagement and facilitates deeper mastery of HOTS, particularly when supported by digital technologies (Hsu & Wu, 2023; Y. M. Huang et al., 2022; Liu & Zhang, 2022). For instance, Y. M. Huang et al. (2022) found that competitive and collaborative simulation-based learning yielded greater cognitive and behavioral engagement gains. These findings highlight that the impact of FL is enhanced when classroom time is dedicated to authentic, problem-based activities that require students to actively apply and extend their knowledge rather than passively consume information. Despite its overall effectiveness, the impact of FL varies across disciplines, learner characteristics, and instructional designs. Differences in outcomes are often linked to course design and sample size; Y. M. Huang et al. (2022) reported stronger learning gains than Liu and Zhang (2022), likely due to collaborative elements and variations in group dynamics. Disciplinary context also mediates FL outcomes. In English as a Foreign Language (EFL) and humanities courses, FL tends to foster reflection, communication, and creativity (Riza & Setyarini, 2020; Samadi et al., 2024), whereas in STEM and business fields, its benefits are more evident in analytical reasoning and problem-solving through data-driven tasks (Hsu & Wu, 2023; Liu & Zhang, 2022). These differences suggest that FL provides discipline-specific affordances and that instructional strategies should leverage these strengths for maximum effectiveness.

The success of flipped learning (FL) is shaped not only by its pedagogical design but also by cultural, geographical, and educational contexts. Studies conducted in China (Hsu & Wu, 2023; Liu & Zhang, 2022), Malaysia (Zain et al., 2022), Iran (Samadi et al., 2024), and Indonesia (Riza & Setyarini, 2020) reveal that technological readiness, familiarity with independent study, and prevailing instructional traditions significantly influence outcomes.

Stronger results are generally observed in environments with robust digital infrastructure and student-centered pedagogies. At the same time, contexts with limited access to technology or learners inexperienced in self-directed learning often require greater scaffolding to achieve comparable gains. Educational level further mediates effectiveness: university students, who typically demonstrate greater independence, abstract reasoning, and digital competence, tend to benefit more consistently from FL (Y. M. Huang et al., 2022; Liu & Zhang, 2022; Samadi et al., 2024), whereas high school students often require more explicit guidance and structured support (Riza & Setyarini, 2020). These findings highlight how contextual variables and learner maturity influence the extent to which FL fosters higher-order thinking skills (HOTS).

Flipped Learning and Critical Thinking

Methodological diversity helps explain variations in reported outcomes. Quasi-experimental studies (Y. M. Huang et al., 2022; Liu & Zhang, 2022; Samadi et al., 2024) generally provide stronger empirical evidence through validated measures and triangulated designs, whereas qualitative research (Riza & Setyarini, 2020; Zain et al., 2022) offers rich contextual insights but suffers from limited generalizability due to small sample sizes and potential subjectivity. These methodological contrasts underscore the need for future research employing mixed-method or longitudinal designs to capture the breadth and depth of FL's impact on HOTS. Building on this foundation, the next section turns to the second research question, which examines how FL influences critical thinking and how this relates to the development of creative thinking (see Table 2).

Table 2. Flipped instruction plays a role in fostering students' critical thinking

No	Author	School Level	Research Design	The Impact
1	Sugrah et al. (2023)	Junior high, 182 students	Quasi-experimental	FCM-SSI model significantly improved critical thinking (especially analysis) and strengthened scientific attitudes (openness).
2	Chimmalee & Anupan (2023)	Undergraduate mathematics, 56 students	Quantitative	Flipped cloud learning enhanced mathematical reasoning and critical thinking.
3	Suwardika et al. (2024)	Elementary school teachers, 83 participants	Mixed-methods	FL with whiteboard animations improved self-regulation, analytical thinking, and communication.
4	Nugraheni et al. (2024)	Economic education students	R&D (4D model)	Developed an integrative FL model (IFCM) that has proven reliable and effective for enhancing critical thinking.
5	Yulian (2021)	English majors, 37 students	Quasi-experimental	FL enhanced critical reading skills, including accuracy, clarity, precision, depth, relevance, and logic.

6	Fadli et al. (2022)	Senior high school, 121 students	Quasi-experimental	FL in history classes significantly improved students' critical thinking abilities.
7	Hao et al. (2024)	University students, China	Quasi-experimental	Project-based FL increased critical thinking and creativity.
8	Etemadfar et al. (2020).	Private institution (intermediate level)	Quasi-experimental	The experimental group outperformed the control in English listening and critical thinking.
9	Orhan (2023)	University students, Turkey	Quasi-experimental	Flipped classes are most effective in improving critical thinking and attitudes, compared to online and traditional classes.
10	Alpat & Görgülü (2024)	Secondary school students	Quasi-experimental mixed-methods	The experimental group showed significant improvement in critical thinking; students expressed positive attitudes toward FL.
11	Helaluddin et al. (2025)	University students, Indonesia	Quasi-experimental	FL supported active and critical thinking growth across multiple critical thinking components.
12	Atwa et al. (2022).	Primary school, Palestine	Quasi-experimental	FL improved critical thinking and math performance, and reduced stress among students.
13	Yang et al. (2024)	International education students, China	Mixed-methods	Case-based FL promoted independent learning and collaboration, enhancing engagement and critical thinking.

This systematic literature review analyzed 13 empirical studies investigating the impact of flipped learning (FL) on higher-order thinking skills (HOTS), namely critical thinking, creativity, and problem-solving, in continuing education contexts. The thematic synthesis of these studies highlights three prominent patterns: first, the integration of FL with active learning pedagogies; second, the use of digital mediation to support learner autonomy; and third, context-specific effectiveness across disciplines and educational levels. While FL consistently shows potential for improving HOTS, its impact is shaped by how it is designed and implemented and by the methodological rigor of the studies reviewed.

Methodological quality varied across the studies. Quasi-experimental designs with larger samples and stronger statistical controls, such as those conducted by Sugrah et al. (2023) and Hao et al. (2024), provided more robust and generalizable evidence. In contrast, small-scale or descriptive studies like Yulian (2021) offered valuable insights into student learning experiences but had limited external validity. Similarly, research that relied on modest samples and self-reported measures (Chimmalee & Anupan, 2023; Suwardika et al., 2024) provided promising results but should be interpreted cautiously due to potential subjectivity and lack of statistical control. On the other hand, comprehensive research and development frameworks, such as Nugraheni et al. (2024), which created and validated the Integrative Flipped Classroom Model (IFCM) through iterative 4D design, reinforce the importance of ensuring content and construct validity when assessing FL outcomes.

Across different contexts, the effectiveness of flipped learning (FL) was closely tied to pedagogical alignment and instructional strategies. Studies incorporating inquiry-oriented methods, such as project-based learning (Hao et al., 2024) and socio-scientific issue instruction (Sugrah et al., 2023), reported stronger gains in both critical and creative thinking, highlighting the importance of engaging learners in authentic, problem-based tasks. Similarly, digital platforms and asynchronous discussion forums promoted self-regulation and reflective engagement, particularly within mathematics and teacher education programs (Orhan, 2023; Suwardika et al., 2024). The Integrative Flipped Classroom Model (IFCM) proposed by Nugraheni et al. (2024) provides further evidence of the value of thoughtful integration of content, technology, and pedagogy, effectively enhancing critical thinking among economics education students.

Flipped Learning and Creative Thinking

Evidence from five reviewed studies shows that flipped learning (FL) significantly enhances students' creative thinking, particularly in applied disciplines where tasks emphasize solution-based exploration and experimentation. As summarized in Table 3, FL creates space for learners to build foundational knowledge independently before class and then use in-class time for collaborative projects, brainstorming, and creative applications.

Table 3. The flipped learning approach affects creative thinking skills

No	Author	School Level	Research Design	The Impact
1	Moghadam & Razavi (2022)	Third-grade elementary students	Quasi-experimental (quantitative)	FL significantly improved both academic performance and creativity; the test group outperformed the control.
2	Molina-Torres & Pastor Blázquez (2024)	University students, Córdoba (Spain)	Mixed-methods, non-experimental	FL with active learning and supportive tech use fostered creativity and enhanced problem-solving.
3	Egwutvongsa (2022)	Technology institute students (Thailand)	Quasi-experimental (quantitative)	FL using varied teaching methods produced more creative ideas than the traditional teacher-centered model.
4	Tabieh & Hamzeh (2022)	10th-grade students, private schools (Jordan)	Quasi-experimental (quantitative)	Blended-FL improved students' creative thinking in mathematics.
5	Ariani et al. (2022)	Pre-service elementary teachers (geometry)	Quasi-experimental (quantitative)	Android-based inquiry FL enhanced creative thinking and mathematical problem-solving.

Findings from the five reviewed studies demonstrate that flipped learning (FL) significantly enhances students' creative thinking, particularly in applied disciplines where solution-based tasks allow for divergent thinking and experimentation. In product design education, Egwutvongsa (2022) found that FL using varied teaching techniques improved students' ability to generate original ideas, offering greater opportunities for exploration and collaboration compared to traditional teacher-centered instruction. Similarly, in

mathematics education, both Tabieh and Hamzeh (2022) and Ariani et al. (2022) reported that FL approaches, such as blended learning and Android-based inquiry models, enabled students to engage in problem-solving that promoted flexibility and originality. In these contexts, pre-class preparation allowed learners to absorb foundational knowledge independently, freeing classroom time for collaborative projects and creative application. These findings suggest creativity can flourish even in structured domains like mathematics when instructional time is reallocated toward active learning.

By contrast, creativity manifests through reflective thinking and pedagogical innovation in theoretical areas such as bilingual teacher education rather than the generation of novel designs or products. Molina-Torres and Pastor Blázquez (2024) emphasized that FL in higher education fosters creativity by encouraging learners to approach problem-solving reflectively, supported by institutional emphasis on digital pedagogy and learner autonomy. Such disciplinary differences likely reflect the nature of tasks assigned: applied fields provide more room for tangible experimentation, whereas theoretical fields emphasize conceptual innovation. Cultural context also influences these outcomes. For example, FL-based collaborative design in Thailand aligns with cultural values of group harmony (Egwutvongsa, 2022), while in Jordan it helps students move away from rote learning toward originality (Tabieh & Hamzeh, 2022). In Spain, it supports creativity through institutional frameworks prioritizing ICT and autonomy (Molina-Torres & Pastor Blázquez, 2024).

The effectiveness of FL in fostering creativity can also be interpreted through Amabile's (1983) componential theory, which highlights the interplay between domain-relevant skills, creativity-relevant processes, and task motivation. Within FL, pre-class activities such as video lectures or digital content build foundational knowledge, while class time emphasizes collaborative problem-solving, brainstorming, and creative production. This structure reduces cognitive load, provides psychological safety, and maintains learner autonomy, conditions essential for risk-taking and innovative thinking. Across contexts, FL's collaborative and ICT-supported environments encourage continuous engagement, experimentation, and idea formation, making it a valuable model for developing creativity and supporting competency sustainability.

Flipped Learning and Problem-Solving

Findings from eight reviewed studies demonstrate that flipped learning (FL) consistently enhances students' problem-solving abilities across educational levels. However, its impact often depends on how it is integrated with other pedagogical strategies. As outlined in Table 4, FL encourages learners to approach complex issues through collaborative tasks, real-world simulations, and technology-enhanced exploration, strengthening individual and group problem-solving skills.

Table 4. Flipped learning impact on students' problem-solving abilities.

No	Author	School Level	Research Design	The Impact
1	Pimdee et al. (2024)	Thai student-teachers	Mixed-methods sequential exploratory	A mix of teaching methods within FL improved problem-solving skills and overall academic performance.
2	G. J. Hwang & Chen (2023)	University students, Taiwan	Quasi-experimental	Group-based problem-solving in FL led to better learning outcomes.

3	Thi-Huyen et al. (2021).	HUST engineering students	Experimental	The DTIC model in FL improved teamwork and problem-solving attitudes by engaging students in solution-focused tasks.
4	Ivan et al. (2023)	Polytechnic Makassar, engineering students	Mixed-method	Maritime students showed enhanced problem-solving abilities and positive responses toward FL.
5	Thi Tan Nguyen et al. (2023)	Secondary school students, Vietnam	Quasi-experimental	FL with GeoGebra improved problem-solving skills, test performance, and attitudes toward learning.
6	Qomara et al. (2024).	High school students, Kutorejo	Quasi-experimental	FL with the Khan Academy app boosted problem-solving and critical thinking.
7	Ayunda et al. (2024)	High school students, Seyegan	Quasi-experimental (ADDIE model)	FL-based e-module enhanced problem-solving and fostered learning independence; user-friendly design confirmed.
8	Tung & Alissa (2021)	Senior high school students	Classroom action research	Problem-solving abilities improved progressively across cycles, achieving targeted competency levels.

Analysis of the eight reviewed studies indicates that flipped learning (FL) positively and significantly enhances students' problem-solving skills across diverse educational levels. However, its effectiveness often depends on how it is integrated with other pedagogical strategies. For example, Pimdee et al. (2024) found that Thai student-teachers' gains in problem-solving and academic achievement were more strongly linked to a blended problem-based learning (PBL) framework than to FL alone, suggesting that FL may function best as a complementary rather than a standalone model. Such blended approaches align with the principles of sustainable education by promoting collaboration, reflection, and adaptive thinking.

Several studies emphasize the value of collaborative problem-solving environments within G. J. Hwang and Chen (2023) and Thi-Huyen et al. (2021) demonstrate that when flipped classrooms incorporate collective problem-solving mechanisms, students achieve better performance, interaction, and knowledge construction. The DTIC model implemented by Thi-Huyen et al. (2021) further highlights how structured teamwork and design-thinking stages (such as empathy and problem reframing) nurture a problem-solving mindset among engineering students. These findings reinforce that collaborative learning designs, which foster shared cognitive responsibility and diverse perspectives, are more effective than purely individual approaches for developing solutions to complex, real-world problems.

Evidence from vocational education further illustrates the applicability of FL. Ivan et al. (2023) report that maritime students in a polytechnic program improved their problem-solving abilities and responded positively to FL, indicating its potential to cultivate adaptive, solution-oriented mindsets in professional training contexts. Similar outcomes were observed in mathematics education when FL was combined with interactive digital tools. Thi

Tan Nguyen et al. (2023) integrated GeoGebra, a dynamic geometry and algebra platform, enabling students to investigate mathematical concepts and explore multiple solution paths before class. Qomara et al. (2024) found comparable benefits using Khan Academy's phased practice modules, which provide personalized feedback and allow students to engage in self-directed problem-solving before in-class discussions. Both studies suggest that technology-enhanced FL supports conceptual modeling, visualization, and independent exploration, making classroom time more efficient and interactive.

Other disciplines show similar patterns. Ayunda et al. (2024) demonstrated that systematic instructional design using the ADDIE framework led to the development of FL-based e-modules that enhanced students' problem-solving abilities and self-regulation in biology learning. Tung and Alissa (2021) likewise reported that differentiated instruction in a flipped classroom supported gradual, cyclical improvements in problem-solving, with students progressing steadily through multiple reflective cycles. Together with Thi-Huyen et al.'s (2021) DTIC model, these findings underscore that iterative design processes within FL, emphasizing empathy, collaboration, and authentic application, foster teamwork and creative problem-solving.

Implications of Flipped Learning for Sustainable Education

The synthesis of reviewed studies shows that flipped learning (FL) holds strong potential for advancing sustainable education by fostering higher-order thinking skills (HOTS), learner autonomy, and resource-efficient practices. By shifting instructional content delivery to pre-class activities and using in-class time for active engagement, FL promotes reflective and collaborative learning while using available resources better (Araiza-Alba et al., 2021; Suwardika et al., 2024). It has also been shown to support environmentally conscious and collaborative practices, aligning with the broader goals of 21st-century education (Supiandi et al., 2019; Zain et al., 2022).

However, outcomes are not uniform. Several studies indicate that FL's effectiveness depends heavily on contextual factors such as digital literacy, instructional design quality, and learner readiness. For example, in contexts with low technological infrastructure or limited scaffolding, students struggled to fully benefit from FL, and in some cases, low learner motivation reduced its expected impact (Fan et al., 2024; Samadi et al., 2024). Methodological limitations, such as small sample sizes, absence of control groups, and inconsistent reporting of statistical significance, also constrain the generalizability of findings, underscoring the need for careful interpretation and more rigorous future studies.

Beyond immediate outcomes, FL contributes to the sustainability of education by cultivating self-regulated learning skills. Students trained in FL settings learn to manage their study schedules, set personal learning goals, and evaluate their progress independently, competencies that are critical for lifelong learning and resilience in a rapidly changing world (Ibrahim et al., 2018; Samadi et al., 2024). The adaptability of FL has been demonstrated across diverse cultural contexts, from Indonesia and Iran to Vietnam and Spain, reflecting its global relevance and flexibility (Ivan et al., 2023; Molina-Torres & Pastor Blázquez, 2024; Thi Tan Nguyen et al., 2023).

The practical implications of these findings highlight the need for adaptive curriculum design, targeted teacher training in flipped classroom management, and investment in inclusive digital infrastructure. Effective implementation also requires formative

assessments that promote deep reflection and collaborative tasks linked to global or local issues (G. J. Hwang & Chen, 2023; Rahmatika et al., 2024). These insights suggest that FL should not be viewed merely as a teaching technique but as a sustainable pedagogical framework capable of transforming education systems toward inclusivity, adaptability, and long-term relevance.

CONCLUSION

Flipped learning (FL) has shown considerable potential to enhance higher-order thinking skills (HOTS), critical, creative, and problem-solving, across various educational levels and contexts between 2021 and 2025. By shifting content delivery outside the classroom and using class time for active, reflective, and collaborative learning, FL supports student autonomy, academic achievement, and sustained cognitive engagement. Each dimension of HOTS benefits uniquely: critical thinking is strengthened through structured analytical tasks and evidence-based reasoning; creativity thrives in inquiry-based and interdisciplinary activities supported by digital media; and problem-solving develops through authentic simulations and team-based projects. Beyond individual skills, FL aligns with continuing education's broader goals of resource efficiency, lifelong learning, and learner resilience, with its adaptability confirmed across sociocultural settings, including Indonesia, Spain, Iran, and Vietnam.

Despite these promising outcomes, several limitations remain. Most of the reviewed studies were small-scale or quasi-experimental, limiting the generalizability of findings. Longitudinal evidence on the sustained development of HOTS is scarce, and possible publication bias toward positive outcomes warrants caution. Research on FL in resource-constrained or underrepresented contexts is also limited, and systematic cross-cultural comparisons are lacking. These gaps highlight the need for a more nuanced and rigorous understanding of FL's impact. Future studies should therefore employ large-scale, mixed-method, and longitudinal designs to capture both immediate and long-term effects of FL on HOTS. Comparative research across diverse cultural and socioeconomic contexts is also necessary to examine how contextual factors influence implementation and outcomes. Additional attention should be given to FL's feasibility in low-resource settings and its integration with other pedagogical models.

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