

REVIEW ARTICLE

Integrating Artificial Intelligence into Language Teaching Approaches: A Systematic Review of Flipped Classrooms

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ABSTRACT - Including artificial intelligence (AI) in flipped classrooms has become a revolutionary technique for education since it provides creative ideas to improve the teaching and learning environments. Still under investigation, though, is the degree and impact of such integration, especially in relation to language learning and educational developments. Examining papers published between 2015 and 2024, this systematic literature review looks at the integration of artificial intelligence in flipped classrooms using the PRISMA framework for a rigorous and open approach. Using Scopus and Web of Science databases, advanced searches turned out 31 important studies from which this review is based. Three major themes define the results: (1) AI integration in flipped classroom models, (2) the use of ChatGPT and conversational AI in flipped learning, and (3) the role of AI in fostering language learning and student engagement. Results revealed several uses of artificial intelligence in offering customised education, real-time feedback, and flexible learning opportunities even as issues including accessibility and ethical considerations are resolved. Understanding artificial intelligence-driven changes in interactive and cooperative learning settings highlights how imaginatively the flipped classroom idea could be considered. Recent studies highlight the need for research on scalable implementation, equitable access, and long-term impact to enhance the effectiveness of AI-driven flipped classrooms. This paper contributes to the expanding body of information on the junction of artificial intelligence and flipped learning and has important implications for legislators, teachers, and academics aiming at creative innovation in modern educational methods.

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1.0 INTRODUCTION

Recently, the flipped classroom model is a pedagogical strategy that reverses conventional teaching approaches by giving individual learning in the pre-classroom and group activities in the classroom top priority that has attracted interest. This creative approach turns the emphasis of education to the student, where before class students interact with teaching materials, which are usually videos or reading materials. Under teacher direction, students engage in interactive, problem-solving, app-based activities in class. The quality and accessibility of the pre-class materials as well as the capacity of teachers to involve various students during class define the effectiveness of the flipped classroom even if it has great potential to improve learning results (Anbu et al., 2021; Fira et al., 2024; Sudarmaji et al., 2021). Teachers and researchers have been motivated by this issue to investigate how the development of technology such as artificial intelligence (AI) may transform the flipped classroom paradigm by tackling these issues and thus provide a more customised and effective learning environment. Due to these challenges, teachers and researchers have started exploring how new technologies like artificial intelligence (AI) can improve the flipped classroom by making learning more personalised and effective.

Artificial intelligence can replicate human cognitive ability and handling of difficult problems. So far, it has been progressively included in the curriculum. For flipped classrooms, which include virtual instructors, adaptive learning systems, and natural language processing technologies, artificial intelligence techniques are invaluable. These tools can provide personalised learning experiences before class by tailoring content to individual students' needs, monitoring progress, and providing real-time feedback. For example, generative AI such as ChatGPT allows students to explore topics interactively, clarify doubts instantly, and practice language skills through contextual coaching (Bin-Hady et al., 2023; Rahman & Watanobe, 2023; Xiao & Zhi, 2023). Such synthetic artificial intelligence skills enable students to arrive for class better prepared, thereby enhancing the cooperative and problem-solving activities that are fundamental to the flipped paradigm. Beyond classroom participation, artificial intelligence systems help educators by providing insights into student performance, advice on numerous teaching strategies, and support of inclusive, data-driven decision-making.

Bringing AI into flipped classrooms marks a big change in how to approach education, blending the strengths of human teaching with the reach and accuracy of modern technology. However, using AI in this setting also brings challenges. There are important concerns around ethics, access, data privacy, and the risk of relying too much on technology. Furthermore, it is essential that teachers be adequately trained, supported with proper infrastructure, and educated about the technology's nuances, including its strengths and weaknesses. This article aims to systematically review existing research on the integration of AI in pre-class and in-class learning within the flipped classroom model. It focuses on how AI is applied, the tools involved, and the impact on teaching practices. The

review draws from recent studies to explain how AI supports these learning phases and contributes to more engaging, inclusive, and effective instruction.

1.1 Artificial Intelligence in Flipped Classrooms: Opportunities and Challenges

The use of artificial intelligence (AI) in education, particularly in flipped classrooms, holds tremendous promise in enhancing learning personalisation and active participation. In teaching and learning processes, AI tools such as generative AI and intelligent teaching assistants enable the development of personalised learning experiences through adaptive content, real-time assessment, and feedback (López-Villanueva et al., 2024; Mohamad et al., 2024; Zharmukhanbetov & Singh, 2023b). As an example, Zharmukhanbetov & Singh (2023b) examined how adaptive content delivery systems recommend tailored learning materials and also track student milestones, which helps in capturing and sustaining attention in the classroom. Huang et al. (2023) also noted the positive impact of AI-powered personalised video recommendations for students on their motivation and participation in the flipped class structure. The integration of AI in the flipped classroom model also facilitates the acquisition of advanced skills like creativity, critical thinking, and problem solving due to the responsive and interactive nature of the learning experiences (Silitonga et al., 2024). Moreover, the personalisation of instruction by AI-powered intelligent teaching assistants can reduce the burden of educators and increase the efficacy of flipped classrooms (Teng et al., 2024).

The integration of artificial intelligence (AI) in flipped classrooms comes with considerable advantages, and at the same time, presents notable challenges. Like Zharmukhanbetov & Singh (2023a) pointed out, greater ethical issues such as the protection of data privacy and the mitigation of bias in AI systems require attention for the safe use of these technologies. Moreover, the unequal access to technology remains a huge challenge that has the potential to widen educational gaps (Zouhri & Mallahi, 2024). For effective use, teachers also need to be trained on emerging tools and instructional methods, which brings a different dimension to professional development in the field (Zouhri & Mallahi, 2024). Another challenge is the students' openness towards these changes; comprehension of learner attitudes towards AI tools is essential for the successful implementation of AI-driven flipped classrooms. Research shows that although academic performance improves, some students find these classrooms stressful and overwhelming (Lapitan et al., 2023). Therefore, the successful use of AI in enhancing personalised learning opportunities and engagement in flipped classrooms will require careful strategising around ethical, logistical, and perceptual matters (Lapitan et al., 2023; López-Villanueva et al., 2024).

1.2 Developing Research Questions Using the PICO Framework

As with any other systematic literature review, SLRs start with formulating research questions, which is the most critical part of conducting an SLR, because it sets the anchor and focus for the entire review process. These questions help delineate the boundaries and aspects of the SLR, enabling informed inclusion or exclusion of studies while ensuring relevance and specificity. Comprehensive and precise scope outlines avoid major gaps in the search results and ensure every important study covering critical angles of the subject matters researched using systematic methodology. Such an approach strengthens efforts made towards proving or disproving a hypothesis and adds to existing literature. Research questions greatly help in the classification and arrangement of data extracted from included studies and serve as an outline for the advanced analysis of the findings and results towards meaningful conclusions. They aid in making the review unambiguous and non-vague while focusing the study towards specific issues, which in turn makes the results relevant and actionable. Precise research questions help in transparency and reproducibility of a review, especially in enabling other researchers to validate the results or broaden the study by extending it to other interconnected areas. In sum, the gaps in literature, assessing intervention effectiveness, or trends within a certain area all require research questions that will keep them aligned with the objectives of the study. Hence, the whys of a purpose stand to be the foundation of a valuable and thorough attempt at a systematic literature review.

This review adopts the PICO framework to structure its research questions. PICO, introduced by Lockwood et al. (2015), is especially useful in qualitative reviews and comprises three elements: Population, Interest, and Context.

- i. Population (P) refers to the specific group under investigation, such as a defined age group, educational level, or learner category.
- ii. Interest (I) identifies the core issue, behaviour, intervention, or phenomenon being studied.
- iii. Context (CO) denotes the setting or environment in which the population and interest interact. This may include geographic, cultural, or institutional factors.

Using the PICO framework ensures that research questions are focused, structured, and aligned with the review's goals. This study addresses the following three research questions:

1. How does the integration of artificial intelligence (AI) enhance the learning outcomes of students in flipped classroom models?
2. What do existing studies report about students' perceptions and experiences when using ChatGPT and conversational AI tools in flipped classroom settings for language learning?
3. What does the literature reveal about the effects of integrating AI tools into flipped classroom pedagogy on language skill development and learner engagement in ESL and EFL contexts?

2.0 METHODOLOGY

The PRISMA framework (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) set by Page et al. (2021), has become one of the accepted frameworks concerning systematic literature reviews ensuring open, complete, and consistent processes.

Adherence to PRISMA criteria facilitates accuracy and the thoroughness of analyses by providing a detailed approach to the study of reviews which includes a controlled framework for examination, selection, and inclusion of screening components. In addition, PRISMA highlights the importance of randomised studies owing to their ability to reduce bias and provide substantial evidence for a review's determination, thereby strengthening its conclusions. For this study, the Web of Science and Scopus databases were chosen because of their wide coverage and reliability.

The PRISMA framework identifies four essential stages as identification, screening, eligibility, and data abstraction. In the identification stage, study materials are retrieved to the relevant scope through exhaustive search within databases. The screening phase includes checking the studies against specific criteria to remove irrelevant and poor-quality research work. In the eligibility stage, a full assessment of the remaining studies is conducted to ascertain that all meet the requirements set for inclusion. Lastly, in the data abstraction step, data from the chosen studies are extracted and combined in an organised manner, forming reliable conclusions. The craftsmanship of this approach guarantees that the systematic review is performed alongside academic standards and trustworthy frameworks that uphold credibility to support other research endeavours and practical implementations.

2.1 Identification

This study undertook several steps of a systematic review to obtain an extensive collection of pertinent literature. The work commenced with the generation of the initial keywords, which were refined by generating corresponding words from dictionaries, encyclopaedias, prior research, and thesauri. After all words were compiled, appropriate search strings were prepared as shown in Table 1 for the Scopus and Web of Science databases. This step of the systematic review process resulted in recovering 412 publications from the two databases, which were aligned with the review's focus.

Table 1

The search string

| Database | Search String |
|----------------|--|
| Scopus | TITLE-ABS-KEY (("artificial intelligence" OR "ai") AND ("flipped classroom" OR "flipped learning" OR "inverted classroom" OR "reverse teaching" OR "active learning classroom")) AND (LIMIT-TO (SUBJAREA , "SOC") OR LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "ARTS")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024)) AND (LIMIT-TO (PUBSTAGE , "final")) Date of Access: December 2024 |
| Web of Science | ("artificial intelligence" OR "ai") AND ("flipped classroom" OR "flipped learning" OR "inverted classroom" OR "reverse teaching" OR "active learning classroom") (Topic) and 2024 or 2022 or 2023 or 2021 or 2020 or 2019 or 2018 or 2017 (Publication Years) and Article (Document Types) and English (Languages) Date of Access: December 2024 |

2.2 Screening

In this systematic literature review (SLR), the screening process was crafted to ensure that the studies selected as part of the review answered the relevant research questions and followed the inclusion and exclusion criteria set for the study. Each record of relevant publications was also free of duplicates and underwent a comprehensive review to assess relevance. Artificial intelligence tools were particularly useful for screening studies centred on the flipped classroom model. A total of 304 publications were excluded from the start because they contained non-English publications, publications prior to 2015, documents that fell under conference papers, book series, reviews, chapters, works in press, and other English language works of non-social sciences, computer science, or arts and humanities.

Following the preliminary screening, 108 publications were retained and processed following the specific set of inclusion and exclusion criteria, which are detailed in Table 2. The primary focus of the criteria was to capture only peer-reviewed journal articles to maximise relevance and ensure that the contribution to the field is recent; hence, articles published between 2022 and 2024 were considered. In a bid to maintain the relevance of the literature, certain types of publications were excluded, such as book series, book reviews, meta-syntheses, meta-analyses, conference proceedings, and non-peer reviewed chapters. Additionally, 18 duplicate records were identified and removed in this stage. This process combines a comprehensive review as well as careful assessment of the studies in order to be confident that they are relevant and reliable, which in turn enhances the robustness of the SLR process.

Table 2*The selection criterion in searching*

| Criterion | Inclusion | Exclusion |
|-------------------|--|--|
| Language | English | Non-English |
| Timeline | 2015 – 2024 | < 2015 |
| Literature type | Journal (Article) | Conference, Book, Review |
| Publication Stage | Final | In Press |
| Subject Area | Social Sciences, Computer Science, and Arts and Humanities | Besides Social Sciences, Computer Science, and Arts and Humanities |

2.3 Eligibility

In the third step, labelled as the eligibility stage, a total of 90 articles were selected for review. At this step, the titles and main parts of each article were checked against the criteria to ensure that they met the objectives and goals of the research. This process resulted in 59 articles being excluded, which were irrelevant to the scope of the study, abstract titles, unrelated abstracts, no full text, claim titles or were not empirical based. In the end, 31 articles were retained for review.

2.4 Data Abstraction and Analysis

This study used integrative analysis as an evaluation strategy to assess and combine disparate research designs, especially those involving quantitative research. The focus for this approach was to organise and discern central themes, primary issues, and sub-issues alongside the context of the study. The initial part of the thematic development process began during the data collection stage. Figure 1 demonstrates that the authors combed through all 31 analysed publications to identify claims and content related to the study's themes as described in the topic outline. The authors also reviewed some primary studies around the use of AI in the flipped classroom model and analysed the methodologies alongside the findings presented in those studies.

To build themes within the scope of the study, the first author worked closely with the co-author so that the thematic structure was constructed based on the available evidence. Throughout the data analysis, a detailed log was kept to record any observations and interpretations, interpretations that were not questions, as well as reflections linked to the data analysis. In the last stage, the authors reviewed the findings with the goal of resolving all inconsistencies that were observed during the thematic development stage. Conceptual interpretation differences were resolved through discussions among all authors for the sake of unified agreement on the design coherence of the themes. The number and details of the primary studies analysed are presented in Table 3 (see Appendix).

2.5 Quality of Appraisal

As per the guidelines established by Kitchenham (2007), after selecting the primary studies defined as the original research articles, papers, or documents directly incorporated into the systematic review following the initial selection process and serving as the principal sources of evidence for addressing the research questions, their quality must be evaluated and quantitatively compared. This study employs the quality assessment criteria established by Abouzahra et al. (2020), comprising six quality assessments for our systematic literature review (SLR). The evaluation methodology for each criterion encompasses three potential ratings: "Yes" (Y), assigned a score of 1 when the criterion is completely satisfied; "Partly" (P), receiving a score of 0.5 when the criterion is partially fulfilled but exhibits deficiencies; and "No" (N), which is allocated a score of 0 when the criterion is entirely unmet.

QA1. Is the objective of the study explicitly articulated?

QA2. Is the significance and utility of the work explicitly articulated?

QA3. Is the research technique distinctly defined?

QA4. Are the concepts of the methodology distinctly articulated?

QA5. Is the work evaluated and assessed against comparable projects?

QA6. Is the scope of the task considered restricted, and what criteria contribute to this distinction?

All steps in the evaluation procedure have been formulated in a systematic manner in order to guarantee that all clear and consistent steps are implemented in the study selection process and scoring. In Table 3, there is presented a quality appraisal (QA) that is conducted on the study considering three experts and several criteria. Each expert judges the study based on a set of criteria, and for each criterion, he/she assigns a score of either "yes," "partly," or "no". An explanation is given:

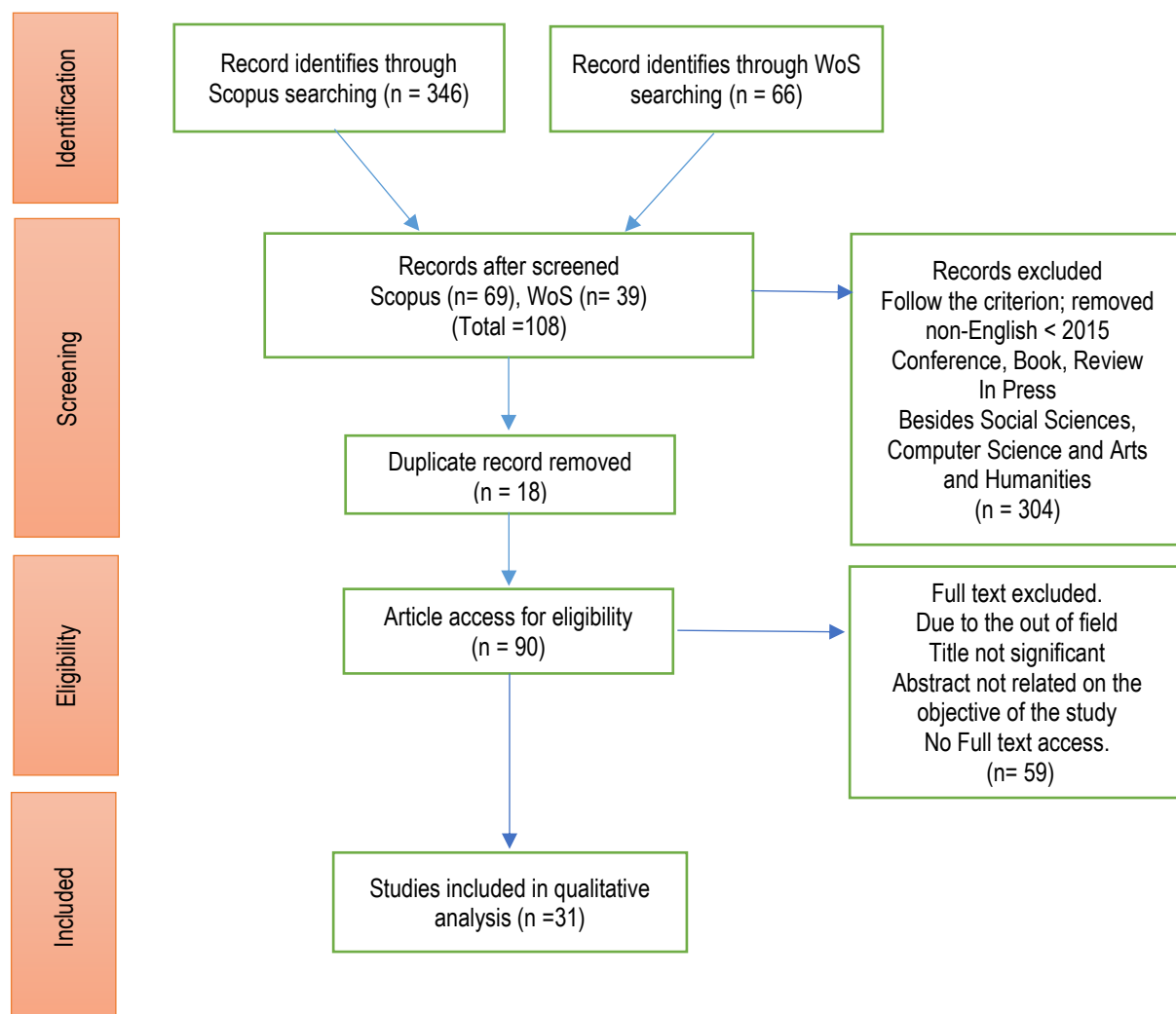
Table 4

Criteria-Based Quality Assessment (QA) process for study evaluation

| Quality Appraisal | Criteria Description |
|--|---|
| QA1. Is the objective of the study explicitly articulated? | This criterion considers if the study's objective is clearly defined, described, and documented. Clearly defined objectives allow focus on particular areas of an investigation. |
| QA2. Is the significance and utility of the work explicitly articulated? | This criterion evaluates the clarity of the study's significance and potential impact. It measures the importance and scope of influence of the study. |
| QA3. Is the research technique distinctly defined? | This assesses the adequacy and clarity of the approach to the research problem in terms of the study objectives. Clear methodology is vital in establishing the validity and reproducibility of the study. |
| QA4. Are the concepts of the methodology distinctly articulated? | This evaluates the coherence of the theoretical framework and important concepts. Well defined concepts are needed for the accurate implementation of the study's methodology. |
| QA5. Is the work evaluated and assessed against comparable projects? | This evaluates whether the work has been put into relation with other available works. Comparative studies situate the work within the broader field of scholarship and highlight the work's contributions. |
| QA6. Is the scope of the task considered restricted, and what criteria contribute to this distinction? | These criteria with revisions of a comparative nature serve as the individual grade component assigned by each expert to the evaluations. To pass for the next stage, the sum derived from the three experts' scores must exceed the score of 3.0 to enable the next phase. This benchmark ensures advancing phases is restricted to only studies that follow a specific quality threshold. |

Figure 1

Flow diagram of the proposed searching study



3.0 RESULTS

In accordance with the quality evaluation, Table 5 outlines the results from the selected primary studies, focusing on their compliance with the evaluation benchmarks. The review, synthesised in this section, provides revealing snapshots regarding the academic rigour and methodological rigour of the research activities focused on AI-based applications in education undertaken by the educational institutions within the scope of this review. In particular, there are various proportions of compliance with the set quality parameters which inform about the field's advancement and its shortcomings.

The papers, as a whole, exhibit an above-average level of methodological uniformity and singularly favourable scoring on the key indicators of the quality assessment in the study design (QA1), data collection (QA2), and data analysis (QA3) stages. This reinforces the notion that there is a growing instructional emphasis directed towards the use of rigorous qualitative AI educational integration frameworks. Papers fulfilling these criteria attest to compliance with prevailing scholarly norms, which preconditioned the trustworthiness, repeatability, and reproducibility of the outcomes presented.

Table 5

Quality assessment of research papers on AI integration in flipped classrooms

| PS | QA1 | QA2 | QA3 | QA4 | QA5 | QA6 | Total Mark | Percentage (%) |
|----|-----|-----|-----|-----|-----|-----|------------|----------------|
| 1 | 1 | 1 | 1 | 0.5 | 0.5 | 1 | 5 | 83.33 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 3 | 1 | 1 | 1 | 1 | 1 | 0.5 | 5.5 | 91.67 |
| 4 | 1 | 1 | 1 | 0.5 | 1 | 1 | 5.5 | 91.67 |
| 5 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 6 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 7 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 9 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 11 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 13 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 15 | 1 | 1 | 1 | 0.5 | 1 | 1 | 5.5 | 91.67 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 17 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 18 | 1 | 1 | 1 | 0.5 | 1 | 1 | 5.5 | 91.67 |
| 19 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 20 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 21 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 22 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 23 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 24 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 25 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 26 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 27 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 28 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |
| 29 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 30 | 1 | 1 | 1 | 0.5 | 0.5 | 0.5 | 4.5 | 75 |
| 31 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 100 |

As ChatGPT's use in the flipped classroom model and exploring the AI's influence on cognitive skills development, the highest-rated studies stand out, particularly in concern of relevance and innovations. These papers proudly claiming flawless or near flawless overall assessments of 100% and over 90%, seamlessly integrate theory and practice while offering novel contributions that advance the research horizon in educational technology.

A study subset, however, displayed gaps in explaining the justification of AI tool integration (QA4) and being thorough with ethical reflections (QA5). Papers scoring lower with these attributes where percentages were below the 80% threshold highlight concerning gaps in framing AI's role in pedagogy as well as in proactively dealing with the inequity and accessibility challenges. These gaps point toward a need for more bounded AI in education efficacy frameworks.

The results focus on concerns related to the scope where some papers integrate other disciplines compared to narrow scope approaches. Studies with mediocre overall ratings, often due to insufficient engagement with QA6 (discussions on limitations and future research), underline the dire need to contextualise their findings within the educational technology discourse. Addressing these gaps would increase the practical and/or theoretical contributions of future research.

As with all other domains of activity, the application of research in AI-assisted education is very active. Even though in many studies there are commendable quality levels, the spread of scores on some indicators identifies gaps for improvement, especially those that deal with the ethical and contextual complexities of AI integration. These assessments are important for developing academic dialogue in this emerging field. The quality assessment for the selected papers is summarised in Table 4.

Highest Score: The paper associated with PS 2 received the highest score of 100% (6.0). This was granted on the grounds that claiming clear purpose, usefulness, methodology, defined concepts, comparison with other work, and even limitations were discussed.

Lowest Score: The paper with PS 5 was the lowest scoring paper, receiving 75% (4.5). This paper met the criteria for a concept of the approach and comparison with other work but did not address the limitations in a satisfactory manner.

The analysis process included verification of preconceived problems through group discussions to eliminate biases during theme formulation. Aside from gathering opinions from other co-authors, the themes were systematically evaluated to determine their decisiveness, relevance, and alignment with the study. Any elements or themes that had distinct discrepancies were merged to form a more consistent outcome through a logical approach. Figure 2 presents the finalised themes, visually depicting the intersection of AI integration in education and the flipped classroom model, which collectively form the foundation of AI-powered flipped learning. Final theme adjustments were made after the themes were thoroughly critiqued for plausibility and enhancement of conciseness with the authors' insights.

3.1 AI Integration in Flipped Classroom Models

The incorporation of artificial intelligence (AI) in the flipped classroom model has demonstrated the promise of improving educational outcomes for virtually every discipline. Multiple studies pointed out the improvement of student involvement, learning outcomes, and AI academic performance when employing AI-driven approaches. Lv (2023) and Liu (2024) reported significant academic achievements regarding piano learning with the use of AI-integrated flipped classrooms. Engagement was also noted by Lv (2023) who reported mean scores of 3.54 (SD =1.07) with regard to the construct of involvement, and Liu (2024) focused on predictive models that evaluated teaching per fuzzy neural inference systems and affirmed AI's role in consistent results. Equally, Hu (2021) reported the enhancement of English listening skills through AI fusion algorithms, where the experimental group's scores far exceeded controls (82.95 to 79.9). With these findings, it is evident that AI serves to provide custom-fit learning experiences which increase participation and academic achievements.

AI also enhances the efficiency and precision of instructional delivery and assessment. Sanchez-Gonzalez & Terrell (2023) reported that the integration of AI through voice-over lectures in medical education shortened the length of the lecture hours (54.1 ± 14.3 hours) while still achieving appropriate levels of understanding. In the context of music education, Peng & Wang (2022) found that convolutional neural network analysis was associated with a 98.25% accuracy rate in comparison to a 5.01% higher accuracy level using a traditional approach. Moreover, Tan & Cao (2022) demonstrated the objective and accurate assessment capabilities of a GA-BPNN model, which evaluated music flipped classrooms and surpassed traditional models with a genetic algorithm optimised backpropagation neural network. This was furthered by Cheng & Wang (2021) who added real-time feedback and video feedback in sports education, greatly enhancing the efficiency of evaluation and supporting teachers' professional development. All these applications indicate a shift towards more individualised, feedback oriented, and data-driven pedagogies in the context of the flipped classroom.

In addition, the artificial intelligence (AI) greatly facilitates students' cognitive and behavioural engagement. Li & Peng (2022) reported that platforms assisted by AI reduced the cognitive load of students, aided autonomy, and increased the confidence in classroom interactions. Zhang et al. (2022) demonstrated how AI and edge computing can be used in the creation of immersive audiovisual resources in increasing the motivation of learners and helping them gain better comprehension. In spite of these developments, key research problems are still there. As Lv (2023) and Tan and Cao (2022) stated, more nuance is in demand in terms of exploring motivation, cognitive burden, and self-regulation. To evaluate the long-term viability of the suggestion on how AI would approach academic success, Sanchez-Gonzalez and Terrell (2023) suggested that additional long-term longitudinal research is required, and Liu (2024) reported that perfecting its predictive models should also be given more consideration to improve cross-

disciplinary applicability. They are crucial to fill the mentioned gaps and maximise the use of AI and achieve its transformational value in the educational setting.

3.2 ChatGPT and Conversational AI in Flipped Learning

Integration of ChatGPT and conversational AI in the flipped learning settings has led to vast improvement of cognitive involvement of learners, learning ability, and academic achievement. Li (2023) proposed the ChatGPT-based flipped learning guiding approach (ChatGPT-FLGA) that was observed to enhance the aspects of self-efficacy, motivation, creativity, and overall performance of the learners. Similarly, Essel et al. (2024) stated that ChatGPT enabled critical, reflective, and creative thinking skills in the undergraduate students. Huesca et al. (2024) have reported significant improvements in standardised learning outcomes in the context of ChatGPT being utilised in a flipped classroom framework in the context of an educational programming course. All these studies indicate the strength of ChatGPT in providing personalised academic assistance and encouraging higher-order thinking on a broad range of academic subjects and student types.

One of the strong points of ChatGPT is the possibility to close the gap between in-class and out-of-class, as it once again emphasises continuous learning and communication. Jeon & Lee (2024) have shown that the use of chatbots in flipped learning increased the engagement and interaction of learners in EFL classrooms to a significant level, where the experimental group showed an increased ability in the speaking skill and the perception level of communicative interaction when compared to the control group. In addition, Lin & Mubarak (2021) demonstrated that AI chatbot systems which were facilitated by mind maps enhanced the speaking and interactional organisation of the students. Wang et al. (2024) supported that the structured prompt engineering did increase the efficiency of information retrieval and learning; the role of good prompt design could not be underestimated. Collectively, the findings prove that ChatGPT enables real-time communication, self-study, and access to high-quality resources, which makes it an affordable educational tool that could be scaled.

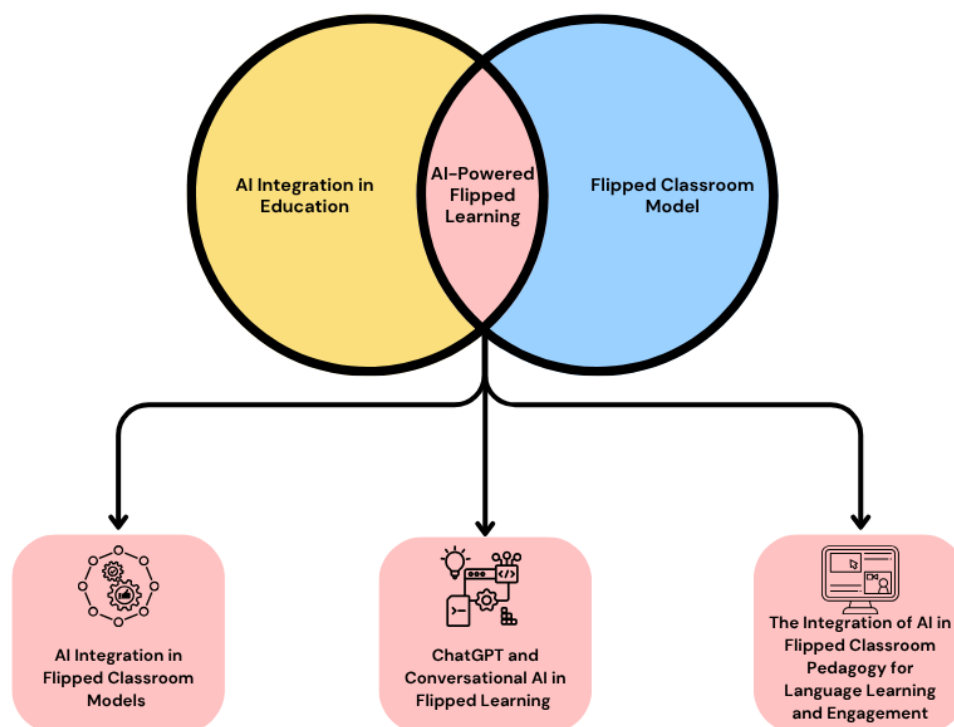
ChatGPT utility in technical fields has also been described in detail. Especially in programming and engineering training, where task-specific instruction and rehearsal are essential. Gasaymeh & Almohtadi (2024) proposed the FIL model, which integrates ChatGPT and has been shown to yield better results in programming skill development compared to traditional flipped classrooms. This was reaffirmed by the engineering course evidence given by Huesca et al. (2024), who pointed out that ChatGPT assisted in making learners understand complicated topics more efficiently. The results are additionally backed by the research that highlights the fact that ChatGPT can be used to offer personalised scaffolding, motivation management, and creativity boosts (Li, 2023; Essel et al., 2024; Lin & Mubarak, 2021). In general, the ability of ChatGPT to offer personalised learning pathways makes it valuable in a flipped learning model, especially when the learners should be provided with differentiated instructions. The future research needs to focus on improving the area of prompt engineering and investigating the large-scale use of it and long-term results by providing constant feedback and assessment in the classroom.

3.3 The Integration of AI in Flipped Classroom Pedagogy for Language Learning and Engagement

Artificial intelligence (AI) use in flipped classroom teaching has been shown to be effective in teaching language, especially when it comes to motivation, interest, and mastering the skills. Recently, Jiang et al. (2023) recently examined the effects of automatic speech recognition (ASR) on oral fluency and accuracy, finding that learners who used ASR during pre-class activities achieved higher scores in phonological fluency and accuracy compared to those in the control group. The results, however, further showed that learners once again showed poor balance of fluency and accuracy, thus showing the necessity of high precision in task design. A similar study by Wu & Wang (2021) also came to the conclusion that the AI-enhanced flipped classrooms had resulted in learning autonomy in acquiring listening and speaking skills, but the problems with self-management skills development remained an issue. Overall, all of these empirical works indicate that AI has the potential to enhance active and critical language learning and, at the same time, uncover the weaknesses that need improvement in pedagogy.

In addition, AI-based platforms have played a pivotal role in catalysing the provision of individualised learning and learner participation in flipped environments. As shown by Huang et al. (2023), this had the benefit of improving the learning performance and engagement, specifically among moderately motivated learners during a systems programming course through personalised video recommendations created using AI. A similar investigation by Li (2021) revealed that a mobile-based flipped classroom implemented through Tencent QQ facilitated asynchronous engagement and distribution of resources as well as the easing of a long-term discussion, which aids in self-directed learning. All these studies can confirm the potential of AI to adapt the instructions to the needs of learners, enhance the engagement with the content, and develop autonomy in the flipped learning cycle.

The implementation of AI in a flipped language instruction setting is also reformulating the roles of pedagogy and may hold avenues of opportunity as well as shortcomings for both instructors and learners. López-Villanueva et al. (2024) noted that AI has the potential to individualise learning, revolutionise classroom-based participation, and at the same time increase the necessity of educator flexibility due to the speed at which technology is changing. Wu and Wang (2021) pointed out that when learners engaged with the internet-related resources mediated via AI, they were provided an opportunity to investigate language resources actively, which facilitated the enhanced participation and performance. However, there are still a number of limitations. Jiang et al. (2023) found that while oral accuracy improved, fluency sometimes declined. Similarly, Huang et al. (2023) observed that AI suggestions were most effective for moderately motivated learners, indicating limitations for those who were either highly motivated or unmotivated. In addition, López-Villanueva et al. (2024) highlighted that the need for educators to master new tools could place an added burden on teaching staff. These findings, in combination, afford the dynamic, changing nature of AI-enabled flipped classrooms and the need to consider them carefully in terms of long-term viability and future pedagogical relevance.

Figure 2*Themes identified in AI integration for flipped learning pedagogy*

4.0 DISCUSSION

This systematic review intended to explore the integration of artificial intelligence (AI) into flipped classroom pedagogy across disciplines with a specific focus on learning outcomes, student experiences, and language skill development. Based on the findings, AI integration holds significant pedagogical promise by enhancing learner engagement, academic achievement, and instructional precision. Studies by Lv (2023), Liu (2024), and Hu (2021) show evidence that music, language, or medical education provided better engagement and learning outcomes in AI-based flipped classrooms. These benefits are supported by constructivist principles, where students are actively engaged with personalised tools and feedback mechanisms that deepen understanding. However, challenges such as students' motivation, cognitive burden, and cross-disciplinary applicability remain underexplored. This highlights the importance of conducting longitudinal studies to ensure the sustainable impact of AI, particularly when the combination of AI and flipped pedagogy is positioned as a long-term teaching innovation.

The use of ChatGPT and conversational AI in flipped classrooms further reinforces the educational benefits of adaptive technologies. The reviewed studies showed that ChatGPT, in addition to making the students creative and motivated, also provides them with greater autonomy and communication abilities in various settings (Li, 2023; Essel et al., 2024; Jeon & Lee, 2024). These results are tightly connected to schema theory and scaffolding theory, as the AI tools can assist in pre-classes and in-classes because they facilitate the activation of the levels of prior knowledge and graduated support. In addition, ChatGPT serves as a transitioning method between real-time and self-paced learning, ensuring continuous reinforcement of academic content. Nonetheless, with its favourable feedback, the literature also shows the need to optimise prompt engineering and investigate the long-term outcomes. This level of refinement would support that AI tools get to serve differentiated instruction in ways that do not reinforce the surface-level engagement and reliance, particularly in the settings that necessitate complex language application and higher-order thinking.

AI integration in language learning settings also reveals important insights into how flipped classrooms can be optimised. Studies by Jiang et al. (2023) and Wu and Wang (2021) described improvements in oral accuracy, listening skills, and learner autonomy through AI tools such as automatic speech recognition and mobile-based flipped platforms. These results confirm the relevance of Corrective Feedback Theory, in which the feedback that can be provided by the AI and in a time-sensitive manner reinforces language proficiency. Additionally, Huang et al. (2023) also highlighted AI tools catered effectively to moderately motivated learners, which may not be universally applicable. The indicators of practical constraints include concerns over task design, trade-offs between fluency and accuracy, and teacher preparedness. Though the theoretical basis is strong, the implications of the findings indicate that the distribution of the benefits of the use of AI in the flipped language classrooms might be unequal and contingent depending on whether or not it is carefully calibrated.

Overall, this review highlights that flipped classrooms with the integration of AI are a transition in the direction of more personalised, interactive, and data-driven teaching. The integration of constructivist learning principles, scaffolded instruction, and corrective feedback mechanisms has taken the potentials of flipped models to a new level in contrast to the traditional versions. Nonetheless, some theoretical and practical shortcomings with limitations are evident in the discussion, including the fact that there is a requirement

of sound cognitive load, flexible instructional design, and readiness of the teacher in an AI-mediated environment. These constraints indicate the significance of the future studies that should be aimed at addressing the long-term efficacy, inclusivity, and ethical use of AI-related tools. Finally, although incorporation of AI into a flipped classroom is considered an indicative change in the teaching and learning domain, sustainability of success cannot be achieved without critical consideration of theory, practice, and dynamic classroom conditions.

5.0 CONCLUSION

This systematic literature review identifies the transformative potential of artificial intelligence (AI) integration within flipped classroom models across various disciplines. Based on the findings, AI enhances student engagement, academic performance, and instructional efficacy, particularly when paired with constructivist, schema, and scaffolding theories. ChatGPT and adaptive learning tools encourage higher-order thinking, personalised learning, and immediate corrective feedback, which leads to better autonomy and engagement of learners. Nevertheless, these benefits are not shared equally. They are often linked to the learners of moderate motivation and digital readiness and cannot be applied to other learning environments without specific scaffolding, educating of teachers, and ethical safeguarding. Flipped classrooms that are powered by AI have a lot of potential but need to be implemented carefully to achieve their pedagogical promise.

However, there are several limitations identified based on this review, such as most studies are confined to short-term interventions in higher education, with limited attention to primary, secondary, or marginalised learner groups. Furthermore, ethical issues, prompt engineering, teacher readiness, and learner diversity are often underexplored. Research quality varies, with some studies lacking robust theoretical grounding, longitudinal insight, or contextual diversity. These constraints hinder the scalability and inclusiveness of AI integration in flipped learning environments, particularly in under-resourced or culturally varied settings.

Future research should broaden its scope to include younger and low-achieving learners, particularly in ESL and EFL contexts. Longitudinal and scalable studies are needed to evaluate sustained impact and adaptability across disciplines. In order to facilitate this change, the policymakers and educators should focus on preparing high-quality teacher trainings, ethical guidelines, and equitable access to AI tools. Curriculum reforms and innovations must at the same time be accommodative of technological changes so as to be gradual and have their relevance. The researchers must also explore the impact of AI integration on classroom dynamics, such as teacher–student interaction and peer collaboration. These efforts will contribute to the realisation of the fact that AI-driven flipped classrooms can become a more universal, flexible, and future-ready educational approach.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest to report regarding the present study.

AUTHOR CONTRIBUTIONS

Farhana Atiqah Ahmad Radzuan (Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Validation; Writing - original draft; Writing - review & editing)

Marina Mohd Arif (Formal analysis; Investigation; Supervision; Validation; Writing - review & editing)

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APPENDIX**Table 3**

Number and details of primary studies database

| No | Authors | Title | Year | Journal | Scopus | Web of Science |
|----|--|--|------|--|--------|----------------|
| 1 | Lv H.Z. | Innovative Music Education: Using an AI-Based Flipped Classroom | 2023 | Education and Information Technologies | / | / |
| 2 | Li H.-F. | Effects Of a ChatGPT-Based Flipped Learning Guiding Approach on Learners' Courseware Project Performances and Perceptions | 2023 | Australasian Journal of Educational Technology | / | / |
| 3 | Jiang M.Y.-C.; Jong M.S.-Y.; Lau W.W.-F.; Chai C.-S.; Wu N. | Exploring The Effects of Automatic Speech Recognition Technology on Oral Accuracy and Fluency in A Flipped Classroom | 2023 | Journal of Computer Assisted Learning | / | / |
| 4 | Essel H.B.; Vlachopoulos D.; Essuman A.B.; Amankwa J.O. | ChatGPT Effects on Cognitive Skills of Undergraduate Students: Receiving Instant Responses From AI-Based Conversational Large Language Models (LLMs) | 2024 | Computers and Education: Artificial Intelligence | / | / |
| 5 | Li B.; Peng M. | Integration of an AI-Based Platform and Flipped Classroom Instructional Model | 2022 | Scientific Programming | / | / |
| 6 | Tan M.; Cao Y. | Evaluation Of the Online Music Flipped Classroom Under Artificial Intelligence and Wireless Networks | 2022 | Wireless Communications and Mobile Computing | / | / |
| 7 | Li L. | English Translation Teaching Model of Flipped Classroom Based on The Fusion Algorithm of Network Communication and Artificial Intelligence | 2021 | Wireless Communications and Mobile Computing | / | / |
| 8 | Kong S.-C.; Man-Yin Cheung W.; Zhang G. | Evaluation Of an Artificial Intelligence Literacy Course for University Students with Diverse Study Backgrounds | 2021 | Computers and Education: Artificial Intelligence | / | / |
| 9 | Huesca G.; Martínez-Treviño Y.; Molina-Espinosa J.M.; Sanromán-Calleros A.R.; Martínez-Román R.; Cendejas-Castro E.A.; Bustos R. | Effectiveness Of Using ChatGPT as A Tool to Strengthen Benefits of The Flipped Learning Strategy | 2024 | Education Sciences | / | / |
| 10 | Jeon J.; Lee S. | The Impact of a Chatbot-Assisted Flipped Approach on EFL Learner Interaction | 2024 | Educational Technology and Society | / | / |
| 11 | Wu S.; Wang F. | Artificial Intelligence-Based Simulation Research on The Flipped Classroom Mode of Listening and Speaking Teaching for English Majors | 2021 | Mobile Information Systems | / | / |
| 12 | Lin C.-J.; Mubarak H. | Learning Analytics for Investigating the Mind Map-Guided AI Chatbot Approach in An EFL Flipped Speaking Classroom | 2021 | Educational Technology and Society | / | / |

| No | Authors | Title | Year | Journal | Scopus | Web of Science |
|----|--|--|------|---|--------|----------------|
| 13 | Ng D.T.K.; Xinyu C.; Leung J.K.L.; Chu S.K.W. | Fostering Students' AI Literacy Development Through Educational Games: AI Knowledge, Affective and Cognitive Engagement | 2024 | Journal of Computer Assisted Learning | / | |
| 14 | Gasaymeh A.-M.M.; Almohtadi R.M. | The Effect of Flipped Interactive Learning (FIL) Based on ChatGPT on Students' Skills in A Large Programming Class | 2024 | International Journal of Information and Education Technology | / | |
| 15 | Lapitan L.D., Jr; Chan A.L.A.; Sabarillo N.S.; Sumalinog D.A.G.; Diaz J.M.S. | Design, Implementation, And Evaluation of An Online Flipped Classroom with Collaborative Learning Model in An Undergraduate Chemical Engineering Course | 2023 | Education for Chemical Engineers | / | |
| 16 | Huang A.Y.Q.; Lu O.H.T.; Yang S.J.H. | Effects Of Artificial Intelligence–Enabled Personalized Recommendations on Learners' Learning Engagement, Motivation, And Outcomes in a Flipped Classroom | 2023 | Computers and Education | / | |
| 17 | Li F.; Cao Z.; Li X. | College Translation Teaching in The Era of Artificial Intelligence: Challenges and Solutions | 2023 | Journal of Higher Education Theory and Practice | / | |
| 18 | Jivani S.R.; Chetehouna M.; Hafeez S.; Adjali M.H. | Effects Of Game-Based Learning on Engagement and Academic Performance for Undergraduate Science and Engineering Students | 2024 | International Journal of Engineering Education | / | |
| 19 | Hang C.N.; Wei Tan C.; Yu P.-D. | MCQGen: A Large Language Model-Driven MCQ Generator for Personalized Learning | 2024 | IEEE Access | / | |
| 20 | Liu Y. | Evaluation of Interactive College Piano Teaching's Effect Based on Artificial Intelligence Technology | 2024 | International Journal of Web-Based Learning and Teaching Technologies | / | |
| 21 | Cheng J.; Wang X. | Artificial Intelligence Based on Effectiveness of Inverted Classroom Teaching of College Sports | 2021 | Journal Of Intelligent and Fuzzy Systems | / | / |
| 22 | Peng Y.; Wang X. | Online Education of a Music Flipped Classroom Based on Artificial Intelligence and Wireless Network | 2022 | Wireless Communications and Mobile Computing | / | / |
| 23 | Wang M.; Wang M.; Xu X.; Yang L.; Cai D.; Yin M. | Unleashing ChatGPT's Power: A Case Study on Optimizing Information Retrieval in Flipped Classrooms Via Prompt Engineering | 2024 | IEEE Transactions on Learning Technologies | / | / |
| 24 | Zhang L.; Wei P.; Zhang Y.; Wang N. | Artificial Intelligence and Edge Computing Technology Promote the Design and Optimization of Flipped Classroom Teaching Models for Higher Vocational, Ideological, And Political Courses | 2022 | Mobile Information Systems | / | |
| 25 | López-Villanueva D.; Santiago R.; Palau R. | Flipped Learning and Artificial Intelligence | 2024 | Electronics (Switzerland) | / | / |
| 26 | Garber A.M. | Flipping Out! Utilizing an Online Micro-Lecture for Asynchronous Learning Within the Acting Internship | 2020 | Medical Science Educator | / | / |

| No | Authors | Title | Year | Journal | Scopus | Web of Science |
|----|----------------------------------|--|------|--|--------|----------------|
| 27 | Kong, SC; Zhang, G; Cheung, MY | Pedagogical Delivery and Feedback for An Artificial Intelligence Literacy Programme for University Students with Diverse Academic Backgrounds: Flipped Classroom Learning Approach with Project-Based Learning | 2022 | Bulletin of the Technical Committee on Learning Technology | | / |
| 28 | Sanchez-Gonzalez, M; Terrell, M | Flipped Classroom with Artificial Intelligence: Educational Effectiveness of Combining Voice-Over Presentations and AI | 2023 | Cureus Journal of Medical Science | | / |
| 29 | Hu, B | English Listening Teaching Model in Flipped Classroom Based on Artificial Intelligence Fusion Control Algorithm | 2021 | Mathematical Problems in Engineering | | / |
| 30 | Ye, WW; Li, SH; Liu, SB; Zhou, Y | Application Of Artificial Intelligence Technology in Martial Arts Education Governance | 2022 | Discrete Dynamics in Nature and Society | | / |
| 31 | Maalek, R | Integrating Generative Artificial Intelligence and Problem-Based Learning into The Digitization in Construction Curriculum | 2024 | Buildings | | / |