OmniaScience

Journal of Technology and Science Education

JOTSE, 2026 – 16(1): 315-332 – Online ISSN: 2013-6374 – Print ISSN: 2014-5349

https://doi.org/10.3926/jotse.3799

INFLUENCE OF THE FLIPPED CLASSROOM ON AUTONOMOUS LEARNING AT THE UNIVERSITY LEVEL: A SYSTEMATIC REVIEW

Ivan Adrianzén-Olano

Universidad Cesar Vallejo (Peru)

aolanoiv@ucvvirtual.edu.pe

Received August 2025

Accepted November 2025

Abstract

University-level learning requires autonomous student development, a need that traditional teaching methods fail to adequately address. This systematic review aims to determine whether there is an influence between the application of the Flipped Classroom (FC) model and the development of autonomous learning in university students through a comprehensive analysis of pedagogical strategies, technological resources, learning outcomes, and cross-curricular skill development across diverse academic disciplines. Using PRISMA methodology, a comprehensive literature search was conducted in Scopus database (2020-2024). From 198 initial publications, 15 studies met inclusion criteria for systematic analysis. Results indicate that FC implementations predominantly utilize integrated technological ecosystems including Learning Management Systems (Moodle), multimedia platforms (YouTube), social networking applications (WeChat), and interactive assessment tools. China and Spain emerge as research leaders with six publications each, demonstrating distinct approaches: Spanish studies emphasize pedagogical evaluation across traditional disciplines, while Chinese research integrates advanced technologies including big data analytics, neural networks, and mobile learning platforms. Consistent positive outcomes include enhanced student autonomy, improved academic performance, increased classroom engagement, and development of cross-curricular competencies including critical thinking, problem-solving, and metacognitive skills. However, this review has methodological limitations including reliance on a single database (Scopus), a restricted temporal scope (2020-2024), and absence of formal risk of bias assessment. In conclusion, the Flipped Classroom model shows promise as a student-centered learning environment that may promote autonomous learning development when combined with appropriate technological resources and complementary pedagogical approaches, though the strength of evidence is limited by the small sample size (15 studies) and methodological heterogeneity of included studies.

Keywords **–** Flipped classroom, Flipped learning, Autonomous learning, University level, Systematic review.

To cite this article:

Adrianzén-Olano, I. (2026). Influence of the flipped classroom on autonomous learning at the university level: A systematic review. *Journal of Technology and Science Education,* 16(1), 315-332. https://doi.org/10.3926/jotse.3799

---

1. Introduction

The "Flipped Classroom" emerged in the early 2000s through development of educational technologies, with its use expanding exponentially during the pandemic. This model is grounded in constructivist theories that emphasize active learning and use of class time for activities that encourage application and critical analysis of knowledge previously acquired independently.

The Flipped Classroom (hereafter FC) has gained prominence in higher education as a strategy promoting autonomous learning and active student participation. This methodology reorganizes the educational process by transferring theoretical content to independent study through digital resources such as videos, reading, or interactive presentations. Students access materials before face-to-face sessions, building prior knowledge and developing self-management skills. Classroom time is then devoted to practical activities, problem-solving, debates, and collaborative projects that deepen understanding and reinforce critical thinking.

Autonomous learning is a process in which students self-regulate their learning and become aware of their own cognitive and socio-affective processes. It involves being independent and self-managing, demonstrating the ability to self-regulate actions to learn and achieve goals under specific conditions (Crispín-Bernardo, Caudillo-Zambrano, Doria & Esquivel-Peña, 2011). This capacity for self-direction has become increasingly critical in contemporary higher education, where students must develop metacognitive skill and take greater responsibility for their own learning trajectories.

Contemporary education in the knowledge society requires substantial changes to enhance learning capacity among new generations of students (Tourón, Santiago & Díez, 2016). This necessitates redefining teaching processes and methodologies, with FC emerging as a representative approach, particularly when combined with other active learning strategies.

The FC model promotes improved learning, and when combined with other active methodologies, enhances autonomous learning, crucial for implementation of blended, virtual, and distance learning modalities in professional training. This approach optimizes classroom time, as it transfers by transferring responsibility to students who access teaching resources through virtual platforms before class, enabling more focused engagement during classroom sessions on active learning activities.

Despite growing interest in FC implementation, several questions remain regarding its effectiveness in promoting autonomous learning across different educational contexts and disciplinary areas. Specifically, there is limited comprehensive understanding of how geographical and cultural factors, theoretical innovations, sample characteristics, and model elements interact to influence FC outcomes in university settings across multiple disciplines including engineering, health sciences, education, and humanities.

Therefore, this systematic review addresses the following research question operationalized through a modified SPIDER framework (Sample, Phenomenon of Interest, Desing, Evaluation, Research type): How does the Flipped Classroom model influence autonomous learning development in university students, and what patterns emerge across different territorial contexts, theoretical contributions, sample characteristics, and model elements?

To answer this question, the review examines four key dimensions:

1. Territorial distribution: Geographic patterns of FC research and implementation, identifying regional approaches and cultural adaptation in different university contexts.
2. Innovative theoretical contributions: Novel conceptual frameworks and pedagogical innovations integrating FC with complementary strategies (e.g., problem-based learning, CLIL, OBE) and advanced technologies.
3. Sample characteristics: Diversity in population size, academic disciplines, and educational levels across studies, demonstrating the model's scalability and cross-disciplinary applicability.
4. Model elements: Technological infrastructure, learning resources, assessment strategies, and instructional design components that facilitate autonomous learning development.

Effective FC implementation requires high-quality, relevant pre-class materials designed by instructors aligned with learning objectives. Well-designed resources and appropriate guidance provide students valuable opportunities to enhance their learning and skills. Under this model, students manage their learning pace while teachers assume supervisory and guiding roles. Advanced applications incorporating artificial intelligence further personalize education by tailoring content to individual student interests. However, successful FC adoption depends on careful planning and stakeholder communication. Instructors must design activities and develop teaching resources, primarily through virtual classrooms, aligned with learning objectives. Without proper planning and explanation, the model may encounter significant resistance.

By systematically analyzing these dimensions across selected studies, this review aims to provide a comprehensive understanding of FC's influence on autonomous learning in university contexts, identifying best practices, challenges, and opportunities for future implementation. This multi-dimensional approach ensures alignment between the study's scope and the analytical framework applied throughout the results and conclusions sections.

The following sections develop the research structure. First, a theoretical framework establishes key concepts. Next, the PRISMA methodology is explained, emphasizing the variables: territorial distribution, learning strategies, sample characteristics, and learning resources, and main results obtained in selected articles. Subsequently, results are presented and analyzed through comprehensive examination of the four key dimensions, and the study concludes with limitations and recommendations for future research.

2. Literature Review

2.1. Flipped Classroom: Foundational Framework

The Flipped Classroom concept was formally introduced and systematized by Bergmann and Sams (2012) in their seminal work "Flip Your Classroom: Reach Every Student in Every Class Every Day". Bergmann and Sams developed this pedagogical model while teaching chemistry at Woodland Park High School in Colorado, initially as a solution to help students who missed classes. Their innovation involved recording lectures for students to watch at homes, transforming classroom time into active learning spaces for problem-solving, discussions, and hands-on activities (Bergmann & Sams, 2012).

The FC model represents a fundamental restructuring of traditional instructional time, inverting Bloom's Taxonomy in educational practice. Lower-order cognitive tasks (remembering, understanding) occur outside class through pre-recorded lectures and readings, while higher-order thinking skills (applying, analyzing, evaluating, creating) are developed during face-to-face sessions with instructor guidance and peer collaboration (Bergmann & Sams, 2014). This inversion aligns with constructivist learning principles and social learning theories, positioning the instructor as facilitator rather than primary information source.

Subsequent research has expanded the theoretical foundations of FC beyond Bergmann and Sams' initial framework. Bishop and Verleger (2013) provided one of the first comprehensive systematic reviews of FC in engineering education, defining it as an educational technique consisting of two distinct components: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom. Their framework emphasizes that both components must be present for true FC implementation, distinguishing it from other blended or active learning approaches.

Abeysekera and Dawson (2015) further developed FC theory by connecting it to cognitive load theory and self-determination theory, arguing that FC effectiveness depends on careful consideration of students' cognitive architecture and motivational factors. They proposed that FC reduces extraneous cognitive load during initial exposure to content while increasing germane cognitive load during in-class application activities, thereby optimizing learning efficiency.

2.2. Autonomous Learning: Conceptual Clarification and Measurement Indicators

For this systematic review, autonomous learning is operationally defined as a multidimensional construct encompassing: (1) self-regulation of learning processes, including goal-setting, strategy selection, and

self-monitoring (Zimmerman, 2002); (2) metacognitive awareness of one's cognitive processes and learning strategies (Flavell, 1979); (3) volitional control and intrinsic motivation to engage in learning activities (Deci & Ryan, 2000); and (4) capacity for independent decision-making regarding learning pathways and resource utilization (Knowles, 1975).

It is essential to distinguish autonomous learning from related but distinct constructs that appear throughout the reviewed literature:

- ✓ Self-directed learning: Emphasizes the learner's initiative in diagnosing needs, formulating goals, and evaluating outcomes, with less emphasis on metacognitive processes (Knowles, 1975).
- ✓ Self-regulated learning: Focuses specifically on cyclical processes of forethought, performance, and self-reflection in academic tasks (Zimmerman, 2002).
- ✓ Student engagement: Refers to behavioral, emotional, and cognitive investment in learning activities, which may occur with or without autonomous learning capacity (Fredricks et al., 2004).
- ✓ Academic performance: Represents measurable learning outcomes (grades, test scores), which may result from autonomous learning but does not itself constitute autonomous learning.
- ✓ Cross-curricular competencies: Include critical thinking, problem-solving, and collaboration skills that may be developed through autonomous learning but represent broader transferable skills.

Measurement indicators for autonomous learning in the reviewed studies include: time management behaviors, independent study hours, self-reported autonomy scales, learning strategy inventories, metacognitive awareness questionnaires, academic self-efficacy measures, and qualitative evidence of self-directed behaviors in learning logs or reflective journals. This clarification ensures consistent interpretation of findings across the heterogeneous studies reviewed.

2.3. Theory of Autonomous Learning

The Theory of Autonomous Learning, promoted by Malcolm Knowles, maintains that students, especially adults, are capable of managing their own learning process. This involves identifying their training needs, setting goals, selecting strategies, implementing actions, and evaluating results. Knowles argues that this approach is based on the premise that learners are more effective when they have control over their learning, which promotes motivation, cognitive maturity, and personal development.

Recent research reaffirms the validity of this theory in various educational contexts. Self-directed learning, supported by theories such as self-determination and constructivism, has been shown to improve students' intrinsic motivation and academic engagement (Nazarieh, Delzendeh & Beigzadeh, 2024).

In school settings, it has been observed that students exposed to self-directed environments show greater use of metacognitive strategies, positive emotions, and autonomous attitudes toward learning, especially when they have teacher support that encourages autonomy (Schweder & Raufelder, 2022).

Likewise, Mohiyeddini proposes extending the notion of self-direction to the teaching role, introducing the concept of "self-directed teaching," which promotes more adaptive and student-centered pedagogical practices achieved through the continuous professional development of educators (Mohiyeddini, 2024).

Autonomous learning recognizes the learner as a subject capable of managing their learning through self-regulation, decision-making, and continuous reflection. Current theoretical and empirical contributions reinforce the relevance of this theory in the educational process, highlighting its effective application through the use of technologies, metacognitive strategies, and flexible environments that promote self-management.

2.4. Information Processing Theory

Information Processing Theory is a cognitive approach that compares the functioning of the human mind to that of a computer, highlighting how people receive, encode, store, and retrieve information. This

theory, initially developed by George A. Miller and other cognitive psychologists in the mid-20th century, has been fundamental to understanding the internal mechanisms of human learning.

The model proposes three basic stages: sensory memory, working memory, and long-term memory. Attention and perception are essential processes that allow stimuli to pass from sensory memory to working memory, where active information is manipulated. Subsequently, through encoding processes such as organization, elaboration, and visualization, this information can be stored in long-term memory for later retrieval (Eggen, 2020).

Recent studies highlight the applicability of this theory in educational settings, implementing strategies based on this model, which, when done properly, will achieve significant improvements in participation and meaningful learning through instruction that respects cognitive processing limitations and abilities (Wang, 2021). They have also emphasized that information processing can be enhanced by activating prior schemas, using meaningful visual and auditory stimuli, and teaching metacognitive strategies that allow students to monitor and regulate their learning (Coman, 2024). Some studies have complemented this theory with the use of artificial intelligence tools that allow for personalized teaching, optimized cognitive load, and immediate feedback, thereby improving students' retention and comprehension of content (Yassin & Mabanja, 2024).

This theory provides a solid foundation for designing effective learning environments, especially when considering the limits of working memory and applying pedagogical techniques that promote efficient information encoding.

3. Methodology

This systematic review followed the PRISMA methodology guidelines (Prisma, 2024), whose purpose was to ensure transparency and clarity. Articles hosted in the Scopus database were used, which are based on rigorous acceptance criteria by the global scientific community. China can be identified as one of the countries with the most implementations of the FC methodology for the education of its citizens at all educational levels (Huang & Yu, 2022). Applied research articles on FC and autonomous learning, with their synonyms, in English and Spanish were taken into account. These were found by applying a specific search equation, using Boolean operators AND and OR, as shown in Table 1. The process of researching the articles took place between July and August 2024, while the in-depth analysis and information gathering process was carried out between September and December 2024.

Language	Search equation
English	TITLE-ABS-KEY (flipped AND classroom) AND (TITLE-ABS-KEY (autonomous AND learning) OR TITLE-ABS-KEY (autolearning))

Table 1. Search equation

3.1. Protocol Registration and Methodological Transparency

This systematic review acknowledges a significant methodological limitation: the protocol was not prospectively registered in platforms such as PROSPERO, INPLASY, or Open Science Framework (OSF) prior to conducting the review. This represents a deviation from optimal systematic review standards and introduces potential risk of selective reporting bias. Future systematic reviews in educational technology should prioritize protocol pre-registration to enhance transparency and methodological rigor.

3.1.1. Search Strategy Expansion

The search strategy employed in this review was deliberately focused but consequently limited in scope. The exclusive use of Scopus database, while comprehensive and rigorously curated, potentially excludes relevant studies indexed in other major databases. Specifically, searches were not conducted in:

- ERIC (Education Resources Information Center): the primary database for education research, which indexes numerous practitioner-oriented journals and grey literature
- Web of Science: offering broader multidisciplinary coverage with different indexing criteria than Scopus
- Google Scholar: providing access to conference proceedings, dissertations, and non-indexed publications

Additionally, the search string utilized focused exclusively on "flipped classroom" AND "autonomous learning" (with synonym "autolearning"), potentially missing studies using alternative terminology such as:

- "Flipped learning" (an increasingly common alternative term)
- "Inverted classroom" (particularly in non-English literature)
- "Self-directed learning" (a closely related construct)
- "Learner autonomy" (common in language education contexts)
- "Self-regulated learning" (emphasized in educational psychology literature)

These search limitations are acknowledged as potentially introducing selection bias and limiting the comprehensiveness of the review. The restricted temporal scope (2020-2024) also excludes foundational studies that established the FC field, though it ensures focus on recent implementations incorporating current technological affordances.

Of the 198 publications found, 171 went on to the screening stage, 54 met the eligibility criteria, and in the final stage, 15 met the inclusion criteria, as shown in Figure 1, which illustrates the flow of the article search and selection process.

The review takes into account articles published in Scopus, in English and Spanish, resulting from applied research in which the use of the FC model is based and in which its impact on learning (especially autonomous learning) in university students from different specialties was evaluated.

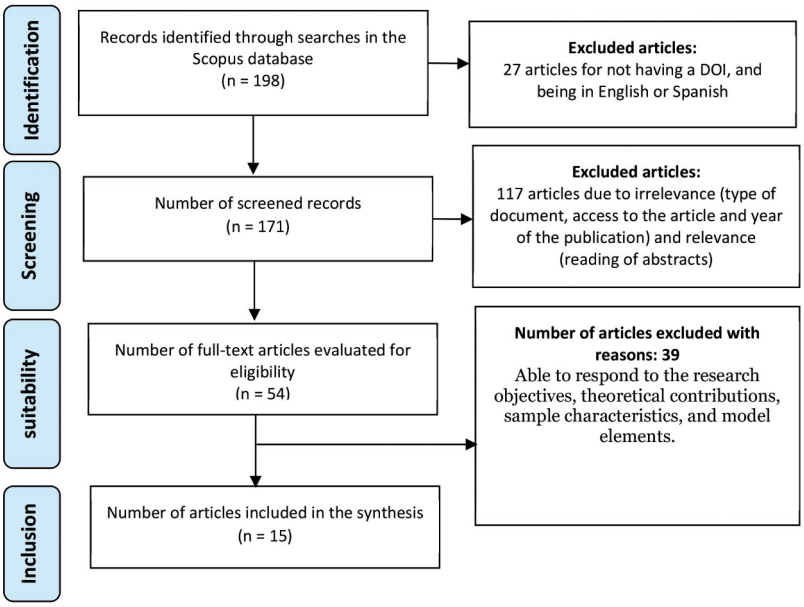

Figure 1. Flowchart of the article search and selection process (Prisma, 2024)

3.2. Quality Assessment and Risk of Bias

A critical limitation of this systematic review is the absence of formal quality assessment or risk of bias evaluation for included studies. Standard systematic review methodology requires appraisal of study quality using established instruments such as:

- Mixed Methods Appraisal Tool (MMAT) for studies employing diverse methodological approaches
- Joanna Briggs Institute (JBI) Critical Appraisal Tools for various study designs
- Critical Appraisal Skills Programme (CASP) checklists
- Risk of Bias 2 (RoB 2) for randomized controlled trials
- ROBINS-I for non-randomized intervention studies

Without formal quality assessment, this review cannot differentiate findings from methodologically robust studies versus those with significant design limitations. This absence prevents application of quality-based weighting in synthesis and limits confidence in conclusions. Readers should interpret findings with awareness that study quality varied substantially across the 15 included articles, ranging from small-scale exploratory implementations (n=15 students) to larger quasi-experimental designs with control groups (n=284 students). Methodological heterogeneity included qualitative case studies, quantitative pre-post comparisons, mixed methods investigations, and controlled experiments, with varying degrees of rigor in data collection, analysis, and reporting.

This limitation is partially mitigated by the inclusion criteria requiring peer-reviewed publications in Scopus-indexed journals, which ensures a baseline quality threshold. However, formal quality assessment remains a critical omission that should be addressed in future systematic reviews of FC effectiveness.

4. Results

Following the PRISMA methodology, 198 records were initially identified, of which 27 were excluded for lacking a DOI or being in languages other than English or Spanish. During the screening stage of 171 records, 117 were excluded based on relevance criteria: by document type (only full research articles were accepted), article access (open access and downloadable articles), publication year (period from 2020 to 2024) and content relevance. After reviewing abstracts and conclusions to assess university level focus and FC autonomous learning relationship, 54 records advanced to the eligibility stage. The main suitability criteria included: research objectives clearly specified and related to the FC model, the research contains theoretical contributions on trends in promoting autonomous learning using the FC model, the research clearly defines and explains the characteristics of the sample, and the elements of the FC model are relevant to achieving the research objectives. Thirty-nine records were excluded, leaving 15 articles included for systematic analysis. The summary of the inclusion and exclusion criteria is shown in Table 2.

Based on the articles included in the systematic review, a table will be created containing the bibliographic citation of the authors, the country of the institution where the research was conducted, and the objective of the research, as shown in Table 3.

Spain and China lead with six publications each among the 15 analyzed studies. Spain, studies tend to focus on the university environment, focuses on the FC model's application in specific areas such as organic chemistry and business law, and its application in architecture modules. China research is very diverse, focusing on research diversifies across areas such as nursing, physical education, university English, and dermatology, integrating advanced technologies such as neural networks and mobile learning. Indonesia and Chile contribute fewer studies but offer alternative perspectives, such as multimedia for autonomous learning promotion and flipped classrooms in human anatomy. With regard to objectives, these vary widely depending on the context and area of focus. In Spanish research, the common objective is to evaluate the perception and usefulness of the FC model in different university disciplines, highlighting pedagogical innovation and the student experience. In contrast, studies in China focus more on the impact of the methodology combined with advanced technologies or specific models, such as CDIO and OBE, in practical areas such as nursing. Indonesia and Chile are oriented toward the development of autonomous learning and innovation in traditional teaching.

	Inclusion criteria	Exclusion criteria
DOI	It has a DOI	No DOI available
Language	Articles in English and Spanish	Language other than English or Spanish
Type of document	Published articles on applied research.	Not published articles
Access	Open access and downloadable	Any type of access other than open and downloadable
Year	Journals published between 2020 and 2024	Articles published before 2020
Scope	University	Different educational level than university
Variables of interest	Application of the FC model for autonomous learning. Research objectives. Innovative theoretical contributions. Characteristics of the sample. Elements of the model.	Other variables
Reported results	Effects or impact of the model on learning	Not related to the model or learning.
Methodology	FC and active methodologies	Other methodologies

Table 2. Inclusion and exclusion criteria

Author(s)	Country	Objectives
(Magaña, Magaña, Guillén-Gámez & Ariza, 2022)	Spain	Analyzing future teachers' perceptions of FC as an active methodology
(Colomo-Magaña, Soto-Varela, Ruiz-Palmero & Gómez-García, 2020)	Spain	Analyze higher education students' perceptions of the usefulness of FC as a methodology.
(Nahuelcura-Millán, 2023)	Chile	Describe the application of the FC model in teaching human anatomy in a university setting and evaluate its impact on the teaching-learning process.
(Ni, Huang, Yang & Wang, 2024)	China	Exploring the experiences of nursing students when applying a learning model that combines FC with problem-based learning in a pediatric nursing course.
(Nong, Ye, Chen & Lee, 2023)	China	Examine the relationship between academic self-efficacy, commitment to learning, cognitive load, and improvement in students' academic confidence using the FC model.
(Chang, 2021)	China	Propose a new model for teaching English at university level using FC with Big Data and deep neural networks.
(Aprianto, Purwati & Anam, 2020)	Indonesia	Investigating the use of multimedia-assisted learning in an FC model to promote autonomous learning among university students studying English as a foreign language.
(Noguera, Albó & Beardsley, 2022)	Spain	Demonstrate that first-year university students prefer flexible teaching models, specifically FC, that encourage constructivist practices.
(Jimenez-Cardona, 2021)	Spain	Analyze the effectiveness of the FC methodology in teaching commercial law at a university in Barcelona.
(Feijóo, Suárez, Chiyón & Alberti, 2021)	Spain	Evaluate the results of implementing various web-based learning support tools in CF approaches in engineering modules.
(Li, Tang & Cheng, 2023)	China	Exploring the effects of a microvideo-based FC teaching model on standardized training for dermatology residents in China.
(Arteaga, Ruiz, Delgado & Ríos, 2021)	Spain	Implement a teaching strategy based on the FC model in some teaching units of subjects in the Chemistry Degree program at the University of Huelva in Spain.
(Kong, Wang & Rajabov, 2024)	China	Explore the new model of university physical education teaching based on CF and outcomes-based education.
(Zhang, 2022)	China	Explore how integrating mobile learning into a distance learning model can improve the autonomous learning ability and academic performance of university students studying English.
(Su, Ning, Zhang, Liu, Zhang & Xu, 2023)	China	Explore and develop a new teaching method to improve the clinical practice skills and overall quality of nursing students.

Table 3. Overview of articles selected for systematic review

Table 4 presents a summary of the factors investigated in each of the articles, analyzing the research objectives, main results, sample characteristics, and main elements of the CF model.

Author(s)	Learning strategies	Sample characteristics	Learning resources	Main results
(Magaña et al., 2022)	Student perception of the flipped classroom as a teaching methodology.	284 students (155 women and 129 men) in their first year of the Primary Education program at the University of Malaga, Spain.	Videos, virtual campus, other digital resources such as readings, online presentations, etc.	Significant improvement in student perception, with the pedagogical dimension being the most highly valued, highlighting the ability to improve digital competence, feedback, independent learning, and group work.
(Colomo-Magaña et al., 2020)	Student perception of the flipped classroom in university settings.	123 students from the Faculty of Education Sciences at the University of Malaga in Spain.	Videos, readings, simulations, podcasts, applications, Moodle platform as a virtual classroom, Google Meet and Blackboard Ultra as synchronous virtual presence tools, online quizzes.	The methodology is considered very useful in higher education, emphasizing the instrumental dimension, highlighting the pedagogical potential, and promoting the development of skills, as well as independent learning and group work.
(Nahuelcura-Millán, 2023)	Flipped classroom in human anatomy teaching.	41 students from the General Anatomy course in the first year of the Occupational Therapy degree program at the Universidad de la Frontera Chile.	Moodle and YouTube platforms, videos, virtual lessons, quizzes, group activities, assessment rubrics.	There is clear evidence of a strong preference among students for the FC model compared to traditional methodology.
(Ni et al., 2024)	Combination of flipped classroom and problem-based learning in pediatric nursing.	16 third-year pediatric nursing students (12 women and 4 men) from Soochow University, China.	Online learning platform, interactive forum, diverse resources, problem-based methodology.	There is evidence of improvements in stimulating interest in learning and improving independent learning, independent thinking, and problem-solving skills. Improvements in the acquisition of knowledge and skills.
(Nong et al., 2023)	Blended learning in a research methods course.	115 students for preschool teachers at Guangxi University, China.	Tencent Conference videoconferencing platform, Wenjuanxing online questionnaire platform, videos, questionnaires.	Positive impact of academic self-efficacy related to autonomous learning, negative impact on cognitive load, no significant difference in student participation.
(Chang, 2021)	Flipped classroom supported by big data and deep neural networks in English language teaching.	230 second-year English majors at a university in China.	Microvideos, WeChat online learning platform, personalized learning resource based on Big Data and deep neural networks, consolidation exercises.	The teaching model used is effective in improving independent learning skills and academic performance.
(Aprianto et al., 2020)	Multimedia-assisted flipped classroom in English teaching.	15 English students from Negeri Surabaya University in Indonesia.	LMS platform, reading materials, videos, online forums, online applications, and printed materials.	The model helps stimulate independent learning among students.

Author(s)	Learning strategies	Sample characteristics	Learning resources	Main results
(Noguera et al., 2022)	Student preference for flexible teaching models.	First-year students from two Spanish universities. 57 education students and 164 engineering students.	Moodle platform and Google Suite, asynchronous learning resources such as videos, readings, and activities; synchronous sessions.	Students demonstrate their preference for the FC-based model due to its flexibility in managing their time and accessing resources, which contributes to improving their learning.
(Jimenez-Cardona, 2021)	Flipped classroom in business law teaching.	73 Business Administration and Management students in the Business Law course at the University of Barcelona.	Activity sheets, prepared readings, videos, quizzes. Use of an educational platform or virtual campus, online and offline resources. Combination of FC with active methodologies (problem-based learning, service learning, etc.)	There has been an increase in student participation, improved academic performance, greater commitment and involvement of students in their education, as well as the development of cross-curricular skills (critical thinking, independent learning, problem-solving and decision-making skills).
(Feijóo et al., 2021)	Flipped classroom techniques in architecture, engineering, and construction modules.	Civil engineering students from three universities: Polytechnic University of Madrid, University of Jaén (Spain), and University of Piura (Peru).	Pre-recorded videos, short quizzes (Kahoot!, Socrative, and Mentimeter), consultation support tool, use of an LMS, problem repositories.	Properly designed strategies and resources as part of the FC model help students improve their participation in academic activities, which generally improves their learning.
(Li et al., 2023)	Flipped classroom based on micro-videos for training dermatology residents.	78 residents from Anhui Medical University, China.	Micro videos, online platform, analysis of clinical cases.	With regard to theoretical knowledge, the experimental group showed improvement over the control group. There was also improvement in practical clinical skills. Overall, the proposed model had a beneficial influence.
(Arteaga et al., 2021)	Flipped classroom combined with CLIL (Content and Language Integrated Learning) in chemistry teaching.	Chemistry students at the University of Huelva, Spain. Organic Chemistry (73 students), Structural Elucidation of Organic Compounds (56 students), and Organic Chemistry Laboratory (48 students)	Moodle virtual platform, monographs, tutorials, presentations, exercises, self-assessment questionnaires, assessment questionnaires, collaborative activities, CLIL (Content and Language Integrated Learning) methodology.	The flipped classroom model in chemistry teaching, combined with the CLIL methodology, effectively promotes the acquisition of cross-curricular and language skills in university students.
(Kong et al., 2024)	Flipped classroom and Outcome-Based Education (OBE) for teaching physical education.	40 students from Hebei Normal University in China.	Teaching videos, assignments and exercises, appropriate teaching environments.	The model has a positive effect on student learning compared to the group in which traditional methodology was used.

Author(s)	Learning strategies	Sample characteristics	Learning resources	Main results
(Zhang, 2022)	Flipped classroom and mobile learning in university English teaching.	191 students from Taishan University, China.	Mobile learning resources such as social software (WeChat and QQ), Rain Classroom, for access to learning materials and to facilitate communication, exercises, assignments, and tests.	Most participants adapt better and more quickly to the new model by increasing their participation, learning efficiency, developing study habits, and becoming more independent learners.
(Su et al., 2023)	Flipped classroom based on the CDIO concept combined with the mini-CEX assessment model in clinical teaching of orthopedic nursing.	Nursing students. Control group (50 students: 6 men and 44 women) and intervention group (50 students: 8 men and 42 women).	Online learning platform, WeChat, clinical cases, scenario simulations, assessments, study materials.	There is evidence of improvement in clinical practice skills, critical thinking skills, and independent learning skills in general, which is beneficial for improving learning.

Table 4. Summary of the factors investigated in the articles included in the systematic review

Contemporary educational research demonstrates significant diversity in pedagogical approaches, with flipped classroom (FC) methodologies emerging as a prominent framework when integrated with complementary strategies including problem-based learning, Content and Language Integrated Learning (CLIL), and Outcome-Based Education (OBE) systems. The incorporation of sophisticated technological frameworks, including neural network applications and mobile learning platforms, has expanded both theoretical foundations and practical applications while promoting skill development and autonomous learning capabilities among diverse student populations.

Research populations examined across these studies reveal considerable variation in both scope and demographic composition, ranging from focused cohorts of fifteen participants (Aprianto et al., 2020) to comprehensive samples exceeding two hundred eighty-four students (Magaña et al., 2022). These populations encompass students from multiple academic levels and specializations, including undergraduate programs in primary education, chemistry, pediatric nursing, and physical education, demonstrating the adaptable nature of FC models across varied educational contexts and institutional requirements.

Technological infrastructure encompasses platforms such as Moodle, YouTube, and WeChat, alongside multimedia resources including videos, simulations, and interactive assessments. Advanced implementations integrate big data analytics and neural networks (Chang, 2021), and social learning software (Zhang, 2022), while others emphasize collaborative activities and practical evaluations (Su et al., 2023). Empirical findings consistently indicate positive outcomes enhanced student perception of FC methodologies (Arteaga et al., 2021; Jimenez-Cardona, 2021), with measurable improvements in critical thinking, problem-solving competencies, and independent learning skills. Academic performance metrics demonstrate particular effectiveness when FC approaches combine with OBE frameworks, establishing clear advantages over conventional instructional methodologies (Kong et al., 2024) and validating the efficacy of these integrated educational strategies.

4.1. Comprehensive Analysis of the Results

The analyzed researches demonstrate a consistent pattern in FC model implementation across diverse educational contexts, confirming its adaptability and effectiveness for promoting autonomous learning.

The researches show various methodological variants and combinations, applying the flipped classroom as the primary methodology, while others integrate it with complementary approaches such as problem-based learning (PBL), CLIL, outcomes-based education (OBE), or advanced technologies like big data and neural networks. This flexibility underscores the model's capacity to adapt to different teaching approaches and disciplines, confirming its versatility as an educational strategy.

Geographically, China and Spain emerge as leaders in FC research, with six publications each representing 80% of the selected studies. Spanish research focuses on perception and utility evaluation of the FC model in specific university disciplines for example organic chemistry (Arteaga et al., 2021), business law (Jimenez-Cardona, 2021), and architecture modules (Feijóo et al., 2021), emphasizing pedagogical innovation and student experience assessment. Conversely, Chinese research demonstrates a technologically advanced approach, integrating cutting-edge technologies such as neural networks (Chang, 2021), mobile learning platforms (Zhang, 2022), and social software applications, particularly in practical fields like nursing (Su et al., 2023) and physical education (Kong et al., 2024). This technological integration aligns with China's broader educational digitization initiatives.

The research samples show remarkable diversity in both size and academic scope, ranging from intimate groups of 15 students (Aprianto et al., 2020) to substantial cohorts of 284 participants (Magaña et al., 2022). This variation reflects the model's scalability across different educational contexts. The inclusion of diverse academic disciplines - from primary education and chemistry to pediatric nursing and physical education, confirms the FC model's cross disciplinary applicability. Several studies employed experimental designs with control groups (Kong et al., 2024; Li et al., 2023; Su et al., 2023), enhancing validity and reliability. The predominance of university-level samples confirms the model's particular relevance for higher education, where autonomous learning becomes critical for student success.

A common outcome across studies is the intensive utilization of educational technologies and digital platforms, creating comprehensive digital learning ecosystems. The predominant use of pre-recorded videos, Learning Management Systems (LMS) like Moodle, mobile applications, and social networks (WeChat, QQ) reflects a strong asynchronous learning component that allows content adaptation to individual student pace (Colomo-Magaña et al., 2020; Nahuelcura-Millán, 2023; Zhang, 2022). Interactive assessment tools such as Kahoot and Socrative (Feijóo et al., 2021) demonstrate the integration of gamification elements that enhance student engagement. The incorporation of advanced technologies like big data analytics and deep neural networks (Chang, 2021) represents a paradigmatic shift toward personalized, data-driven educational experiences.

Results consistently demonstrate positive impacts on autonomous learning development. Magaña et al. (2022) reported improvements in student perception, particularly enhanced digital competence, feedback mechanisms, independent learning, and collaborative work skills. Similarly, Colomo-Magaña et al. (2020) emphasized the methodology's utility in promoting independent learning and group work skills, while accentuating its pedagogical potential. Ni et al. (2024) reported that combining FC with problem-based learning improved stimulating learning interest, independent thinking, and problem-solving skills among pediatric nursing students. Additionally, metacognitive skills development emerged as a key benefit. Nong et al. (2023) found positive impacts of academic self-efficacy related to autonomous learning, while Zhang (2022) reported that most participants adapted more effectively to the new model by increasing participation, learning efficiency, and developing study habits. These results align with autonomous learning theory, which emphasizes self-regulation and metacognitive awareness.

The studies consistently establish the FC model's effectiveness in developing cross-curricular competencies essential for 21st-century learners. Jimenez-Cardona (2021) reported increased student participation, improved academic performance, and enhanced commitment, alongside the development of critical thinking, independent learning, problem-solving, and decision-making skills. Arteaga et al. (2021) found that combining FC with CLIL methodology effectively promoted the acquisition of both cross-curricular and language skills in university chemistry students. In clinical education, Su et al. (2023)

provided evidence of improvements in clinical practice skills, critical thinking abilities, and independent learning skills in orthopedic nursing education, while Li et al. (2023) demonstrated enhanced theoretical knowledge and practical clinical skills among dermatology residents. These results suggest that FC is particularly effective in professional education contexts where the integration of theoretical knowledge with practical application is very important.

Student perception studies expose positive attitudes toward FC implementation. Nahuelcura-Millán (2023) found evidence of strong student preference for the FC model compared to traditional methodology in human anatomy teaching. Noguera et al. (2022) demonstrated that students prefer flexible teaching models, specifically FC, due to flexible time management and resource accessibility that enhance learning. Additionally, student engagement increased significantly. Feijóo et al. (2021) reported that properly designed FC strategies and resources help students improve participation in academic activities. Kong et al. (2024) found positive effects on student learning compared to traditional methodology groups, while Aprianto et al. (2020) demonstrated the model's effectiveness in stimulating independent learning among English language students.

Although most outcomes were favorable, several studies also highlighted significant limitations and challenges. Nong et al. (2023) observed an increase in cognitive load, indicating that without thoughtful instructional planning, students may face cognitive overload. This finding underlines the need to integrate principles from cognitive load theory into FC design, so that the demands of preparatory tasks and classroom activities remain well balanced. A recurring theme is the importance of sound instructional design and adequate teacher preparation. The usefulness of pre-class resources, clarity of teacher guidance, and the coherence between preparatory and classroom tasks all play a decisive role in determining effectiveness. Moreover, while not examined in depth in the reviewed literature, issues related to unequal access to technology and the digital divide remain relevant concerns, particularly when seeking to scale FC across varied socioeconomic settings. The evidence reviewed provides strong support for the theoretical underpinnings of the FC model, especially its consistency with constructivist learning and learner autonomy. Furthermore, the deliberate organization of preparatory and classroom tasks reflects concepts from information processing theory, highlighting the importance of acknowledging learners' cognitive limitation and capacities. The integration of FC with other pedagogical strategies, including problem-based learning, CLIL, and outcomes-based education (OBE), shows its adaptability to diverse instructional frameworks. Such flexibility indicates that FC should not be viewed as an isolated practice but rather as a versatile structure that can complement and be strengthened by other evidence-based teaching approaches.

Based on the analyzed evidence, several concrete practical implications emerge for higher education institutions seeking to implement the FC model effectively. First, institutions should establish a phased implementation strategy beginning with pilot programs in selected courses before scaling university-wide. This gradual approach, evidenced by successful implementations in Spain and China, allows for systematic refinement of pedagogical approaches and technological infrastructure while minimizing institutional disruption and student cognitive overload.

Second, faculty development programs must prioritize three core competencies: (1) digital content creation skills for developing high-quality pre-class materials including videos, interactive presentations, and formative assessments; (2) facilitation techniques for managing active learning sessions that transform classroom time into collaborative problem-solving and application activities; and (3) assessment design capabilities that evaluate both content mastery and autonomous learning skill development. The studies by Magaña et al. (2022) and Jimenez-Cardona (2021) demonstrate that instructor preparedness directly correlates with student outcomes and satisfaction.

Third, technological infrastructure investment should focus on reliable, user-friendly Learning Management Systems that integrate multiple functionalities: content delivery, communication tools, assessment platforms, and learning analytics. The successful implementations documented across studies consistently utilized platforms like Moodle combined with complementary tools (YouTube, WeChat,

Kahoot) rather than complex proprietary systems. Institutions should prioritize interoperability and accessibility to ensure equitable student access regardless of socioeconomic status or technological proficiency.

Fourth, student orientation programs are essential for FC success. Institutions should develop comprehensive onboarding modules that explicitly teach students how to engage with pre-class materials effectively, develop time management strategies for autonomous learning, and participate actively in collaborative classroom activities. The transition from passive to active learning roles requires deliberate scaffolding, as evidenced by studies showing initial student resistance that diminishes with proper preparation and support (Noguera et al., 2022; Nahuelcura-Millán, 2023).

Fifth, assessment frameworks should incorporate both traditional content knowledge evaluation and metacognitive skill development measures. Rubrics should explicitly evaluate students' self-regulation capabilities, collaborative competencies, critical thinking skills, and independent learning progress alongside disciplinary content mastery. The integration of formative assessments throughout the learning cycle, as demonstrated by Su et al. (2023) and Li et al. (2023), provides continuous feedback that supports autonomous learning development.

Finally, institutional support structures must include dedicated instructional design teams, technical support services, and continuous quality improvement mechanisms. Regular collection of student feedback, peer observation protocols, and learning analytics review ensure ongoing refinement of FC implementations. The evidence suggests that successful FC adoption requires sustained institutional commitment rather than isolated individual faculty efforts, particularly when integrating advanced technologies or complementary pedagogical approaches like PBL or CLIL.

5. Conclusion

This systematic review suggests that the Flipped Classroom (FC) model shows promise for enhancing autonomous learning among university students across disciplines, though conclusions must be tempered by methodological limitations. Analysis of fifteen studies provides preliminary evidence for FC as a potentially effective pedagogical strategy in higher education, with reported improvements in self-directed learning behaviors, academic performance indicators, and transferable competencies. However, the strength of this evidence is constrained by the small sample size, absence of formal quality assessment, and methodological heterogeneity.

China and Spain emerge as dominant research contexts, with six publications each. Spanish studies primarily examine pedagogical evaluation and student perceptions across traditional disciplines (education, chemistry, law, architecture), while Chinese research emphasizes technological integration including big data analytics, neural networks, and mobile learning platforms in applied fields (nursing, physical education, language instruction). This geographical concentration (80% from two countries) significantly limits generalizability to other educational, cultural and institutional contexts.

Theoretical analysis indicates FC's conceptual alignment with constructivist and autonomous learning principles, particularly when pre-class preparation activities combine with collaborative in-class engagement. FC demonstrate compatibility with complementary pedagogical approaches including problem-based learning, CLIL, and outcomes-based education frameworks. The model's structured sequencing of learning activities reflects information processing theory principles, thought the extent to which observed benefits derive specifically from FC versus these complementary approaches remains unclear without appropriate comparison conditions.

Technological integration constitutes a defining characteristic of contemporary FC implementation. Digital infrastructure including learning management systems, multimedia content repositories, and interactive assessments platforms enables personalized learning experiences. Advanced applications, particularly evident in Chinese contexts, suggest future potential for intelligent tutoring systems providing

adaptive feedback and individualized content pathways to enhance student autonomy, though evidence for these sophisticated applications remains limited.

Effective implementation appears to require strategic institutional planning integrating technological investment, comprehensive faculty development, and thoughtful instructional design. Gradual adoption may minimize cognitive overload and ensure adequate student support during transition from traditional pedagogical approaches. Success factors identified across studies include robust digital platforms, interactive assessment integration, strong pedagogical facilitation skills, and student orientation programs, though the relative importance of these factors cannot be determined from the available evidence.

Important methodological limitations constrain confidence in these conclusions: (1) reliance on single database (Scopus) potentially excluding relevant studies from ERIC, Web of Science, and grey literature; (2) narrow search terminology potentially missing studies using alternative FC terminology; (3) restricted temporal scope (2020-2024) excluding foundational literature; (4) absence of protocol pre-registration enabling potential selective reporting; (5) lack of formal quality assessment or risk of bias evaluation preventing differentiation of robust versus weak evidence; (6) geographical concentration limiting cross-cultural generalizability; (7) predominance of perception and satisfaction measures versus objective learning outcomes; (8) absence of long-term follow-up data; and (9) methodological heterogeneity preventing meta-analytic synthesis.

Therefore, while FC represents a theoretically sound and apparently promising approach for promoting autonomous learning in higher education contexts, definitive conclusions regarding its effectiveness, optimal implementation conditions, and comparative advantage over alternative pedagogical approaches require substantially more rigorous investigation. Future research should address the methodological limitations identified, employ randomized or well-controlled quasi-experimental designs with appropriate comparison conditions, implement formal quality assessment protocols, expand geographical and disciplinary representation, incorporate objective learning measures alongside perceptions, and examine long-term retention and transfer effects.

6. Limitations and Future Research

The main limitation of this research lies in the reliance on a single database, SCOPUS, which, although highly comprehensive, may exclude studies indexed elsewhere. Another significant limitation concerns the geographical bias in the analyzed sample. The heavy concentration of studies from China (40%) and Spain (40%), totaling 80% of the reviewed literature, limits the generalizability of findings to other geographical. Future research should intentionally seek studies from underrepresented regions to provide a more comprehensive and globally representative understanding of FC's impact on autonomous learning.

Another significant limitation refers to disciplinary applications. Although the general objective focused on determining the influence of the Flipped Classroom model on autonomous learning development at the university level, the analysis revealed substantial variations in disciplinary applications (ranging from nursing and chemistry to physical education and language teaching). Future research should explicitly define whether the focus will be on specific, or alternatively, ensure more balanced representation across diverse contexts to support broader generalizations.

The absence of a quantitative meta-analysis in this review—limits the ability to provide consolidated statistical evidence regarding FC's effectiveness. Future systematic reviews should consider conducting meta-analyses when sufficient methodological homogeneity exists.

Future research should also address the temporal scope more fully, as technological resources and pedagogical approaches evolve rapidly. Longitudinal studies examining the implementation of CF over long periods would provide valuable insights into long-term sustainability and effectiveness.

Finally, although this review identifies positive outcomes associated with the implementation of FC, it provides limited guidance on the practical mechanisms and specific conditions necessary for successful

adoption. Future research should focus on implementation science approaches that document the "how" of FC adoption.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author received no financial support for the research, authorship, and/or publication of this article.

Authors' contributions

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Data Availability

Data requests can be made in Spanish to corresponsal author via this email: aolanoiv@ucvvirtual.edu.pe.

Use of Artificial Intelligence

The author states that he used the Sonnet 4.6 tool in the discussion of results to improve the English grammar.

References

Abeysekera, L., & Dawson, P. (2015). Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research. *Higher Education Research & Development, 34*, 1-14. https://doi.org/10.1080/07294360.2014.934336

Aprianto, E., Purwati, O., & Anam, S. (2020). Multimedia-Assisted Learning in a Flipped Classroom: A Case Study of Autonomous Learning on EFL University Students. *International Journal of Emerging Technologies in Learning, 15*(24), 114-127. https://doi.org/10.3991/ijet.v15i24.14017

Arteaga, J.F., Ruiz, P.R., Delgado, J.A.G., & Ríos, D.G. (2021). Flipped Classroom Teaching in Organic Chemistry in the Context of CLIL. *Journal of Higher Education Theory and Practice*, *21*(13), 164-172. https://doi.org/10.33423/jhetp.v21i13.4798

Bergmann, J., & Sams, A. (2012). Before You Flip, Consider This. *Phi Delta Kappan, 94*(2), 25. https://doi.org/10.1177/003172171209400206

Bergmann, J., & Sams, A. (2014). *Flipped learning: Gateway to student engagement.* International Society for Technology in Education. https://books.google.com.pe/books/about/Flipped_Learning.html?id=r4OZCgAAQBAJ&redir_esc=y

Bishop, J.L., & Verleger, M.A. (2013). The flipped classroom: A survey of the research. *ASEE Annual Conference and Exposition, Conference Proceedings*. https://doi.org/10.18260/1-2--22585

Chang, H. (2021). College English Flipped Classroom Teaching Model Based on Big Data and Deep Neural Networks. *Scientific Programming*. Wiley. https://doi.org/10.1155/2021/9918433

Colomo-Magaña, E., Soto-Varela, R., Ruiz-Palmero, J., & Gómez-García, M. (2020). University students' perception of the usefulness of the flipped classroom methodology. *Education Sciences, 10*(10), 1-19. https://doi.org/10.3390/educsci10100275

Coman, N. (2024). Cognitive perspectives in learning – from theory to practice in education. In *Instruire prin cercetare pentru o societate prosperă.*

Crispín-Bernardo, M.L., Caudillo-Zambrano, L., Doria, C., & Esquivel-Peña, M. (2011). *Aprendizaje Autónomo* (49-63). https://ri.ibero.mx/bitstream/handle/ibero/3367/CZML_Cap_Lib_01.pdf?sequence=1

Deci, E. L., & Ryan, R. M. (2000). La Teoría de la Autodeterminación y la Facilitación de la Motivación Intrínseca , el Desarrollo Social, y el Bienestar Teoría de la Autodeterminación. *American Psychologist, 55,* 68–78.

Eggen, P. (2020). Information Processing and Human Memory. *Oxford Research Encyclopedia of Education*. https://doi.org/10.1093/ACREFORE/9780190264093.013.864

Feijóo, J.C.M., Suárez, F., Chiyón, I., & Alberti, M.G. (2021). Some web-based experiences from flipped classroom techniques in aec modules during the covid-19 lockdown. *Education Sciences, 11*(5). https://doi.org/10.3390/educsci11050211

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906–911. https://psycnet.apa.org/doi/10.1037/0003-066X.34.10.906

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School Engagement: Potential of the Concept, State of the Evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059

Huang, J., & Yu, D. (2022). Application of Deep Learning in College Physical Education Design under Flipped Classroom. *Computational Intelligence and Neuroscience.* Wiley. https://doi.org/10.1155/2022/7368771

Jimenez-Cardona, N. (2021). Effect Business law in a Flipped Classroom Environment. *Revista de Educación y Derecho Universidad de Barcelona, 24*. https://doi.org/10.1344/REYD2021.24.36300

Knowles, M. S. (1975). *Self-directed learning* (Vol. 291). Association Press New York.

Kong, Y., Wang, W., & Rajabov, B. (2024). New model of college physical education teaching based on the algorithm and data structure of flipped classroom and OBE. *Heliyon, 10(*11), e31368. https://doi.org/10.1016/j.heliyon.2024.e31368

Li, Y., Tang, X.F., & Cheng, H. (2023). Application of a flipped classroom teaching model based on micro-videos in the standardized training of dermatological residents in China. *Frontiers in Medicine*, *10(October),* 1-6. https://doi.org/10.3389/fmed.2023.1250168

Magaña, A.C., Magaña, E.C., Guillén-Gámez, F.D., & Ariza, A.C. (2022). Analysis of Prospective Teachers' Perceptions of the Flipped Classroom as a Classroom Methodology. *Societies, 12*(4), 1-15. https://doi.org/10.3390/soc12040098

Mohiyeddini, C. (2024). Self-directed teaching: a holistic framework for educator autonomy. *Frontiers in Medicine*, *11,* 1479885. https://doi.org/10.3389/FMED.2024.1479885/BIBTEX

Nahuelcura-Millán, N. (2023). Innovación en la Enseñanza de la Anatomía Humana: Aula Invertida y su Aplicación. *International Journal of Morphology, 41*(2), 389-394. https://doi.org/10.4067/s0717-95022023000200389

Nazarieh, M., Delzendeh, M., & Beigzadeh, A. (2024). Flipped learning in medical education: Enhancing engagement through innovative pedagogy. *Research and Development in Medical Education, 13*(1), 20-20. https://doi.org/10.34172/RDME.33258

Ni, Z.H., Huang, J., Yang, D.P., & Wang, J. (2024). Nursing students'experience of flipped classroom combined with problem-based learning in a paediatric nursing course: a qualitative study. *BMC Nursing*, *23*(1), 1-9. https://doi.org/10.1186/s12912-024-01744-z

Noguera, I., Albó, L., & Beardsley, M. (2022). University students' preference for flexible teaching models that foster constructivist learning practices. *Australasian Journal of Educational Technology*, *38*(4), 22-39. https://doi.org/10.14742/ajet.7968

Nong, W., Ye, J.H., Chen, P., & Lee, Y.S. (2023). A study on the blended learning effects on students majoring in preschool education in the post-pandemic era: An example of a research-method course in a Chinese university. *Frontiers in Psychology*, *13(January),* 1-13. https://doi.org/10.3389/fpsyg.2022.962707

Prisma (2024). *Preferred Reporting Items for Systematic reviews and Meta-Analyses*. https://www.prisma-statement.org/

Schweder, S., & Raufelder, D. (2022). Examining positive emotions, autonomy support and learning strategies: Self-directed versus teacher-directed learning environments. *Learning Environments Research*, *25*(2), 507-522. https://doi.org/https://doi.org/10.1007/s10984-021-09378-7

Su, X., Ning, H., Zhang, F., Liu, L., Zhang, X., & Xu, H. (2023). Application of flipped classroom based on CDIO concept combined with mini-CEX evaluation model in the clinical teaching of orthopedic nursing. *BMC Medical Education, 23*(1), 1-9. https://doi.org/10.1186/s12909-023-04200-9

Tourón, J., Santiago, R., & Díez, A. (2016). *The Flipped Classroom. Cómo convertir la escuela en un espacio de aprendizaje*. Digital Text.

Wang, S. H. (2021). The Application of Information Processing Theory in Higher Education. *Proceedings - 2021 2nd International Conference on Education, Knowledge and Information Management, ICEKIM 2021* (930-933). https://doi.org/10.1109/ICEKIM52309.2021.00209

Yassin, A., & Mabanja, A. (2024). Integrating information processing theory with artificial intelligence for enhanced learning outcomes. *International Conference on Aplied Social Sciences in Education, 1*(1), 1-13. https://doi.org/10.31316/ICASSE.V1I1.6902

Zhang, H. (2022). A Study on the Application of Flipped Classroom Teaching Model in College English Based on the Mobile Learning. *Theory and Practice in Language Studies*, *12*(2), 319-326. https://doi.org/10.17507/tpls.1202.13

Zimmerman, B. J. (2002). Becoming a Self-Regulated Learner: An Overview. *Theory Into Practice, 41*(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2

Published by OmniaScience (www.omniascience.com)

Journal of Technology and Science Education, 2026 (www.jotse.org)