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Improving Autonomous Learning Through Flipped Classrooms in Higher Education

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Abstract: *This paper examines the attitudes of university students at Near East University, Northern Cyprus, regarding autonomous learning through the application of the flipped classroom model. A mixed method research design was employed, and quantitative data were collected from 110 undergraduate students using a structured questionnaire while qualitative data were obtained through semi-structured interviews held with 10 students with the purpose of looking into the perceived challenges regarding flipped learning and potential solutions. Quantitative findings revealed that students displayed a positive attitude in general towards using flipped classrooms in the learning process (mean = 3.67). The results of an independent samples t-test showed that there is no statistical difference between students' attitudes based gender. However, significant differences were found according to academic grade, with students in upper grades having developed a more positive attitude towards flipped learning compared to students in lower grades. Multiple regression analysis showed that self-regulation was the strongest predictor of positive attitudes (beta = .425, $p < .001$), followed by technological accessibility and instructional support. Qualitative findings also supported these findings emphasising that increased flexibility, improved student engagement and the promotion of self-determined learning are the basic benefits of the flipped classroom model. In this study, these findings were examined within a neuro-pedagogical framework, and self-regulation skills were linked to prefrontal executive functions. Despite these advantages, students reported challenges including limited access to technological resources, unstable internet connections, and inadequate digital skills. The findings indicate that when technological infrastructure and pedagogical support are adequate, the flipped classroom model can effectively promote autonomous learning in higher education.*

Keywords: *flipped classroom; autonomous learning; student attitudes; higher education; educational technology.*

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1. Introduction

Rapid progress in information and communication technologies has led to a significant transformation in higher education teaching and learning processes (Aminin & Koiri, 2026; Galindo, 2014; Roehl et al., 2013). Conventional, instructor-centered teaching models meet with increasing criticism due to their limited capacities for meeting the various learning needs of students, improving their high-level thinking abilities, and promoting student autonomy. As a result, higher education institutions are in search of innovative pedagogical approaches that meaningfully integrate technology and place students at the centre of learning processes.

The flipped classroom model is one of these approaches which reverses the conventional teaching sequence by taking direct content delivery outside the classroom and sparing the in-class time for active learning activities (Lage et al., 2000; Milman, 2012; Rahayu et al., 2026; Stone, 2012). In flipped classrooms students usually interact with teaching materials such as video lectures, digital readings or interactive content prior to the class, and class sessions are reserved for discussion, problem-solving, cooperative work and feedback. This pedagogical shift ensures that lecturers assume a facilitator role and the students can engage in deeper interaction regarding the course content. Recent studies have argued that flipped classrooms can encourage active engagement and meaningful interaction between students and improve their participation, motivation and academic performance (Alsancak Sırakaya & Ozdemir, 2018; Arcos, 2014; Farrah & Qawasmeh, 2018). More importantly, the flipped classroom model closely overlaps with modern teaching objectives which emphasise autonomous learning, self-determination, and lifelong learning skills. Autonomous learning implies that students assume the responsibility for planning, overseeing and evaluating their personal learning processes, which is accepted as a critical competency in higher education and professional contexts (Karadag & Keskin, 2017). Despite increased interest in flipped learning, the attitudes of students regarding this teaching approach continue to be an important factor that determines its effectiveness (Alharthi, 2026; Enfield, 2013; Johnson & Renner, 2012; Nolan & Washington, 2013). Positive attitudes towards flipped classrooms can improve autonomous learning by encouraging students to more actively interact with pre-class materials and classroom activities (Kwong et al., 2024). On the other hand, negative perceptions, technological barriers or inadequate digital skills can hinder successful implementation of flipped learning environments. For this reason, examining the attitudes of students regarding flipped classrooms provides valuable information on the applicability and sustainability of this teaching model in higher education. Although the flipped classroom has been widely examined from a pedagogical perspective, its underlying neurobiological foundations have received far less attention, particularly in relation to student motivation and autonomous learning processes (Berrett, 2012).

The flipped classroom model has been extensively and thoroughly studied from a pedagogical perspective in the learning-teaching process. However, the neurobiological foundations related to student motivation, self-regulation skills, and autonomous learning processes remain largely unexplored. Attention should be paid to ensuring compatibility with the brain's learning mechanisms when designing learning environments and course materials at the university level (Bristol, 2014). This research aims to provide a pedagogical perspective by examining students' attitudes towards the flipped classroom model and their autonomous learning experiences, and also to contribute to future neuroscience-based educational research (Rozinah, 2014). In the Northern Cypriot context, empirical studies on flipped classrooms and autonomous learning in higher education are scarce. Understanding how university students perceive flipped learning and whether these perceptions differ according to demographic variables such as gender and academic grade is essential for teaching design and institutional decision-making processes. Accordingly, this study aims to examine the attitudes of university students as regards autonomous learning in Near East University by employing flipped classrooms. The study includes the following research questions to provide direction. The study particularly examines the general attitudes of students regarding flipped learning and investigates potential differences by gender and academic level as well as perceived challenges and suggestions for improvement.

Research questions as follows:

1. What are the attitudes of university students for using flipped classrooms in promoting autonomous learning?
2. Is there any difference between student attitudes for flipped classrooms by gender?
3. Is there any difference between student attitudes for flipped classrooms by their academic level?
4. What are the challenges faced by the students in attending flipped classroom environments?
5. What suggestions are made by the students for improving the application of flipped classrooms in higher education?

2. Theoretical Framework

The flipped classroom model is based on modern learning theories which underline student autonomy and motivation and active knowledge construction. The theoretical foundation of this study was primarily shaped by social constructivism and self-determination theory (SDT). From a constructivist viewpoint, learning is not seen as mere passive information-gathering, but as an active process where students form knowledge through interaction, communication and reflection. The flipped classroom model reinforces this perspective by reallocating the teaching time and allowing students to interact with the content before class sessions and to participate in high-level learning activities during face-to-face sessions. Self-determination theory explains how flipped classroom environments can increase the internal motivations of students which further strengthen the theoretical foundation of this study (Sergis et al., 2018). Self-determination theory argues that autonomy, competence and relatedness are the basic psychological needs for effective learning. Students in flipped classrooms experience autonomy by controlling the pace and timing of their pre-class learning, competence through guided in-class activities and feedback, and relatedness through collaborative learning and peer interaction.

In order to clarify the theoretical logic of the study, Figure 1 offers a conceptual framework demonstrating how the flipped classroom model supports student autonomy through mechanisms proposed by Self-Determination Theory, and how this process contributes to meaningful learning outcomes and broader implications for higher education.

2.1. Constructivist Learning Theory

This model is theoretically grounded, linking flipped classroom design to the achievement of learning outcomes. Student autonomy is reinforced in the transition from pre-class preparation to in-class participation. This process is based on Self-Determination Theory (SDT) which increases student engagement through autonomy, competence and relatedness and informs higher education policy strategies (Dieu, 2024; Li & Wang, 2026). This study conceptualises the synergistic relationship between Constructivist Learning Theory and Self-Determination Theory (SDT) through the “Flipped Classroom” model. The hierarchical structure presented in Figure 1 addresses the process of transforming educational technologies into pedagogical outcomes in three basic stages: first, cognitive preparation and autonomy: The process begins with pre-class digital materials (video-based learning) allows the student to determine their personal learning pace (Fidan, 2023). This, in turn, triggers “student autonomy”, which is the second stage, and the shifting of learning responsibility to the individual. Second, Meeting of Psychological Needs (SDT): The self-determination theory, which rests in the center of Figure 1, satisfies the autonomy, competence and relatedness needs of the student, and transforms external motivation to an internal desire for learning. This transformation sets the ground for cognitive and emotional engagement of the student to the class in addition to physical attendance. Lastly, Strategic Outputs and Policy: The final goal of the model is not only to increase academic achievement, but also to offer a scientific and applicable foundation for higher education policies such as the integration of digital learning, curriculum design, and teaching strategies (Seaman & Gaines, 2013).

Figure 1 depicts the conceptual framework demonstrating how the flipped classroom model fosters learner autonomy through the mechanisms of Self-Determination Theory and contributes to higher education outcomes.

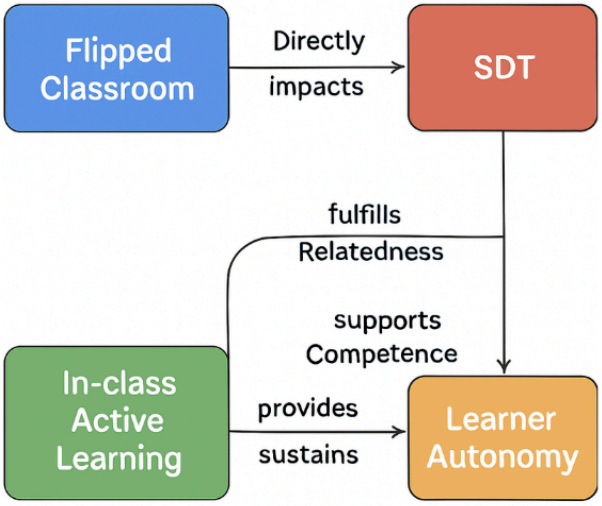

Figure 1. Theoretical Framework of the Flipped Classroom Model Supporting Cognitive Connectivity and Autonomy

The theoretical framework of the flipped classroom model shows the hierarchical relation from flipped classroom design to the improvement of learning outcomes. It is argued that the synergy between pre-class preparation and active participation in the classroom strengthens student autonomy. This process is based on Self-Determination Theory (SDT) which increases student engagement through autonomy, competence and relatedness and informs higher education policy strategies (Sergis et al., 2018).

2.2. Self-Determination Theory

Self-determination theory (SDT) offers an additional theoretical viewpoint to understand the potential impact of flipped classrooms on autonomous learning (Deci & Ryan, 2000; Ryan et al., 2022). SDT emphasises internal motivation and identifies the three core psychological needs (autonomy, competence and relatedness) required to encourage self-determined learning behaviours. The flipped classroom model fosters autonomy by allowing students to control the pace, timing and place of their primary learning experiences. Competence is developed through structured in-class activities which provide immediate feedback, whereas relatedness is promoted through peer cooperation and teacher-student interaction (Herreid & Schiller, 2013). As a result, the learning settings offered by flipped classrooms are closely aligned with the motivational principles summarized in Self-Determination Theory.

Self-Determination Theory (SDT) offers educational benefits and demonstrates a strong parallel between learning and the biological processes at work in the brain (Luria et al., 2021). The sense of autonomy supported by the flipped classroom model has been theoretically associated with executive functions, such as planning and self-regulation. When students take responsibility for

their own learning processes, dopaminergic activity, part of the brain's reward system, is activated. This neural activation increases intrinsic motivation and cognitive engagement, ultimately leading to more effective learning.

From a neuroscientific perspective, when examining the development and change experienced by students during the learning process, it is known that as self-regulation capacity improves, the functional connections between the hippocampus and the prefrontal cortex strengthen. Thus, it has been concluded that this facilitates the transfer of new information to long-term memory (Collins, 2007). Autonomy-supporting learning environments, such as flipped learning, are also known to increase the activity of the anterior cingulate cortex, which is responsible for error monitoring and cognitive flexibility (Pretorius, 2025). This, in turn, deepens students' metacognitive awareness. Thus, the flipped classroom model stands out as a holistic approach that bridges motivational processes and synaptic plasticity, strengthening both the behavioral and neurobiological foundations of learning.

2.3. Flipped Classrooms and Autonomous Learning

Autonomous learning is gaining increasing acceptance as an important consequence of effective higher-education pedagogy (Talbert, 2012). It has been shown that the integration of flipped classrooms urges students to undertake the responsibility of participating in preparation and learning activities and improves self-determined learning competencies. That said, improving autonomous learning through flipped classrooms is a function of factors such as the digital literacy of students, access to technological resources, and the pedagogical design developed by the lecturers (Shanmugapriya & Jayaraman, 2026). Under the guidance of constructivist learning theory and Self-Determination Theory, this study examines how flipped classrooms foster autonomous learning in higher education from the viewpoint of students.

3. Methodology

3.1. Research Design

This study adopted a mixed-methods research design which combines quantitative and qualitative approaches to gain a comprehensive understanding of the attitudes of university students for autonomous learning through flipped classrooms. The mixed-methods design ensured that the digital data obtained from the questionnaires were integrated with the in-depth qualitative information collected through student interviews. Selected quotations from the interviews were presented with the purpose of displaying the viewpoints of the participants in a way that confidentiality could be ensured. This approach was deemed appropriate so as to capture the general tendencies as well as underlying perceptions regarding flipped learning.

3.2. Participants

The study was conducted during the autumn semester of the 2019-2020 academic year at Near East University. A total of 110 undergraduate students participated in the quantitative stage of the study, 57 of whom were male (51.8%) and 53 of whom were female (48.2%). In terms of academic grade, 61 participants (55.5%) were junior students, and 49 participants (44.5%) were senior students. In addition, 10 students participated voluntarily in the qualitative stage and were interviewed with the purpose of obtaining deeper information regarding their flipped classroom experiences.

3.3. Data Collection Instruments

This study employed two data collection instruments, namely a questionnaire form and a semi-structured interview form. The questionnaire was designed to measure the attitudes of students regarding the use of flipped classrooms in the learning process. It consisted of two sections, namely the demographic information section (gender and academic grade) and a 10-item Likert scale regarding flipped learning. The responses were recorded on a five-point scale ranging from 1 (totally disagree) to 5 (totally agree). The questionnaire was distributed online via Google Forms. Qualitative data were collected through semi-structured interviews consisting of open-ended questions which aimed to explore the challenges and deficiencies perceived by students regarding flipped classroom applications as well as their recommendations.

3.4. Validity and Reliability

The reliability of the questionnaire was evaluated using Cronbach's alpha coefficient (α). As a result of the analysis, the α was found to be 0.965, which indicates a high level of internal consistency and verifies that the instrument is reliable for measuring the attitudes of students towards flipped learning. Content validity was ensured through examination by experts who specialise in the fields of educational technologies, curriculum and teaching.

3.5. Data Analysis

Quantitative data were analysed using the Statistical Package for Social Sciences (SPSS), version 23. Descriptive statistics were calculated, including frequencies, percentages, mean values and standard deviations to be able to define the attitudes of students towards flipped learning. An independent sample t-test was conducted to examine the differences between student attitudes by gender and academic grade. In addition to descriptive statistics and independent samples t-tests, multiple regression analysis was also conducted to identify the variables that best explain students' attitudes towards autonomous learning. This method was chosen to examine more comprehensively how the variables Self-Regulation, Technological Accessibility, and Instructional Support relate to each other and to create a stronger analytical framework as suggested in the peer review. The overall significance of the model was assessed using the F-test, and the explained variance was determined using the R-squared (R^2) value. Qualitative data were analysed using thematic analysis methods. First, the data were read and understood in detail, then initial codes were created, and the emerging themes were identified and reviewed. In the final stage, the themes were clarified and named, and the findings were compiled into a report. In this context, this systematic process ensured the accurate identification and orderly classification of participants' views on the flipped classroom model. The integration of quantitative and qualitative findings allowed for triangulation, which improved the reliability of the findings.

4. Results

The quantitative and qualitative data obtained from the study were analysed to test the effectiveness of the flipped classroom model. This study evaluated the effectiveness of the flipped classroom model using a mixed-methods approach addressing five key research questions. Quantitative analysis utilised single-sample and independent-sample t-tests to examine students' general attitudes (RQ1), gender differences (RQ2); according to the t-test result, no significant difference was found ($t(108) = -1.50$; $p > .05$). The calculated effect size (Cohen's $d = 0.28$) was small. This finding shows that gender does not play a determining role in students' attitudes., and differences based on academic grade level (RQ3). According to the results of the independent samples t-test, a significant difference was found between senior students (Mean = 4.11; SD = 0.71) and junior students (Mean = 3.21; SD = 1.16) ($t(108) = 4.82$; $p < .001$). The calculated effect size (Cohen's $d = 0.94$) is quite high. This finding shows that class level strongly influences students' attitudes towards autonomous learning in a flipped classroom environment. Qualitative data were collected through semi-structured interviews to better understand participants' experiences with this

model. Challenges encountered in using the model (RQ4) and potential internal improvement suggestions (RQ5) were also analysed. The findings from these analyses are presented in detail in the following sections.

4.1. Descriptive Statistics

Research question 1: What are the attitudes of university students for using flipped classrooms in promoting autonomous learning? A one-sample t-test was applied to examine the attitudes of university students towards usage of flipped classrooms in promoting autonomous learning. The results showed that students developed a moderately positive attitude towards flipped classroom applications. The mean score of the students' attitudes was found to be 3.67 (with sd=0.84), indicating that the participants usually perceive flipped learning as a supportive teaching approach. These findings show that flipped classrooms positively contribute to the autonomy feeling of students by ensuring flexible access to learning materials, encouraging self-paced learning, and increasing responsibility for learning. The general attitude is not strongly positive, yet the results show that flipped learning is seen as a meaningful alternative to conventional teaching in higher education.

4.2. Differences Based on Gender

Research Question 2: Is there any difference between student attitudes towards flipped classrooms by gender? An independent-samples t-test was performed to examine whether the attitude of students towards flipped classrooms showed any difference by gender. The findings revealed that there was no statistically significant difference between the attitudes of male and female students ($p > .05$). Although female students obtained slightly higher mean scores ($M = 3.73$, $SD = 1.07$) than male students ($M = 3.42$, $SD = 1.10$), this difference was not statistically significant. This finding indicates that flipped classroom practices are perceived by female and male students similarly and that gender does not play a determining role in shaping the attitudes towards flipped learning in higher education contexts.

4.3. Differences Based on Academic Grade

Research Question 3: Is there any difference between student attitudes for flipped classrooms by their academic grade? An independent-samples t-test was performed to examine whether the attitude of students towards flipped classrooms showed any difference by academic grade level. The analysis displayed that there was a statistically significant difference between senior and junior students in terms of their attitudes towards flipped learning. Senior students reported significantly more positive attitudes ($M = 4,11$, $SD = 0,71$) compared to junior students ($M = 3,21$, $SD = 1,16$). This finding clarifies that students with more academic experience and higher learning responsibility are more open to flipped classroom applications probably due to an increased self-regulated and autonomous learning capacity. Specifically,the significantly more positive attitude displayed by upperclassmen in higher education compared to lowerclassmen ($M = 4.11$) may be theoretically linked to the prefrontal cortex and its associated executive functions in the academic maturation process. As students progress through their education, they become more self-aware and conscious of their responsibility for their own learning. Their self-regulation capacity increases with advancing grade levels. In this context, the flipped learning model allows them to manage the cognitive load and independent study process more successfully.

4.4. Multiple Regression Analysis of Factors Influencing Students' Attitudes Towards Autonomous Learning

This analysis aims to identify which factors most strongly explain students' overall attitudes towards flipped learning. Based on Self-Determination Theory (SDT) and considering qualitative findings, three predictor variables were included in the model: Self-Regulation (SR), Technological Accessibility (TA), and Instructional Support (IS).

Table 1. Multiple Regression Results for Predicting Autonomous Learning Attitudes

Predictor Variable	B	SE	β	t	p
(Constant)	0.854	0.312	-	2.737	.007
Self-Regulation (SR)	0.412	0.084	0.425	4.904	<.001
Technological Accessibility (TA)	0.285	0.076	0.312	3.750	<.001
Instructional Support (IS)	0.194	0.065	0.214	2.984	.004

Note: $R^2 = .54$; $F(3, 106) = 41.52$, $p < .001$

Multiple regression analysis was applied in the study.

The established regression model significantly explains 54% of the variation in students' attitudes towards autonomous learning. When the predictor variables are examined, Self-Regulation is found to be the strongest factor (beta = .425, $p < .001$). This finding indicates that a student's ability to plan and manage their own learning process is closely related to success in the flipped learning approach. Technological Accessibility (beta = .312, $p < .001$) and Instructional Support (beta = .214, $p = .004$) are also other variables that make significant contributions. The results show that intrinsic motivation plays a decisive role; however, appropriate digital resources and the teacher's guiding support are also fundamental elements that strengthen learner autonomy in higher education.

4.5. Qualitative Findings

Qualitative data obtained from semi-structured interviews were analysed using content analysis. The findings displayed three main themes: perceived benefits, challenges, and suggestions for improvement. In terms of perceived benefits, students emphasised increased flexibility, improved engagement, and higher responsibility for learning as the basic advantages of flipped classroom model. Participants reported that access to teaching materials prior to the class allowed them to learn at their own pace and better prepare for in-class activities. In terms of challenges, students mentioned limited access to technological resources, unstable internet connections, and inadequate digital skills as the major barriers to effective engagement in flipped learning environments. Some participants also stated that they experienced difficulties in time management and sustaining their motivation at the pre-class learning phase. As regards improvement suggestions, students emphasised the importance of guidance on open education, high-quality learning materials, and technical support. In addition, they recommended gradual application of flipped classrooms to help students adapt to this novel teaching approach.

Research Question 4: What are the challenges faced by students in attending flipped classroom environments? Qualitative data obtained from the semi-structured interviews were examined using content analysis to detect the challenges that students faced in flipped learning environments. The findings displayed various repetitive challenges related to access to technology, motivation, self-discipline and familiarity with flipped learning practices. Quotations from the interviews were presented verbatim to reflect the authentic voices of the participants. The quotations were chosen to reflect repetitive patterns instead of isolated opinions. One of the most cited challenges was inadequate electronic devices and limited access to technological devices including unstable internet connections. Students reported that these limitations had a negative

impact on their ability to timely and effectively reach pre-class learning materials. As stated by one participant:

"Sometimes I wanted to get prepared before the class, but I could not reach the videos as my internet connection at home was slow or even inaccessible." (Participant 3)

Similarly, another student underlined the challenges regarding the availability of devices:

"Not everybody has a laptop or a suitable device, and viewing the materials on the phone is not always comfortable or effective." (Participant 8)

In addition to technology-related limitations, low motivation and inadequate self-discipline emerged as significant challenges especially in the pre-class learning phase. Several students reported that they had difficulties in motivating themselves to independently interact with the teaching materials prior to the class:

"It was difficult to participate in the class if I did not watch the videos in advance, but it was also not easy to motivate myself for studying on my own." (Participant 10)

Another challenge mentioned by the participants was that, especially in the first stages of the application, they were not familiar with the flipped learning practices. Some students confessed that they suffered from confusion as regards expectations from and responsibilities for flipped classrooms:

"In the beginning, I was confused as to what to do before the class because I was not used to this type of learning." (Participant 6)

Generally, these findings show that flipped classrooms offer some pedagogical advantages, and that students' readiness for technology, their self-determination skills, and previous exposure to student-centred learning approaches play a critical role in shaping their learning experiences.

Research Question 5: What suggestions are made by the students for improving the application of flipped classrooms in higher education? Interview findings indicated some recommendations offered by the students with the purpose of increasing the effectiveness of flipped classroom model in higher education. One prominent suggestion was related to the improvement of the technological infrastructure and institutional support to ensure equal access to digital learning resources.

Participants emphasised the need to improve internet connection and technical assistance at institutional level:

"The university must improve internet access on campus and provide better technological assistance to the students." (Participant 5)

In addition, students emphasised the importance of clear teaching directives and well-structured pre-class activities. The participants suggested that lecturers should provide clear statements about expectations and learning tasks prior to the class sessions:

"Teachers should make clearer statements on pre-class assignments so that the students can know exactly how they should be prepared for the class." (Participant 2)

Other students recommended that motivation strategies should be included to encourage consistent interaction with pre-class materials:

"Adding little activities or notes for pre-class preparation might encourage students to take flipped learning more seriously." (Participant 9)

Taken together, these suggestions highlight the need for systematic teaching planning, institutional investment in technological infrastructure, and pedagogical support to improve the engagement and learning experiences of students in flipped classroom settings.

4.6. Neuroscientific Implications for Higher Education

The findings of this research, when examined from a neuroscientific perspective, suggest that environments supporting autonomy in higher education directly parallel the brain's natural learning process. Recent studies in cognitive neuroscience show that effective learning is not merely a mental effort; it is a collaborative product of our brain's executive functions, our source of motivation (reward system), and our ability to control our own learning process (self-regulation) (Chew & Cerbin, 2021). In this context, the flipped classroom model can be seen as a 'brain-aligned'

pedagogical approach that theoretically activates these fundamental neural mechanisms. In this context, the flipped classroom model, which allows students to determine their own learning pace and timing, is thought to activate executive functions such as planning, monitoring, and flexible thinking.

This autonomy not only strengthens students' self-regulation skills but also enables them to process information more deeply and maintain their attention sustainably; processes that are critical for the consolidation of learned information into long-term memory (Schunk & Zimmerman, 2003). Furthermore, the increased participation observed in flipped classroom settings highlights the brain's reward circuit.

When students experience a sense of competence and autonomy, learning ceases to be merely an external necessity and becomes a rewarding experience. This, in turn, strengthens neural motivation, perseverance, effort, active participation, and commitment to the task in students.

Finally, the collaborative nature of activities in the flipped classroom environment can further enrich the social and emotional dimensions of learning. Cognitive feedback given to students and peer discussions during the learning-teaching process have been shown to facilitate cognitive awareness (Huang et al., 2017). In future studies, supporting this behavioural data with brain imaging methods such as EEG or fMRI will play a key role in fully understanding the mental background of autonomous learning in the flipped classroom model.

5. Discussion

The findings of this study provide empirical support for the effectiveness of flipped classrooms in promoting autonomous learning in higher education. The general positive attitudes reported by the students agree with previous research showing that flipped learning encourages active engagement and self-determined learning behaviours (Galindo, 2014; Roehl et al., 2013).

According to the findings of this study, students' positive attitudes (average = 3.67) are consistent with theoretical models suggesting that flipped learning engages the brain's mesolimbic dopaminergic pathway.

The high level of engagement shown by participants largely explains how this model transforms learning into an intrinsic experience. The fact that gender differences are not significant is coherent with previous research claiming that flipped classroom settings provide equal learning opportunities to students regardless of their gender (Alsancak Sırakaya & Ozdemir, 2018). This finding means that flipped learning can be applied in higher education contexts without reinforcing gender inequalities.

The significant difference observed related to academic grade emphasizes the role of learning maturity in autonomous learning processes. The more positive attitudes of senior students can be attributed to more academic experience, higher self-determination levels and their familiarity with independent learning strategies.

This result supports the Self-Determination Theory assumptions, especially the development of competence and autonomy over time (Ryan et al., 2022). This neurobiological transition and its cognitive implications are visually summarised in Figure 2.

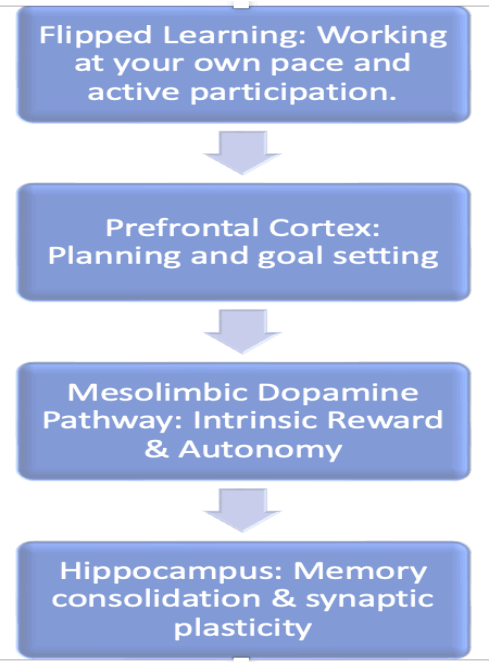

Figure 2. The proposed neuro-pedagogical model of the study. This schema illustrates the theoretical biological interaction between flipped learning activities and cognitive processes in the prefrontal cortex and the dopaminergic reward system, leading to the consolidation of learning and memory enhancement within the hippocampus.

Qualitative findings further strengthen the theoretical foundations of the study. The importance given by students to flexibility and responsibility reflects constructivist principles which prioritise student autonomy and active knowledge building. In light of the findings from this research, the fact that students take on more responsibility and increased active participation in the classroom can be theoretically linked to the activation of the anterior cingulate cortex (ACC) region of the brain (Lockwood et al., 2020). This model shows that when students exhibit active participation in classroom discussions and peer assessments, this brain region facilitates error tracking and the development of metacognitive awareness, thus enabling students to take more responsibility for learning outcomes. At the same time, the reported findings emphasise the importance of technological infrastructure and instructional scaffolding to effectively support the autonomy of students. Viewed from a pedagogical perspective, findings show that when carefully designed and supported flipped classrooms can serve as a valuable teaching strategy to promote autonomous learning. Institutions should provide technological resources, digital literacy training and pedagogical guidance to maximise the benefits of flipped learning. In general, this study contributes to the literature by showing how flipped classrooms can promote autonomous learning and emphasizing the contextual factors that influence its effectiveness in higher education.

6. Conclusion

This study examined the attitudes of university students towards the use of flipped classrooms in promoting autonomous learning of university students in higher education. Drawing on the constructivist learning theory and self-determination theory, it offers evidence that flipped classrooms can promote active engagement, responsibility and self-determination and foster the development of learning autonomy among students. Quantitative findings displayed that students generally developed a positive attitude towards flipped learning and that this teaching approach is perceived as useful for autonomous learning. No significant difference was found by gender, whereas academic grade emerged as an important factor, as senior students displayed a more positive attitude compared to junior students. This finding shows that the academic experiences of

students and their state of readiness for self-determined learning can have an impact on the effectiveness of flipped classroom practices. Qualitative findings added more depth to the results by emphasising the benefits and challenges perceived by students regarding flipped classrooms and their suggestions. Increased flexibility, engagement and responsibility were mentioned as the basic advantages whereas technological limitations and time management were reported as the major challenges. These findings underline that institutional support, pedagogical structuring and gradual application are essential to ensure that flipped learning settings are successfully integrated.

In general, the findings contribute to the increasing literature on flipped classrooms by showcasing their potential for promoting autonomous learning in higher education. From a practical viewpoint, the study suggests that while providing adequate technological resources and guidance, lecturers and institutions should also consider adopting flipped classroom models. Furthermore, the use of AI-powered adaptive learning platforms can further strengthen self-regulation processes by providing students with personalised feedback tailored to their own learning pace.

7. Limitations and Future Research

Despite its contributions, this study has some remarkable limitations. First, the study was conducted at a single university, which can restrain the generalizability of the findings to other higher education settings. Future studies are advised to repeat this study in multiple institutions or cultural environments to increase its external validity. Second, the sample size is relatively small for the qualitative components, as only a limited number of students volunteered to participate in the interviews. Qualitative findings provide valuable information; however, further studies could include larger and more variable qualitative samples to capture a wider spectrum of student experiences. Third, the study is based on self-reported data that can suffer from response bias. Future studies can include additional data sources such as classroom observations, learning analytics or academic performance measures to provide a more comprehensive understanding of the impact of flipped classrooms on autonomous learning. Finally, further research can address longitudinal designs to explore how the autonomous learning skills of students evolve in time in flipped classroom settings. Studying the role of teaching design quality, digital literacy and the support of lecturers can provide more in-depth information on the conditions where flipped classrooms are most effective in higher education.

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Appendix: Survey

Instructions: The following statements are designed to help you determine your attitudes toward the flipped learning model. Please indicate how much you agree with each statement on a 5-point Likert scale: **(1) Strongly Disagree, (2) Disagree, (3) Undecided, (4) Agree, (5) Strongly Agree.**

	Statement	(1)	(2)	(3)	(4)	(5)
1	I feel more responsible for my own learning process in a flipped classroom environment.	☐	☐	☐	☐	☐
2	The flipped model allows me to study at my own pace using pre-class materials.	☐	☐	☐	☐	☐
3	I find it easier to identify my learning needs when I interact with digital materials before the class.	☐	☐	☐	☐	☐
4	Active participation in classroom discussions strengthens my understanding of the course content.	☐	☐	☐	☐	☐
5	I feel a greater sense of autonomy when I manage the timing and location of my study.	☐	☐	☐	☐	☐
6	The flipped classroom model encourages me to search for additional resources beyond the provided materials.	☐	☐	☐	☐	☐
7	I feel more competent in solving complex problems during in-class activities compared to traditional lectures.	☐	☐	☐	☐	☐
8	Interacting with my peers and instructor during class enhances my motivation to learn.	☐	☐	☐	☐	☐
9	I am able to monitor my own progress more effectively through the feedback provided in this model.	☐	☐	☐	☐	☐
10	Overall, the flipped classroom model promotes my self-regulation skills and independent learning.	☐	☐	☐	☐	☐