The Effects of the Flipped Classroom Model on Pre-university Students' Academic Performance and Learning Outcomes

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Abstract
This study investigates the implementation and impact of the flipped classroom model (FCM) on Year 12 pre-university students at one of the six form centres in Brunei Darussalam. Traditional pre-university education often revolves around time constraints to cover syllabi and prepare students for board examinations, leading to a reliance on conventional transmission-based teaching methods. However, the evolving educational landscape calls for a transition towards flexible, student-centred pedagogies. The FCM, an innovative iteration of student-centred learning, emerges as a potential avenue for facilitating this transition. Despite its potential, the application of FCM in pre-university education is relatively new, and its effectiveness across diverse subjects remains unexplored. To evaluate the efficacy of FCM in pre-university teaching and learning, a quasi-experimental design was employed across various A-Level subjects. Pre- and post-test scores were collected and analysed using independent sample and paired sample t-tests. Findings exhibit a substantial improvement in students' post-test performance across all subjects compared to their respective control groups. Furthermore, this study unveils positive effects of FCM on student learning outcomes, particularly in terms of independence, engagement, and collaborative attitude. Interestingly, no significant differences in mental effort and academic stress were reported between FCM and control groups. The accrued favourable outcomes underscore the potential of FCM as a contemporary and effective pedagogical model to be adopted in pre-university settings, contributing to enhanced teaching and learning approaches. This study thus advocates for the incorporation of FCM into pre-university education based on its observed benefits.

Keywords: Flipped Classroom Model, Quasi-experimental Design, Academic Performance, Learning Outcomes

Introduction

The origins of the Flipped Classroom Model (FCM) can be traced back to the innovative work of Jonathan Bergmann and Aaron Sams, chemistry educators in the United States. In 2007, their integration of explanatory content and the utilisation of recording software to create instructional videos marked a paradigmatic shift in educational practices, garnering widespread acclaim within the educational community. Subsequently, the FCM transcended geographical borders, becoming a globally recognised educational methodology.

The advantages of enabling students to learn independently, using online resources, and engaging in classroom activities have been extensively documented in several studies (Goodwin & Miller, 2013; Plunkett & Beckerman, 2014; Sams & Bergmann, 2014). This shift towards student-centered pedagogy not only offers insights into student learning preferences and challenges but also enhances the quality of classroom interactions. It emphasises active student participation, fosters critical thinking abilities, and boosts digital literacy, prompting educators to move away from conventional teacher-centered methods (Wright, 2022).

However, despite the evident advantages in skill enhancement and active engagement, persistent challenges, often associated with teachers, students, or technological demands, remain prevalent. Agung et al. (2020) highlighted technology-related barriers, where numerous students expressed disinterest in online learning due to limited internet access and inadequate technological resources, underscoring the issue of the digital divide. The abrupt shift to e-learning since 2020 uncovered tangible limitations, including an excessive dependence on technology functionality and the absence of interpersonal contact during out-of-class learning, contrasting starkly with traditional teaching settings (Clark-Wilson et al., 2020; Goksu and Duran, 2020).

Continuous research and ongoing reflection remain crucial for effectively integrating this innovative model within ever-evolving learning settings. This research endeavour seeks to enhance comprehension and tailor technology integration methods to adeptly address the evolving needs and dynamic demands of learners, particularly within the context of pre-university education.

Research Questions

The primary emphasis of this study revolves around two key research questions (RQ).

RQ1: What are the effects of FCM on students' learning?

RQ2: Does the extra workload in FCM affect students' learning?

Methodology

Quasi-experimental Design

The research involved students from Year 12, spanning various subjects including Chemistry, English/General Paper, History, Mathematics, and Psychology. The methodology integrated asynchronous learning strategies incorporating interactive resources such as pre-recorded video lectures and multimedia activities. These materials were supplemented by accountability quizzes or summaries, reinforcing independently acquired knowledge at home.

The educational content primarily targeted lower-order thinking skills in alignment with the revised Bloom's taxonomy.

During in-class sessions, students engaged in activities geared towards grasping the learning material, emphasising the refinement of advanced thinking abilities through collaborative group work. The experimental phase spanned three cycles, culminating in the presentation of the final cycle's outcomes. To assess mental effort and academic stress levels, students were exposed to one of three teaching models: the original Flipped Classroom Model (oFCM), the extended Flipped Classroom Model (eFCM), or the Traditional Classroom Model (TCM).

The research utilised a pre-test/post-test quasi-experimental setup to evaluate the influence of FCM on students' academic performance. This involved comparing two groups: one undergoing FCM (the experimental group) and the other receiving TCM instruction (the control group). With a participant pool of 201 students, the study sought a thorough analysis of FCM's effectiveness compared to traditional teaching. Before any instruction, both groups completed a pre-test to establish their initial knowledge or skills. Following the instructional period - where the experimental group experienced FCM and the control group received traditional teaching - a post-test assessed the progress of each group's learning. This design, backed by a substantial sample size, aimed to yield robust data for effectively evaluating FCM's impact on student performance and enabling valid instructional comparisons.

Furthermore, the study employed a comparative method to evaluate how FCM affected students' mental effort and academic stress. It compared results between students exposed to FCM in experimental groups and those taught using TCM in control groups. The oFCM adhered to standard procedures involving out-of-class assignments and active in-class learning sessions. In contrast, the eFCM integrated adjustments based on feedback and formative assessments from both out-of-class and in-class activities. Teachers flexibly adapted their teaching strategies, leveraging both in-class and out-of-class activities to enhance the overall learning experience for students.

Survey

The surveys were administered to participants involved in RQ1 ($n = 201$) and RQ2 ($n = 46$, 56, 32, 65, and 55 for Chemistry, General Paper, History, Mathematics and Psychology respectively).

Data Collection & Analysis

A comprehensive assessment approach was employed for data collection. Pre- and post-tests were utilised to quantify student learning outcomes, while pre- and post-surveys were conducted to elicit qualitative feedback on their FCM experiences. For the comparative analysis assessing the influence of FCM on students' mental effort and academic stress scale questionnaires were administered to students following the conclusion of the oFCM, eFCM, and TCM instructional approaches.

The pre- and post-tests were analysed using independent sample t-tests. Effect sizes (Cohen's *d*) were computed for each statistically significant inferential analysis. Descriptive statistical analysis was applied to the questionnaire survey (Zhao & Li, 2021), while the mental effort (Paas, 1992) and academic stress scale (Bedewy & Gabriel, 2015) surveys were subjected to one-way ANOVA.

Results

There Is a Significant Increase in the Mean Gain Scores of FCM Classrooms

The statistical analysis, conducted through an independent sample t-test to assess mean score gains, yielded statistically significant results. The post-test scores in FCM classes exhibited a substantial increase when contrasted with those in TCM classes (Figure 1). This empirical evidence strongly supports the notion that students exposed to the FCM approach experienced markedly enhanced growth and comprehension of the subject matter.

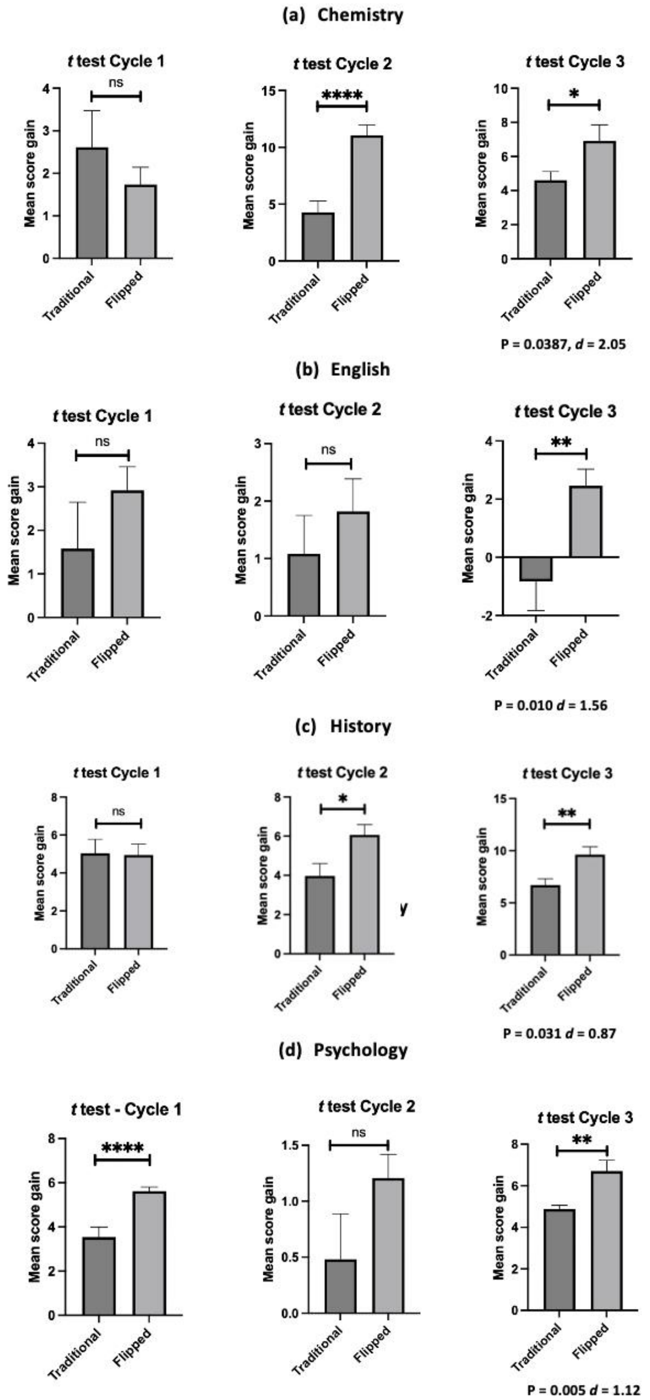

Figure 1: The independent sample t-test reveals a breakthrough of significance in the second or the third cycle of FCM implementation.

During the third cycle of FCM implementation, the independent sample t-test indicates a notable distinction between the FCM and TCM groups This implies that, in this cycle, FCM classes had a more pronounced impact on the measured outcome compared to traditional classes. This change might be attributed to several factors. Students in the FCM classes could have grown more accustomed to FCM concepts and approaches, resulting in enhanced performance. Additionally, teachers might have refined their instructional techniques in the FCM classes over time, better engaging students and aiding their comprehension of the material. This underscores the likelihood that FCM principles require a cumulative understanding, gradually developed over time, with the third cycle possibly representing the point at which both students and teachers had fully adapted to this teaching and learning model.

The noteworthy high effect size in the FCM groups signifies a substantial impact on the studied outcome. This measure assesses the strength of the relationship or difference between groups. In FCM's context, a high effect size implies meaningful and significant changes, not just minor alterations. This indicates a considerable improvement in student performance or the specific variable studied. Moreover, high effect sizes in FCM not only hold statistical significance but also practical importance, suggesting notable improvements in learning outcomes due to FCM. Additionally, a high effect size reinforces FCM's ability to predict or explain changes, establishing a strong, reliable relationship between FCM and outcomes. It signifies a clear distinction between FCM and other methods or interventions, enhancing the study's statistical power and result reliability.

FCM Resulted in a Range of Positive Learning Outcomes

Furthermore, the investigation uncovers a range of positive learning attitudes stemming from students' engagement with the FCM. By analysing survey data (adapted from Zhao & Li, 2021) and conducting in-depth semi-structured interviews with students, valuable insights into the transformative effects of FCM were gained on various aspects of their learning experience.

Importantly, FCM appeared to enhance students' self-regulation which is their ability to manage and control their own thoughts, emotions, behaviors, and actions in order to achieve specific goals as well as their self-efficacy, indicating that they developed a stronger belief in their ability to comprehend and excel in their studies (Table 1). This newfound confidence could potentially lead to greater academic achievements and a more positive outlook on their educational journey. In addition, FCM fostered greater independence among students. They reported a heightened sense of autonomy in managing their learning, which can be attributed to the self-paced nature of FCM. This increased autonomy empowers students to take charge of their education, making them more self-reliant learners. Moreover, our findings revealed that FCM promoted collaboration among students. The interactive elements of FCM, such as group discussions and collaborative projects, encouraged students to work together effectively. This not only enhanced their social and teamwork skills but also enriched their learning experiences through shared insights and perspectives. Lastly, FCM was associated with heightened engagement in the learning process. Students expressed increased enthusiasm for their studies and a deeper involvement with the subject material. This heightened engagement can lead to more meaningful and long-lasting learning outcomes. These emerged themes were corroborated through semi-structured interview of students.

Table 1: The emerging positive learning outcomes of FCM as perceived by students.

Constructs	Question	Median	Mean	Mode
Self-regulation	I am willing to adjust my learning strategy to meet the learning objectives of the topic.	4	3.76	4
	I usually choose a comfortable place when completing the home assigned learning tasks.	4	4.18	5
	I know where I can learn/ complete the home-assigned learning tasks efficiently.	4	3.76	4
	I try to take more thorough notes when learning the out-of-class learning tasks.	4	3.61	4
	I try to overcome the distraction when watching video lectures/online videos.	4	3.70	4
	I seek help from classmates when meeting difficulties in learning/ completing out-of-class learning tasks.	4	3.81	4
Resources/ Independence	Out-of-class learning tasks equipped me to broaden the knowledge.	4	3.58	4
	Out-of-class learning tasks improved my English listening skill.	4	3.56	4
	With out-of-class learning tasks, I improved my independent learning.	4	3.67	4
Self-efficacy	I am confident in socially interacting with other students with respect.	4	3.87	4
	I developed friendship with my classmates.	4	3.87	4
	I am confident in my ability to complete all my out-of-class learning tasks.	4	3.54	4
Collaboration	I enjoy the collaboration experience in the in-class activities (pair-work/group work).	4	3.45	4
	I learned a lot from my in-class activities (pair-work/ group-work).	4	3.66	4
	Pair work/ group work enhanced my communication with classmates.	4	3.80	4
	The experience of cooperating with my partner/ group is pleasant.	4	3.62	4

In essence, the research indicates that FCM positively influences students' learning attitudes in multiple ways. It bolsters self-regulation, self-efficacy, promotes independence, fosters collaboration, and heightens overall engagement in learning. Ultimately, it contributes to more successful and rewarding educational experiences for students. The findings emphasise that FCM significantly enhances students' learning outcomes. This enhancement is evident through increased test scores (improved academic performance) and a deeper grasp of the subject matter. Students exposed to FCM demonstrate marked improvements in knowledge and skills compared to those in traditional classroom setups. Furthermore, our research underscores that FCM actively involves students in the learning process. This involvement is apparent through heightened participation in class discussions, collaborative activities, and exercises that encourage critical thinking (Findlay-Thompson & Mombourquette, 2014). The FCM transforms students from passive recipients of information to active contributors in their own educational journey. This shift in engagement holds significant value in modern education, where interactive and participatory learning experiences are highly prized.

FCM Does Not Impose Extra Mental Effort or Academic Stress

In educational research, understanding how instructional models such as FCM impact students' academic stress and mental effort holds great importance. To investigate this, researchers commonly use questionnaire scales crafted to capture students' perceptions, emotions, and encounters within their learning settings. Academic stress can manifest in various forms, including feelings of being overwhelmed, anxious, or pressured by coursework and learning tasks (Bedewy and Gabriel, 2015). Researchers employ these scales to gauge students' self-reported stress levels, covering aspects like stress-related feelings, time constraints, workload, and the overall perceived stress linked with a specific instructional approach.

Within the learning context, mental effort refers to the cognitive exertion needed to process information and engage in educational tasks, varying based on task complexity and the learning environment. Scales measuring mental effort typically include items relating to concentration, cognitive load, and perceived mental workload. This study investigated how oFCM and eFCM impact mental effort and academic stress compared to the TCM approach, utilising established scales (Paas, 1992; Sweller, 2018).

To evaluate if the increased workload resulting from oFCM and eFCM contributed to increased mental effort and academic stress among students, a one-way ANOVA analysis was performed. This analysis utilised students' feedback obtained through surveys measuring mental effort and academic stress after they completed lessons in TCM, oFCM, and eFCM. The results indicated that there were no statistically significant differences in mental effort and academic stress when implementing FCM (encompassing both oFCM and eFCM) in classroom settings compared to the TCM approach (Figure 2).

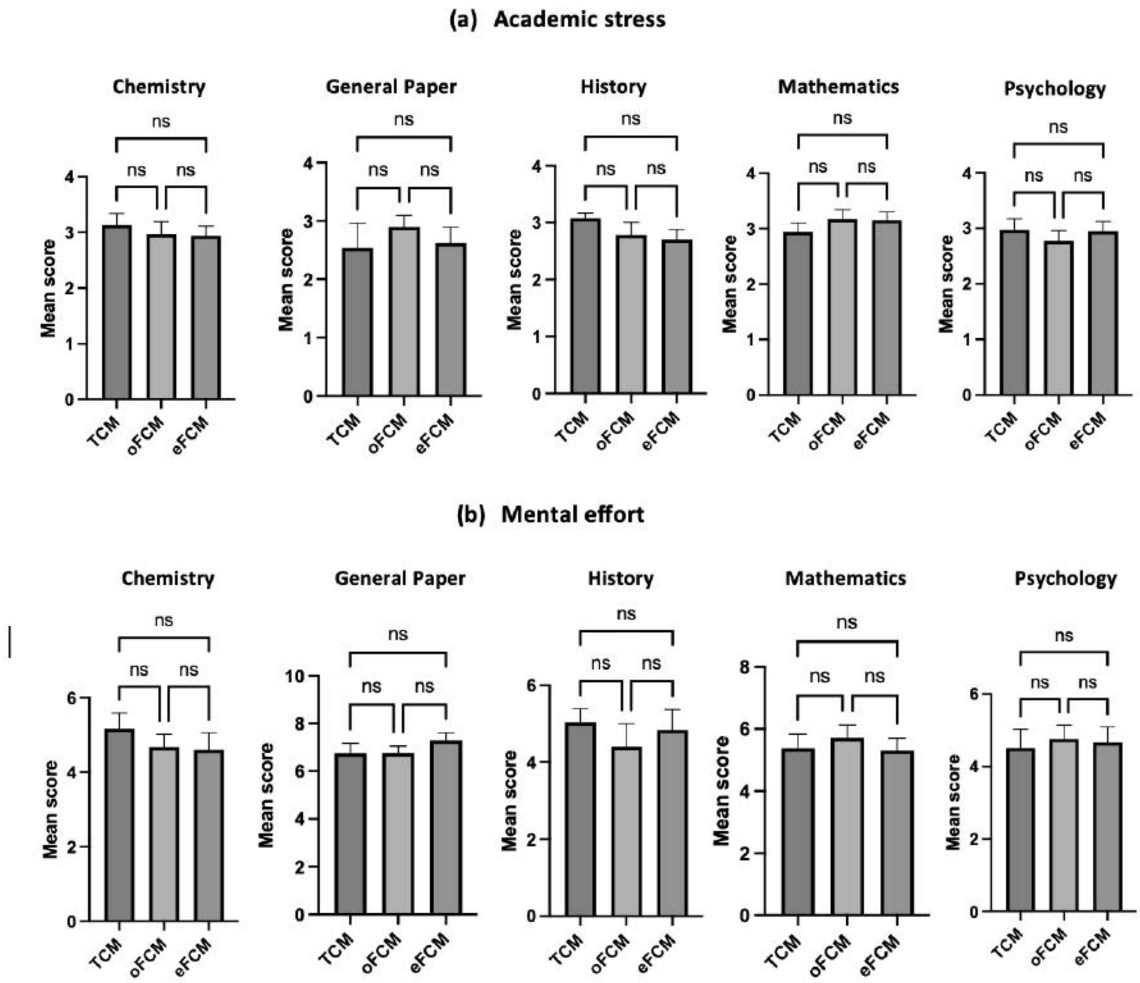

Figure 2: One-way ANOVA indicated that there is no significant difference in terms of students' (a) academic stress and (b) mental effort in the three instructional models.

The absence of significant differences suggests that implementing FCMs does not inherently increase students' academic stress levels compared to traditional teaching methods. This is beneficial as lower stress can promote a healthier learning environment. Additionally, the study implies that students can manage the mental effort needed in FCM without facing notably higher cognitive load. This indicates a viable transition to FCM without overwhelming students. These findings support FCM as a flexible, student-centered approach where students engage with materials at their own pace, potentially easing the constraints of fixed class schedules. With potentially lower academic stress and manageable mental effort in FCM, this could foster a more conducive environment for comprehensive understanding and improved learning outcomes.

These results suggest that FCM can be integrated as an alternative teaching approach without imposing additional academic stress or excessive mental exertion on students. This serves as a positive outcome, offering educators an effective teaching method that encourages active and self-directed learning while upholding a comfortable learning environment for students. This illuminates the practical implications of embracing FCM within educational environments.

Conclusions

In conclusion, this study strongly affirms the positive influence of FCM on students' academic performance and learning attitudes. FCM cultivates crucial 21st-century skills such as self-regulation and collaboration, while also fostering independence and heightened engagement in learning. These collectively contribute to more successful educational experiences, resulting in improved academic performance across all subjects compared to traditional classrooms. Observing the increasing significance of FCM classes over multiple cycles compared to TCM classes offers valuable insights into learning dynamics. This shift could be attributed to learning adaptation, refined teaching strategies, and a cumulative understanding of FCM concepts. Further qualitative research involving student and tutor feedback could refine teaching strategies and enhance the FCM learning process. Importantly, the study dispels concerns about heightened academic stress. Systematic analysis using established scales revealed that FCM implementations did not impose greater cognitive load or perceived academic stress on students compared to traditional classroom approaches. These findings offer reassuring insights for educators considering adopting FCM in their teaching practices without compromising students' well-being.

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