Which Students Thrive in Flipped Classrooms? An Examination of Students' Performance in an Online Flipped Course

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ABSTRACT. Educational disruptions are leading to a shift in flipped classroom delivery, transitioning from a blend of asynchronous and face-to-face instruction to combining asynchronous and synchronous activities in a fully online setup. This study examines the effects of an online flipped course on student clusters with varying prior cognitive outcomes. A college mathematics course is flipped online for a semester. A mixed-methods approach is employed, combining quantitative tests and surveys to assess student performance and perceptions, respectively, with qualitative interviews to explore the experiences of students. Test results show that students in the 'average' and 'low' clusters benefit most. These groups also report higher engagement, effectiveness, and enjoyment. The findings support the potential of flipped learning to advance equity and ensure learning continuity during disruptions. However, the design, sample, context, and exploratory nature of this study present certain limitations. Therefore, interpreting the results with caution is advised.

1.0. Introduction

Teaching and learning with technologies have gained traction in recent years as technological innovations advance. For example, blended learning approaches that combine face-to-face instruction and online engagements are now a common instructional feature in schools and universities. One specific blended learning approach is the so-called flipped learning approach, which reverses the way instruction is delivered by moving content delivery outside of the classroom to allow more active learning opportunities inside the classroom (Bergmann & Sams, 2012). Flipped learning is ideally implemented by providing students with asynchronous learning activities they need to engage in before class to perform more complex learning tasks. These asynchronous learning typically consist of activities involving video lecture watching, readings, and comprehension checks; these activities commonly require minimal assistance from the teacher. On the other hand, more complex learning tasks, commonly requiring the presence of the teacher, are typically carried out through individual or group exercises, presentations, debates, laboratory tasks, and other active learning activities (O'Flaherty & Phillips, 2015).

According to the Flipped Learning Network (2014), flipped learning is ideally achieved by the presence of four key features: (i) a flexible learning environment, (ii) a learning culture that fosters self-regulation, (iii) intentional content that caters to students' needs, and (iv) professional teaching. The 'flexible learning environment' and 'learning culture' deal with the affordance of providing students with choices on how to drive and own their learning. Moreover, 'intentional content' and 'professional teaching' are about providing tailored and scaffolded content to students. If implemented with these key features, flipped learning is argued to aid students in their learning. Significant benefits of flipped learning to students in the literature revolve around increasing student academic performance, increasing student satisfaction, and promoting student empowerment and engagement (O'Flaherty & Phillips, 2015; Talbert, 2017). Nevertheless, despite the seemingly achievable implementation of flipped classes and their promising advantages, challenges may still hinder teachers and students from reaping the most from this approach. Key challenges in flipped learning implementations include students' lack of motivation in performing asynchronous pre-class activities, the increased workload of teachers, and students' lack of access to technologies (Satparam & Apps, 2022).

The use of blended learning approaches was heightened when the COVID-19 pandemic forced school closures. Due to the restrictions on holding face-to-face sessions during lockdowns, educators

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and educational institutions were confronted with the opportunity to modify the conventional structuring of blended learning approaches. In the flipped learning approach, this modification shifted from the conventional combination of asynchronous and face-to-face instruction to combining asynchronous and synchronous activities in a fully online setup. In this online flipped classroom structure, the asynchronous online activities still constitute the tasks students need to engage in before class. However, synchronous online activities now replace conventional face-to-face sessions. The online flipped classroom approach necessitated students to use screens and devices. Hence, the online flipped classroom implementation warranted a sound approach to designing instruction in its implementation. The Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2005) is a useful framework that may guide teachers and instructional designers on how to utilize multimedia in light of how students' brain works to facilitate the process of filtering, selecting, organizing, and integrating information. Several principles anchored on this theory deal with combining words and pictures in instruction (multimedia principle), showing exactly what to pay attention to on the screen (signaling principle), presenting content in chunks or segments (segmenting principle), and providing students with foundational information about a topic (pre-training principle). Depending on the student's level of familiarity with the content, multimedia instruction may impact students differently. For example, students with low prior knowledge of a topic may feel cognitively overwhelmed, especially when the material is difficult and the presentation is fast-paced (Allison, 2015; Mayer, 2005).

Earlier studies investigating the impact of flipped learning implementations on students with varying levels of achievement and self-regulation can be found in the literature (Hwang & Lai, 2017; Jong, 2017; Kostaris et al., 2017; Lo & Hew, 2017; Sergis et al., 2018). These studies, which examined different clusters of students, revealed that students with low achievement and self-regulation levels benefitted most from flipped learning implementations. This suggests that the flipped learning approach has the potential to help students, particularly those who are struggling, to achieve learning gains similar to their more high-achieving peers. Due to teachers' increased time scaffolding students through in-class sessions, struggling students may reap the most benefits from flipped learning implementations. This is primarily attributed to receiving feedback from the teacher and one another during face-to-face sessions (Kostaris et al., 2017). Moreover, the affordance of instructional videos to be accessed anytime and controlled depending on their learning pace is instrumental in providing individualized instruction to students (Nouri, 2016).

While flipped learning has been documented to promote active learning and allow students more control over their learning, it also poses significant challenges for certain groups of students. Students with high self-regulation levels often do well in flipped environments, as they can effectively manage their time, engage independently with pre-class learning materials and tasks, and actively participate in succeeding in-class discussions. However, for students with lower self-regulation levels, the demands of flipped and online learning environments can be particularly daunting. In addition, students with lower prior knowledge levels often struggle to balance independent learning with the complications of managing their cognitive load, which often leads to a range of academic difficulties (Broadbent & Poon, 2015; Wong et al., 2019).

Students with lower prior knowledge often face significant challenges in online learning environments, where they are expected to demonstrate self-regulation and take more responsibility for their learning. Unlike the traditional classroom, where teachers provide real-time scaffolding, online learning environments promote self-directed learning. In this setup, students with lower prior knowledge levels may struggle to understand the content without sufficient cognitive background to contextualize it, leading to increased cognitive load and difficulty grasping important concepts (Paas et al., 2003). Kalyuga (2011) maintains that learners with lower prior knowledge levels often face difficulties choosing appropriate learning strategies and tend to engage in superficial information processing. This limits their ability to make deep and meaningful connections between new and existing knowledge. This problem is compounded in online learning environments where students must explore new materials independently, often without timely teacher intervention (Hodges et al., 2020).

Considering the idea that the design of multimedia instruction may impact students differently and the viability of implementing a subject through an online flipped classroom structure, studies investigating the impact of online flipped classrooms on different groups of students must be conducted to provide initial evidence on its effectiveness. This study aimed to address this gap by exploring two research questions: (a) What is the effect of an online flipped classroom on the performance of students with different prior knowledge levels? and (b) What are the perceptions of students with different prior knowledge levels on the online flipped classroom implementation? To answer these questions, a mixed-methods approach was employed that combined quantitative tests and surveys to assess student performance and

perceptions, respectively, with qualitative interviews to explore the experiences of students.

2.0. Methodology

Research design. The study employed a Mixed Methods Research (MMR) design, specifically an Explanatory Sequential Design, to examine the impact of an online flipped course on students with varying levels of prior knowledge. Quantitative data were collected through pre-tests and post-tests to measure performance across low, average, and high prior knowledge clusters. Following the post-test, data on students' perceptions of the online flipped course were gathered using a Likert-scale survey and focus group discussions. These qualitative and supplementary quantitative data provided contextual explanations for the observed trends, offering an understanding of the online flipped course's effectiveness.

Locale of the Study and Participants. This study was conducted at a teacher education institution in the Philippines, established in 1969. The institution provides training for pre-service teachers and includes integrated schools for preschool, elementary, and secondary education. Participants were 34 first-year Bachelor of Secondary Education students majoring in Mathematics, aged 18 to 20, with 26 females and 8 males. These students were selected based on their enrollment in a required mathematics course and their prior experience with remote learning during Grades 11 and 12 due to the pandemic. This sample allowed for an assessment of the effectiveness of an online flipped classroom, specifically within a higher education context. All participants had prior experience with online learning platforms, owned a personal device, and had internet access.

Course Overview. The study involved a 3-unit College and Advanced Algebra course (54 hours/ semester) delivered entirely online using a flipped classroom approach during the first semester of the 2021-2022 school year. The course utilized a learning management system, video conferencing software, a teacher-owned pen-enabled tablet, video materials, e-books, and student devices. Pre-class activities were available every Saturday, followed by in-class sessions every Tuesday and Friday. The structure of the online flipped course, as outlined in Table 1, guided the study's implementation.

Instrument and data collection process. This study employed a mixed-methods approach to data collection. Quantitative data was gathered through a pre-test and post-test to measure students' problem-solving skills. The tests were rigorously developed and validated following standard procedures, including a review by mathematics educators and a pilot test. The pre-test, administered at the beginning of the semester, determined the grouping of students into low, average, and high prior knowledge clusters, while the post-test was conducted at the end of the semester.

To assess student perceptions of the online flipped classroom experience, a five-point Likert scale survey was adapted from Graziano and Hall (2017). This survey measured student motivation, effectiveness, engagement, and enjoyment. The survey instrument underwent peer evaluation for validity and demonstrated strong internal consistency with a reliability coefficient of 0.79. Students were invited to respond to the survey after their final examination.

Qualitative data was collected through semi-structured focus group discussions. These discussions explored student perceptions of their online flipped classroom experience, focusing on themes like motivation, challenges, and overall satisfaction. The interview questions were peer-reviewed for clarity and alignment with study objectives. All participants were informed of the study's purpose and consented to participate in the survey and focus group discussions.

Data Analysis. Data analysis employed quantitative and qualitative methods to examine the study's findings across three clusters of students (low, average, and high prior knowledge). A paired t-test was conducted within each group to determine whether scores were significantly improved from the pre-test to the post-test, with Cohen's d calculated to assess the effect size of the online flipped course. Descriptive statistics (i.e., means and standard deviations) and inferential statistics (i.e., mean differences, t-values, and p-values) were used to analyze and report the performance data across the groups, highlighting trends and variations. Qualitative data from focus group discussions were analyzed through thematic analysis, identifying recurring themes and patterns and providing deeper

Table 1
Overview of the online flipped course

Week/s	Focus Content	Pre-Class Activities	In-Class Activities
1	*Course Orientation*		
2-4	Review Topics in Algebra	Video watching Readings Comprehension checks	Question and answer Mini-lecture Individual/Group exercises Next-day preparation
5-8	Equations, Inequalities, and Mathematical Modeling		
9	*Midterm Examination*		
10-17	Functions and Their Graphs	Video watching Readings Comprehension checks	Question and answer Mini-lecture Individual/Group exercises Next-day preparation
18	*Final Examination*		

insights into the students' experiences and perceptions of the online flipped course. This mixed-methods approach enabled an understanding of the online flipped course's effectiveness and its differential impact on the three student clusters.

3.0. Results and Discussion

The effect of online flipped classroom on the performance of students with different prior knowledge levels

Table 2 shows students' frequency and percentage distribution in the different prior knowledge level clusters. The pre-test results administered at the start of the course informed the determination of the student's prior knowledge level clusters. Students were grouped into three clusters based on their performance, i.e., high prior knowledge, average prior knowledge, and low prior knowledge. The upper 25% of the students in the pre-test scores were classified as having high prior knowledge levels, while the lower 25% had low prior knowledge levels. The middle 50% represented students with average prior knowledge levels. The actual percentage distribution (25.81% for high prior knowledge and 29.03% for low prior knowledge) slightly deviated from the preset boundaries due to grouping students with the same scores into the same cluster. For example, if several students achieved the same score near the threshold between clusters, they were all grouped in the same category to maintain consistency. This ensured that students were categorized based on their actual performance without separating those with identical scores.

Table 2
Distribution of students in different prior knowledge levels

Prior Knowledge Level	f	%
High	8	25.81
Average	14	45.16
Low	9	29.03
Total	31	100

Table 3 shows the results of the pre-test and the post-test of the overall sample. The total score of both tests was fifty (50). The same set of questions composed the two tests, which covered the identified scope of the course and required students to solve word problems in real-world contexts. A paired t-test showed a significant difference between the pre-test mean (n = 31, M = 6.45, SD = 4.96) and the post-test mean (n = 31, M = 22.10, SD = 10.42), $t(30) = -7.58$, $p < 0.001$. The computed Cohen's d value was 1.89, indicating a large effect size. This result suggests that the exposure to the online flipped course of the students in the overall sample resulted in an improvement in their performance. This notable effect on student performance in the online flipped course matches those in some studies contextualized in conventional flipped learning (Abdelrahman et al., 2017; Bhagat et al., 2016; Chao et al., 2015; Cukurbasi & Kiyici, 2018; D'addato & Miller, 2016; Gariou-Papalexiou et al., 2017; Kong, 2015; Olakanmi, 2017; Schultz et al., 2014), highlighting that flipped learning implementations were effective in supporting students' learning. As this study provided early evidence of the potential of online flipped classrooms to support students learning, more studies and continuous discussions on the online flipped classroom approach should be conducted to strengthen this initial finding in the same way that research on conventional flipped learning should be further investigated since mixed and contradictory results on its effectiveness continue to populate the flipped learning discourse (Satparam & Apps, 2022).

Table 4 shows the granulated results of the pre-test and post-test of students with different prior knowledge levels. Paired t-tests showed significant differences between the pre-test and post-test means of the students with low prior knowledge levels and those with average prior knowledge levels but not with students with high prior knowledge levels.

Specifically, the paired t-test on students with low prior knowledge levels showed a significant difference between the pre-test mean (n = 9, M = 1.56, SD = 1.24) and the post-test mean (n = 9, M = 18.33, SD = 7.84), $t(8) = -6.31$, $p < 0.001$. The computed Cohen's d value was 2.99, which indicates an extremely large effect size. Moreover, the paired t-test on students with average prior knowledge levels showed a significant difference between the pre-test mean (n = 14, M = 5.43, SD = 1.34) and the post-test mean (n = 14, M = 25.07, SD = 11.59), t(13) =

Table 3
Results of the pre-test and post-test of the overall sample

Group	Pretest M (SD)	Posttest M (SD)	MD	t-value	p
Overall sample	6.45 (4.96)	22.10 (10.42)	15.65	-7.58	<0.001

M: Mean, SD: Standard Deviation, MD: Mean Difference

Table 4
Granulated results of pre-test and post-test of students in different prior knowledge levels

Prior knowledge level	Pretest M (SD)	Posttest M (SD)	MD	t-value	p
High	13.75 (3.20)	21.13 (11.13)	7.38	-1.83	0.11
Average	5.43 (1.34)	25.07 (11.59)	19.64	-6.33	<0.001
Low	1.56 (1.24)	18.33 (7.84)	16.78	-6.31	<0.001

M: Mean, SD: Standard Deviation, MD: Mean Difference

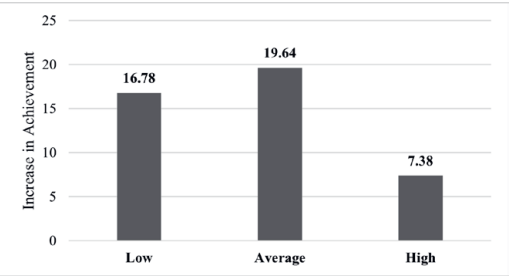
-6.33, $p < 0.001$. The computed Cohen's d value was 2.38, which indicates an extremely large effect size. Lastly, the paired t-test on students with high prior knowledge levels showed an improvement, although not significant, between the mean test scores of students with high prior knowledge levels, i.e., the pre-test mean ($n = 8$, $M = 13.75$, $SD = 3.20$) and the post-test mean ($n = 8$, $M = 21.13$, $SD = 11.13$), $t(7) = -1.83$, $p = 0.11$. The computed Cohen's d value was 0.90, indicating a large effect size.

The results above suggest that the online flipped course benefited the students with low and average prior knowledge levels compared to those with high prior knowledge levels. These findings parallel those early findings in the literature (Kostaris et al., 2017; Sergis et al., 2018). The results also imply that students in the average and low prior knowledge clusters, despite initially having lower prior knowledge than those in the high cluster, were able to catch up with the foundational concepts needed for more complex activities. This may suggest that the principle of pre-training was achieved in implementing the online flipped classroom. According to Mayer (2005), the pre-training principle states that humans learn more efficiently if they know some of the basics, including definitions, terminologies, and procedures, before embarking on a new learning experience. In this study, it can be posited that this was achieved by implementing pre-class sessions, which equipped students with pre-requisite skills and knowledge needed for succeeding in-class sessions.

To add more insights into the effect of the online flipped classroom on different groups of students, the researcher examined the increase in scores among groups of students (see Figure 1). The differences in the scores of students in each cluster in the pre-test and the post-test constituted the data needed for the analysis. Based on the descriptive data, students in average and low clusters obtained the most gains in achievement levels, as evidenced by their improved test scores, with an average of 19.64 for the average students and 16.78 for the low students. These findings slightly differ from the insights articulated in previous works on implementing conventional flipped learning (Sergis et al., 2018). In previous studies, low-achieving students reaped the most gains in learning outcomes, way ahead of average- and high-achieving students. This presents an interesting finding which is worthy of further investigation. Despite the slight difference with earlier findings, this evidence supports the idea that flipped learning, and now its counterpart being fully online, has the potential to promote learning equity as it can benefit low-achieving students as much as it can benefit average-achieving students. This, in turn, may contribute to the development of equally high-achieving students.

The results for students with low and average prior knowledge levels align with the Cognitive Theory of Multimedia Learning (Mayer, 2005), which posits that learning is enhanced when learners can actively engage with materials in a multimedia format that allows for deeper cognitive processing. In the study, students were made to engage in multimedia materials, both in pre-class and in-class sessions. The online flipped course enabled students to review and engage with the pre-class materials at their own pace, which is especially beneficial for those who struggle with foundational concepts (Bishop & Verleger, 2013).

Figure 1
The increase in achievement among prior knowledge level clusters



These were evident in the qualitative feedback of students with low and average prior knowledge levels, as students shared that:

> *Di na po ako nahirapan at nagawa ko po yung activity sa material na hindi overwhelming. Maganda yung pre-class activity at comprehension check, para po siyang reviewer na ginawa po para samin.* [I did not have a hard time, and I could do the activity in the material without feeling overwhelmed. The pre-class activity and comprehension check are good – they feel like a reviewer made just for us.] (Student 1, online interview, January 11, 2022)

> *Through the pre-class activities, nabibigyan na kami ng idea sa mga topics na ididiscuss sa in-class, at di po nakakapressure kasi yung time lang na binibigay para gawin ang activities is tamang tama lang po bago mag in-class session.* [Through the pre-class activities, we are given an idea of the topics that will be discussed in class, and it does not impose pressure because the time provided to complete

> the activities is right before the in-class session.] (Student 2, online interview, January 11, 2022)

The pre-training principle within the CTML underscores the importance of introducing students to key concepts before engaging with more complex material. In the online flipped course, the pre-class content prepared students by providing foundational knowledge that equipped them to participate meaningfully in the succeeding in-class activities. Additionally, the modality principle within CTML, which suggests that learning is more effective when content is presented through both visuals and spoken words rather than text alone, further supported the effectiveness of multimedia resources used in the online flipped course (i.e., lecture videos and e-book for pre-class, and video conferencing sessions for in-class). Also, the coherence principle within CTML posits that students learn better when extraneous information is minimized. This principle is particularly relevant in the online flipped course, as students can focus on essential parts of the lesson, primarily through the pre-class learning tasks, which enhance their understanding and retention of the material.

Online learning allows CTML principles to be implemented in the instructional process, which can greatly help students with lower prior knowledge levels. A study by Gastar and Linaugo (2022) noted that while text-based modules help students acquire complex scientific skills, it was less effective than online learning in fully developing those skills. Educators can reduce cognitive load by using multimedia tools that combine visuals and texts, leading to a better understanding of content among students. Also, in the context of the online flipped course, segmenting content and incorporating pre-training elements help scaffold essential introductory knowledge, making cognitive processes more accessible and supportive of learners. Altogether, these principles demonstrate that the structured approach of the flipped classroom is particularly beneficial for students with lower prior knowledge, as it enables them to build confidence and engage deeper with the content during in-class sessions (Bishop & Verleger, 2013). These also suggest the importance of adapting teaching strategies similar to the online flipped course to promote active engagement in online learning environments. Involving students in creating their learning environment can foster motivation and help replicate the effectiveness of traditional classroom dynamics in virtual settings (Lopena et al., 2021; Petalla, 2022).

The perceptions of students with different prior knowledge levels on the online flipped classroom implementation

Table 5 summarizes the quantitative data collected from the survey on students' perceptions of their online flipped classroom experience in terms of motivation, effectiveness, engagement, and enjoyment. Additional data from the focus group discussions were analyzed and discussed in the succeeding sections. Generally, the sample perceived the online flipped classroom as motivating, effective, engaging, and enjoyable, as evidenced by the high means in each cluster, which translates to a high degree of agreement with the measured dimensions.

Table 5
Summary of the perceptions of students with different prior knowledge levels on their online flipped classroom experience

Dimension	High	Average	Low
Motivation	4.97	4.83	4.67
Effectiveness	4.39	4.86	4.57
Engagement	4.50	5.00	4.72
Enjoyment	4.13	4.15	4.22

To add more granularity to the results, the perceptions of students belonging to different clusters were examined. Generally, those in the high cluster perceived the online flipped course as more motivating. In contrast, those in the average and low clusters perceived it as more effective, engaging, and enjoyable than their high cluster counterparts.

High Prior Knowledge Cluster: Higher Motivation

The results highlighted that the students with high prior knowledge levels were the ones who perceived the online flipped classroom as most motivating. This suggests that those in the high cluster appreciated the value of the pre-class and in-class learning materials and tasks. This primarily included pre-class video watching and comprehension checks for the pre-class learning, question and answer, and active learning for the in-class sessions. The high level of familiarity with the contents of those in the high cluster may have contributed to their perception of the course being motivating. One student shared that they found the online flipped classroom, specifically the pre-class aspect of it, to have stimulated their learning. They shared:

> *Maganda po yung pre-class kase parang narireview namin yung mga topics na parang familiar na samin nung junior high. And parang nag level-up lang this college, so it is a challenge for us po to understand the different topics po.* [I appreciate the

> pre-class activities because they allow us to somehow review the topics we learned in junior high school. Also, there was added complexity, so it was a challenge for us to understand the different topics.] (Student 3, online interview, January 11, 2022)

In contrast, those in the low cluster perceived the online flipped classroom as less motivating than their counterparts in the high cluster. This suggests that their low familiarity with the topics may have influenced their relatively low perception and motivation compared to their counterparts. One student from the low cluster shared when asked about the advantages and disadvantages of the pre-class activities:

> *Sa advantage po – sinukat po yung knowledge namin sa topic. Disadvantage po – majority of the problems di ko po alam, mahirap po isolve. Nagyuyoutube po talaga ako para mas maintindihan ko po. May mga mali po sa sagot ko po.* [In terms of the advantage, the online flipped classroom really posed a challenge. On the other hand, in terms of the disadvantage, I was unfamiliar with most of the problems. It was challenging to solve. I resorted to viewing YouTube videos for me to better understand them. I acknowledge that there were errors in my solutions.] (Student 4, online interview, January 11, 2022)

Low and Average Prior Knowledge Clusters: Higher Effectiveness, Engagement, and Enjoyment

In terms of effectiveness, it was revealed that those in the *average* and *low* clusters perceived the online flipped classroom to be relatively more effective than those in the *high* cluster. Specifically, students in the *average* and *low* clusters had a relatively higher degree of perception that the pre-class and in-class learning were stimulating for learning. They learned more in the online flipped classroom than in full asynchronous or synchronous learning. This supports prior evidence on the potential of flipped learning to advance learning equity (Satparam & Apps, 2022). Due to the flexibility of flipped learning, students with relatively lower achievement levels can catch up with the rest of the class, promoting learning equity among students. The pre-class video-watching activities, for example, allowed students to repeatedly watch the materials if they thought they still lacked understanding of the topic or lesson. Additionally, the in-class learning sessions allowed for the scaffolding and deeper learning of topics to take place. Some students in the *low* and *average* clusters shared:

> *For me po sir, yung sa in-class session po, dun po mas nadidiscuss yung topics na di po masyado naintindihan sa pre-class. If ever mahina connection at may brownout, malaking tulong po yung recording kasi nababalikan po namin yung topic na hindi po kami nakasama nung nag in-class session.* [In the in-class sessions, there is an opportunity to discuss the topics deeper, especially those we did not understand during the pre-class. If there are power and connectivity interruptions, recording the in-class session is a big help because we can revisit the topic discussed during the in-class session.] (Student 5, online interview, January 11, 2022)

> *For me po Sir okay naman po yung pre class at gusto ko po yun kase nabibigyan na po kami ng idea about the lesson tapos po nagkakaroon na din po kami ng chance na pag aralan yung lesson po na itututuro based na po dun sa idea na nakuha namin sa mga pre class. Natetest na po ng mga pre class yung knowledge po namin. So, gustong gusto ko yung pre class.* [The pre-class activities provided us with an idea about the succeeding lesson and the opportunity to explore the topics in advance. Also, our comprehension is tested during the pre-class sessions, hence, I appreciate the pre-class sessions.] (Student 6, online interview, January 11, 2022)

In terms of engagement, students in the *average* and *low* clusters had a relatively higher degree of perception than their counterparts in the *high* cluster that the pre-and in-class aspects of the online flipped classroom implementation were engaging. A couple of students noted:

> *Sakin sir, okay po yung flipped learning kasi unlike sa modular type, yung iba may key to correction na, tinitignan na lang, di naman students yung sumasagot. Sa kanila, nasa kanila na kung babasahin kung hindi. Sa flipped learning, iintindihin mo talaga, kung may questions, nadidiscuss talaga at natatanong kung may questions.* [I appreciate the flipped learning approach because, unlike in the modular type, there is access to the key to correction. Students can easily access those keys and may opt to engage or not engage in

> the learning tasks. In flipped learning, you have to self-regulate. It also offers more opportunities for discussion and scaffolding.] (Student 7, online interview, January 11, 2022)

> *For me po, may natutunan po talaga ako sa course, kasi dun po sa mga graphing, sa high school di ko po masyado alam ang shortcut, pano mo po makikita yung toolkit function, nung high school nalilito po ako, until this Math Ed 1, alam ko na po kung pano basahin ang graph, nalinawan po ako.* [I really learned from the course; for instance, in terms of graphing, in my high school years, I did not completely understand the toolkit function until I engaged in this Math Ed 1 course. It helped me understand how to recognize graphs of functions.] (Student 8, online interview, January 11, 2022)

Lastly, in terms of enjoyment, the students in the *average* and *low* clusters had a relatively higher degree of perception than their counterparts in the *high* cluster that they enjoyed the online flipped classroom implementation more than they would have enjoyed being in a full asynchronous or full synchronous class. A couple of students shared:

> *Ang nagustuhan ko po sir sa in-class is parang face-to-face lang po tayo, mas natuturo po ang lesson and madali po namin maintindihan ang lesson lalo na po mathematics ang course natin.* [Flipped learning resembles face-to-face instruction as lessons are discussed in depth, and scaffolding is afforded so that we can easily understand the lesson, considering that the subject is inherently difficult.] (Student 9, online interview, January 11, 2022)

> *For me po sir I liked the pre-class activity kasi po dun ko po nalalaman kung alam ko pa po yung mga topics noon hanggang ngayon at naging advantage din po yun para sakin.* [I appreciate the pre-class aspect of the flipped learning implementation because it served as a self-check for me to understand if I can still recall the topics taught before.] (Student 10, online interview, January 11, 2022)

The foregoing findings suggest that the online flipped classroom implementation benefited those students in the *average* and *low* clusters relatively more than their counterparts in the *high* cluster. These findings are similar to the insights gained from conventional flipped learning implementations that involved the mixing of online and face-to-face classes (Hwang & Lai, 2017; Jong, 2017; Kostaris et al., 2017; Lo & Hew, 2017; Sergis et al., 2018). Obtaining similar insights with an online flipped classroom implementation suggests that similar benefits may be reaped from full online implementations of the flipped learning approach. This may be due to the apparent need for more scaffolding and teacher contact with the low- and average-achieving students. Jensen et al. (2015) argued that students in their flipped learning experiments considered their contact time with their teacher highly influential to their learning. This suggests that the scaffolding conducted during the in-class sessions could have contributed to the high degree of perceptions of students in terms of effectiveness, engagement, and enjoyment. Also, the role of pre-class videos in the perceptions of students in the *average* and *low* clusters could have contributed to the relatively higher degree of perception compared with those in the *high* cluster. Nouri (2016) argues that instructional videos benefit low-achieving students more than their high-achieving counterparts because of the affordances of videos that can be accessed anytime and paused and replayed, which may provide learners the freedom to control their learning.

Moreover, the findings revealed distinct patterns among prior knowledge clusters in how they benefitted from the online flipped course. Students from the high prior knowledge cluster rated motivation highest, aligning with CTML's pre-training principle. This suggests that students with a sound understanding of the foundational concepts are better prepared to focus on new content. Conversely, students from low and average prior knowledge clusters rated effectiveness, engagement, and enjoyment more highly, likely due to the flipped format's interactive and segmented structure, which made the content more manageable and engaging for them.

To maximize the effectiveness of online flipped courses, educators can implement tailor-fit strategies that directly respond to students' perceptions. For example, students with high prior knowledge appreciated the value of pre-class activities. This suggests that differentiated content that addresses students' levels of understanding can enhance motivation. Pre-class activities may, therefore, utilize targeted scaffolding strategies for low and average prior knowledge students to further enhance their motivation. Additionally, in-class sessions should emphasize scaffolded discussions as students' feedback valued the deeper exploration of concepts allowed in the online flipped course. Interactions are vital, especially for those struggling with the material, which indicates that collaborative learning enhances

understanding in flipped learning environments (Lopez-Perez et al., 2011). Furthermore, continuous feedback is essential as students appreciate the self-check aspect of the pre-class activities. Regular formative assessments have improved student learning outcomes and self-regulation (Hattie & Timperley, 2007). Finally, recorded in-class sessions proved beneficial, as the students noted. Such resources enhance engagement and information retention.

4.0. Conclusion

Modifications in how blended learning approaches are implemented were triggered by the restrictions on holding face-to-face classes due to the COVID-19 pandemic. In the flipped learning approach specifically, this modification centered on shifting the conventional combination of asynchronous and face-to-face instruction to combining asynchronous and synchronous activities in a fully online setup. This modification, however, highly requires students to learn with the use of devices and multimedia. Given that learning with multimedia may impact individual students differently, this study investigated the effect of an online flipped classroom on clusters of students with varying levels of prior cognitive outcomes (low, average, high). Two key insights were drawn from this study: (i) the online flipped course largely benefitted students belonging to the 'average' and 'low' clusters, and (ii) students belonging to 'average' and 'low' clusters were found to have perceived higher effectiveness, engagement, and enjoyment in their learning experience compared to those in the 'high' cluster.

5.0. Limitations of the Findings

The design, sample, context, and exploratory nature of this study presented certain limitations. Therefore, interpreting the results with caution is advised. Future research endeavors on online flipped classrooms may utilize research designs other than pre-experiments, e.g., experiments and quasi-experiments, to draw more comparable data. Additionally, students from different contexts and year levels may be examined to further discuss the effectiveness of online flipped classrooms and how they can support low- and average-achieving students. Also, designing and implementing online flipped courses may be further considered.

6.0. Practical Value of the Paper

Overall, regardless of the limitations and recognizing the potential for future research directions, this study has supported prior evidence on the potential of flipped learning to advance learning equity among students. By allowing students to engage with foundational material at their own pace before in-class activities, online flipped classrooms can help bridge gaps and support learners with different levels of understanding. This study has also provided evidence of the potential of online flipped classrooms to support learning continuity in times of educational disruptions. Adopting online flipped classroom models may help institutions better adapt to unforeseen challenges, such as school closures, by implementing flexible learning that can transition between online, asynchronous, and synchronous formats.

7.0. Directions for Future Research

The study's findings suggest several directions for future research. Firstly, artificial intelligence (AI)-based scaffolding in pre-class sessions could benefit students with lower prior knowledge, who frequently need additional support in navigating online learning environments effectively. This aligns with the study's findings, highlighting the significant benefit students in the low and average prior knowledge clusters reaped from pre-class support. Moreover, exploring various strategies to improve students' motivation, effectiveness, engagement, and enjoyment can address the perception differences noted among the clusters. Additionally, integrating adaptive learning systems to offer individualized support could enhance the experience and performance of students in the different clusters by personalizing content and support depending on the student's needs, potentially boosting performance.

8.0. Declaration of Conflict of Interest

The author wishes to confirm that this study has no known conflicts of interest and that significant financial support for it could not have influenced its outcome. All of the data-gathering procedures were conducted with the participant's consent.

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