INVESTIGATING THE IMPACT OF THE FLIPPED METHOD ON UNDERGRADUATE AND GRADUATE STUDENTS AT AUS

by

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Dedication

To my family,

for their endless love and support …

Abstract

The main driver of this research is the continuous high demand of improving the teaching and learning experience in higher education so students are meeting their learning needs, and developing the needed skills for the workforce. Flipped learning is one of the pedagogies that aims to address this improvement where the students review content before the class, while the class time is devoted to activities such as problem solving and discussions. There are few initiatives by some instructors who are applying the flipped methodology at AUS in the College of Engineering and the College of Arts and Sciences at the graduate and undergraduate levels. The objective of this research is to investigate the impact of the flipped method on the students' perceived learning experience at AUS, in addition to provding a comparison with the lecture-based method regarding both the students' perceived learning experience and their academic performance. Furthermore, this study looks into the factors contributing mostly to the impact of the flipped method. The research purpose will be addressed by investigating the flipped classes in addition to selected lecture-based ones, adopting the Revised Community of Inquiry framework (RCOI) to assess students' perceptions of their learning experience, and comparing the students' academic performance to look for any significance difference as a possible result of the teaching methodology. The study showed that students' perceptions for the flipped method were mainly related to the nature of the course and the use of pre-class videos, where students in the technical courses with pre-class videos, and in the conceptual courses in the absence of pre-class videos, had reported significantly higher satisfaction compared to students in the technical courses in the absence of pre-class videos with a p-value $\leq$ 0.025. Furthermore, students in the technical courses with pre-class videos had outperformed their peers in the lecture-based classes regarding academic performance with a p-value $\leq$ 0.057 and estimated course grade median deference of 0.3. The outcome of this research helps instructors to decide on future pedagogies to apply in their classes in addition to showing 10 recommendations to be considered in the design of future flipped courses.

Keywords: ***Flipped Learning, Flipped Class, Flipped Classroom, RCOI, Students' Perceptions of Instruction, Students' performance, Higher Education, Undergraduate, Graduate***

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List of Abbreviations

COI	Community of Inquiry
CP	Cognitive Presence
ESM	Engineering Systems Management
G	Graduate
In-class	In-class Construct
LP	Learning Presence
RCOI	Revised Community of Inquiry
SL	Study Load Construct
SP	Social Presence
TP	Teaching Presence
UG	Undergraduate

Chapter 1. Introduction

In this chapter, we present an overview of flipped learning, revised community of inquiry framework, teaching and learning at AUS, and flipped learning in UAE.

1.1. Flipped Learning

In order to promote quality in higher education, policy makers, researchers and educators have been recently emphasizing, and demanding the student-centered learning approaches [1]. Student-centered learning is rooted to constructivist view of learning in which students are at the heart of the learning process taking responsibility of their own learning and actively participating in higher order activities that support deep understanding [1], [2]. As noted by [3], there is a significant amount of research that supports the effectiveness of active learning theories in increasing student learning and achievement. Various student-learning theories have emerged in the past such as problem-based learning, peer-assisted learning, cooperative learning, collaborative learning, and active learning [4]. The latter (active learning) has been considered by [4] as a super set of the other student-centered learning theories.

However, one of the challenges that educators face in applying student-centered theories and creating active learning environments is "How to free up time during class" [5]. The finite class time and the limited number of face-to-face classes makes it hard for the educator to balance between lectures and active learning practices. One of the promising ways in addressing this challenge is through the adoption of the flipped learning model which gives more time for active learning practices during the class by moving the students' first exposure of content for the pre-class time [6], [7]. As noted by [3], a key feature of flipped learning is increasing the opportunity of applying active learning strategies by shifting the direct instruction from a teacher-centered to a student-centered approach. In a flipped classroom, teachers provide students before the class time with access to the class materials to prepare for the face-to-face class sessions that are utilized with active learning practices in support of the pre-class material understanding [8], [3], [9]. Figure 1 depicts the traditional classroom versus the flipped classroom settings showing how the direct instruction in the flipped classroom is moved from the group space to the individual space, resulting in changing the classroom dynamics. Flipped learning can be classified as a type of blended learning approaches;

that is, it integrates face-to-face learning experiences with online learning experiences [10].

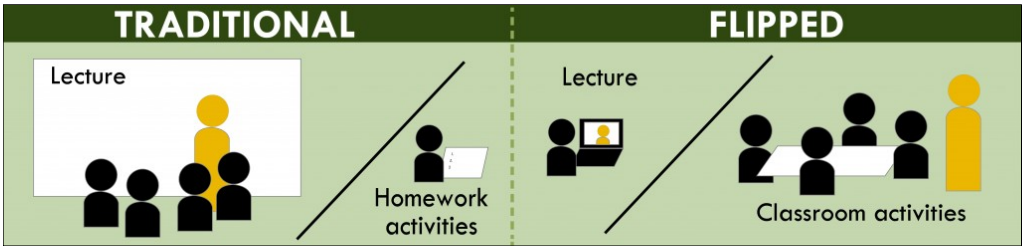

Figure 1: Traditional Vs. Flipped classroom structure [11]

As noted by [12], flipped learning pedagogy is underpinned by the concepts of self-regulation [13] and social constructivism [14]. The former refers to students taking an active role in managing their learning process [13], where the latter emphasis on the role of social interactions in developing higher order cognitive skills such as reasoning and problem solving. Classroom discussions are one way of achieving interactions among students [14].

Flipped Learning Network (FLN), a non-profit online community devoted for flipped learning, distinguishes between the flipped classroom and flipped learning, mentioning that a flipped class may not always lead to flipped learning [15]. In 2014, the FLN's board members composed a formal definition of flipped learning as: "a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter." [15]. Higher Education Academy defined flipped learning on their website as: "a pedagogical approach in which the conventional notion of classroom-based learning is inverted, so that students are introduced to the learning material before class, with classroom time then being used to deepen understanding through discussion with peers and problem-solving activities facilitated by teachers." [16].

Researchers in [4] suggested the mandatory use of computer-based pre-class learning material referring mainly to the use of videos. Others in [17] considered this limitation for the flipped instruction method as unnecessary and unjustified, supplementing their view with a study applied by [18] showing in a quasi-experimental design that adopting the flipped pedagogy with pre-class reading assignment complemented with worksheets can be as effective as pre-class videos in increasing students' academic performance. Thus, researchers in [17] identified three attributes that must be presented in flipped class; (a) mandatory pre-class learning of a new material followed by (b) the use of active learning techniques in the class time that support the pre-class knowledge, where (c) class attendance is mandatory. Based on the above discussion and noting that both Flipped Learning Network [15] and Higher Education Academy [16] didn't refer to the required use of videos for the pre-class learning, thus, in our research, we are following the broader identification of the flipped instruction as in [17]. Thus, the pre-class learning activity can be in the form of reading material, watching videos, and/or listening to podcasts.

Researchers suggested many benefits for the flipped methodology. Removing the lecture part from the class time allows time for active learning techniques to be applied to promote productive use of knowledge, engage students in learning and provide them with individualized support [17], [3]. Instructors can use the class time for peer instruction, problem-solving, discussions, group work, collaborative learning and many other active learning techniques [19]. As many flipped classrooms use videos for pre-class learning, students can view the learning materials at their own pace, anytime and anywhere [20], [9]. Furthermore, students can pause and replay videos many time as needed; this may also be more helpful for whom English is not their first language but is the language of instruction [9]. Studies showed that the pre-class material learning reduced the cognitive load on learners and thus make it easier to process information in the class and so facilitate learning [3], [21]. Flipped classrooms give students more ownership of their learning, which would help in developing their critical thinking and domain expertise [22]. Furthermore, it would help students who usually hesitate to ask questions during a lecture as they can better prepare their questions after learning the pre-class material or they can be more likely to seek assistance from the teacher through group time or one-to-one feedback time [23]. In addition, since the flipped classroom increases the student/teacher interaction, it gives the opportunity for teachers to gain greater insight about the students' understandings and learning [23]. Furthermore, many studies suggested that flipped learning improves students' academic performance in exams [24], [25], [7], [26], [27], [28]. Other studies show that there is no statistical difference among student performance between flipped and traditional classrooms [29], [25].

Studies also suggested that the flipped learning model has a positive impact on equipping students with skills needed for the 21st-century problems such as they are well prepared to join the workplace [30], [22]. Hwang, Lai and Wang [31] showed a detailed relationship between seamless flipped learning and 5C competencies of the 21st century; Communication, Collaboration, Critical thinking, Complex problem solving, and Creativity. As noted by [32], today's graduates are more concerned about their problem-solving abilities rather than knowledge of facts.

The effectiveness of flipped learning had been largely expressed also through Bloom's Taxonomy: Taxonomy of Educational Objectives. As noted by [33], The taxonomy is a framework for classifying statements of what students are expected or intended to learn as a result of instruction. It consists of six categories of skills or abilities in the cognitive domain. Categories are ordered in a cumulative hierarchy pyramid from simple to complex levels; that is, the mastery of the next more skill or ability requires the mastery of the prior one [33]. It was originally developed in 1956 by Benjamin S. Bloom and a group of educational psychologists [34]. Then in 2001, the taxonomy was revised by Anderson, Krathwohl and other contributors [35] renaming the levels by using verbs to describe each of the original categories. The categories of the Revised Bloom's Taxonomy are remember, understand, apply, analyze, evaluate, and create. The last four levels require higher-order thinking that characterizes critical thought [36].

In flipped learning, students before the class are exposed to the lower levels of Bloom's taxonomy of understanding and remembering through the content they are given to explore, while at the class time with the class activities, they are exposed to higher levels of thinking of applying, analyzing, evaluating, and creating with the presence of instructor support and peer students' support [37]. While in the traditional class where lectures are given into the class, students are exposed to lower levels of learning with the presence of teacher [38] but are left to work on assignments and projects away from the class and teacher support, addressing higher levels of thinking in more individual manners [39]. Thus, the flipped learning dynamics enables the presence of instructor and peer-support when the students are engaging in higher levels of intellectual endeavour; the time when they more need the support. From this angle, we are quoting Sams insight at the time when he and Bergmann started to flip their chemistry classes stating: “The time when students really need me physically present is when they get stuck and need my individual help. They don’t need me there in the room with them to yak at them and give them content; they can receive content on their own” [8]. The teacher’s role in the flipped classroom is therefore seen more as a facilitator and a problem-solving counsellor [31]. Figure 2 illustrates the Bloom’s Taxonomy with flipped model vs. traditional model.

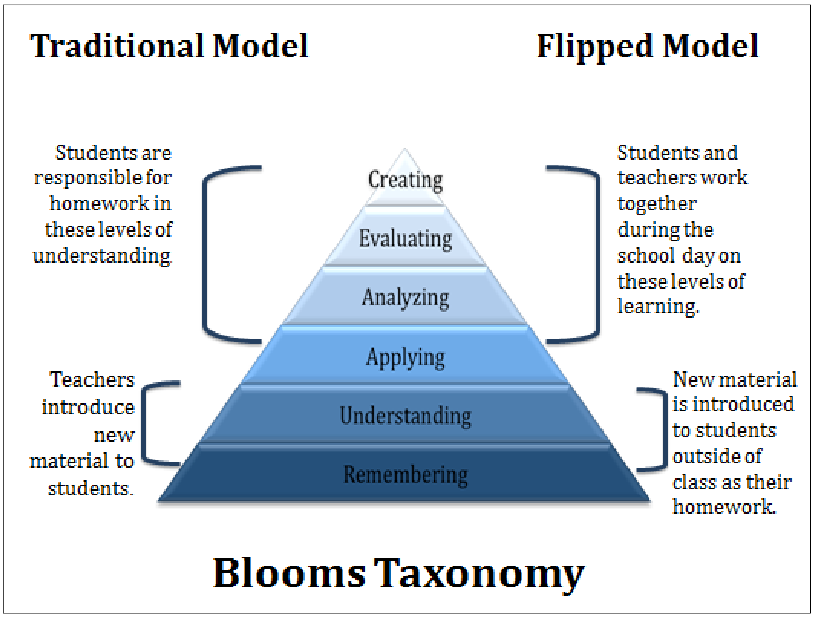

Figure 2: Blooms Taxonomy for traditional vs. flipped model [40]

There are some challenges for adopting flipped classrooms. When the video medium is used for the pre-class learning which is the common among flipped classrooms, then instructors need to spend a significant amount of work and time to prepare the material. Adding the need for new technological skills which most of the instructors, adopting lectures, are not used for. Furthermore, preparing and managing in-class activities is also time intensive and require efforts to ensure developing an effective flipped course [39]. Another challenge is students’ resistance to the new learning form [41]. As a result, student may come not prepared to the class and therefore find difficulties in participating in the class activities [42]. As noted by [43], students tend to resist non-lecturing methods because active learning alternatives provide a sharp contrast to the very familiar passive listening role to which they get used to. Therefore, students may require some time in order to adapt to the new flipped method [8].

A literature review through June 2012 by [4] revealed 24 studies related to the flipped classroom where the inclusion of video lectures in pre-class activity was a necessary criterion. They distinguish between full and partial flip implementation. Furthermore, among many dimensions used to characterize the studies, their encoding shows in-class and out-of-class activities, measurement instruments in addition to the theoretical framework used in guiding the design of the in-class activities. Their studies showed that students overall perceived the flipped classrooms positively, they also tend to prefer the in-class activities over lectures but the in-person lectures to the video ones. Researchers called for more studies to measure objectively the impact of flipped methodology on students learning outcomes.

A scoping review is done by [22] during 2014 targeting higher education and employers adopting the flipped classroom. Their research revealed 28 papers from five countries. Out of these; 23 studies were conducted in the United States, two in Australia, one in the United Kingdom, one in Taiwan and one in Malaysia. For each study, they identified the class structure, resources used, measurement assessments, outcomes, limitations, and recommendations. Results indicated that flipped class improves students' engagement in and out of the class, and contribute to building lifelong learning skills. However, they noted a misunderstanding among educators on how to effectively implement the flipped class which is a danger that should be addressed.

Another study in 2014 [24] conducted by Flipped Learning Network showed a list of studies for universities adopting flipped learning into their classes showing empirical evidence on the impact of the flipped model on students' achievements and engagement. The list includes the University of North Carolina, Texas A&M University, the University of British Columbia, Chapel Hill, Capital University, the University of Memphis, Georgia Institute of Technology, and Harvey Mudd College. Most of these studies showed that students are satisfied with the flipped model and they were scoring slightly better in exams as well.

A recent paper in 2015 [44] showed a useful summary table of 17 studies reviewed in their literature about the implementation of flipped classrooms in engineering education identifying sessions flipped and in-/out-class activities.

A systematic review of research on the flipped learning method in engineering education in applied by [45]. The review revealed 62 articles published between 2000 and May 2015 in peer-reviewed journals or conference proceedings and involve empirical research into flipped learning in engineering higher education contexts. Findings showed that flipped learning in engineering in education gained its popularity after 2012. The review identified 13 studies adopting a theoretical framework to guide their research and teaching practices. Evaluation methods noted in the studies involve quantitative evaluation such as exam scores, surveys, and system logs, in addition to qualitative evaluation but to a lesser degree such as interviews and class observations. Out of the 30 studies that compared students learning between flipped and traditional class, 13 studies reported that students in the flipped classroom outperformed their peers in the traditional classroom. Benefits reported involved, flexibility of learning, increased interaction, improvement in professional skills and student engagement. Challenges reported involved, increased workload for instructors, student resistance for active learning, in addition to accessibility issues or uninteresting online materials for students.

Lo, Hew and Chen [46] showed a recent literature review analyzing peer-reviewed journal articles of mathematics flipped classroom studies in K-12 and higher education contexts. Their review involved work published from January 2012 to December 2016, where videos are offered before face-to-face lectures. Their research revealed 61 studies for qualitative synthesis and 21 studies for quantitative meta-analysis. Results of meta-analysis of studies comparing students' achievement between flipped and traditional classrooms revealed significance higher performance for students in the flipped mathematics classroom (Hedges' $g = 0.298$, 95% CI {0.16, 0.44}, $Z = 4.186$, $p < 0.001$) with no evidence for publication bias. The synthesis analysis showed that the most reported benefits for flipped classrooms were: instructor feedback, peer-assisted learning, more in-class time to apply concepts through activities and on-demand access to video lectures. The top two reported challenges were students' unfamiliarity with the flipped method and the significant start-up efforts needed by instructors. Other reported challenges but to a lesser degree included the students' unpreparedness and their un-ability to ask questions during the pre-class learning.

In July 2013, the Australian Government Office for Teaching and Learning has funded a project titled “Radical Transformation: Reimagining Engineering Education Through Flipping the Classroom in a Global Learning Partnership” with the goal of exploring course development through flipped classroom models [47]. The project was led by the University of Queensland (Australia) in partnership with Purdue University (USA), RMIT University (Australia), Stanford University (USA), The University of Sydney (Australia), University of Pittsburgh (USA). The project lasts up to June 2015 and it involved running workshops, keynote presentations, online webinars, and interviews. In 2017, a major output of the project had been published in a book titled “The Flipped Classroom, Practice and Practices in Higher Education” through Springer [48].

Through the review, MEF University in Istanbul, Turkey was discovered as the first and only university that uses flipped classroom method across all of its programs. MEF [49]. The university has reported their knowledge and experience in flipped learning through the publication of a book titled “The Flipped Approach to Higher Education” [50].

Many universities were found to be encouraging the adoption of flipped learning by providing teachers with related learning materials on their websites. Out of these are; University of Cornell [19], Vanderbilt University [51], The University of Texas [52], Stanford University [53], University of Washington [11], University of Leicester [54], University of British Columbia [55], California State University, LA [56], and New York University [57].

The flipped learning approach has been used in many disciplines such as numerical analysis [58], system analysis and design [59], electronic systems engineering [60], calculus [61], [62], [63], general chemistry [64], [65], [17], economics [66], [28], systems analysis [67], systems design and implementation [67], Introductory Engineering Programming [25], Statics/Mechanics [25], Intro to Mechanical Engineering Design [25], Bio-thermodynamics [25], Facility Layout/ Material Handling [25], Chemical Engineering Dynamics, Modeling & Control [25], Digital Circuits [26], introductory financial accounting [68], Operations Management [69], Big Data [70], Introduction to Server Environments and Architectures [71], and pharmacy [72], [73].

1.2. Revised Community of Inquiry / Community of Inquiry

This research adopts the Revised Community of Inquiry (RCOI) framework [74], [75] to assess students' perception of the quality of their learning experiences. The RCOI framework consists of four constructs. Three of them are the constructs of Community of Inquiry framework [76], [77], [75], Teaching Presence, Social Presence, and Cognitive Presence. The fourth construct is Learning Presence discussed in [74], [75] proposing the RCOI framework which is adopted in this research.

The concept of Community of Inquiry gained much attention after it was modeled into a concrete framework by [76]. The framework outlines three core elements that contribute to a successful learning environment: Teaching Presence, Social Presence, and Cognitive Presence. Through the integration of these core elements, COI framework posits the development of collaborative constructivist learning experience where deep and meaningful knowledge is constructed. The framework emphasis knowledge construction through community where teachers and students are its key participants in the education process. Lipman [78] noted that the existence of community is essential for a learning environment that aims to facilitate critical thinking and provides deep learning as its outcome. Community of inquiry in broad definition refers to "group of individuals employing an interpersonal method for arriving at results" [79].

Cognitive presence is the extent to which participants in the COI are able to build knowledge through sustained reflection, discourse and critical and creative thinking [80]. Social presence refers to the creation of a functional collaborative environment where discourse among participants of the community is encouraged promoting positive affect, interaction, and cohesion [75].

Teaching presence refers to functions that are seen as the primary responsibilities of teacher covering content and activities design, facilitation and direct instruction [76].

Social presence is seen as the main support for cognitive presence, facilitating critical thinking through the learners' community. Cognitive development can't be separated from the social context. Together social and cognitive presence promote collaborative constructivist learning environment where meaningful and deep knowledge is constructed through a collaboration process among participants of the community.

To complete the picture, teaching presence comes as the binding element for cognitive and social ones. Therefore, the interaction of all three elements of COI is necessary for a successful educational experience. In summary “When social presence is combined with appropriate teaching presence, the result can be a high level of cognitive presence leading to fruitful critical inquiry” [76].

Peter and Temi [74], Peter *et al.* [75], proposed that the introduction of Learning presence construct can better enhance the COI framework calling for a Revised Community of Inquiry (RCOI). In the recent work [75], they refer to learning presence as learner self-regulation which is the extent to which students are metacognitively, motivationally, and behaviourally active participants in the learning process, thus indicating the exercise of agency and control. In an attempt to further explain the learning presence, [75] referred in their work to what [81] mentioned that much of learner discussion in a collaborative learning environment is about strategies to distribute tasks, manage time and define a goal to successfully complete group assessments. All of these strategies describe indicators of self- and co-regulation.

1.3. Teaching and Learning at AUS

AUS is a semi-government, non-profit, co-educational university established in 1997 in the United Arab Emirates. It offers undergraduate and graduate programs through College of Engineering, College of Architecture, Art and Design, College of Arts and Sciences, and School of Business Administration. By the end of the year 2016-2017, there was a student body of approximately 5400 representing over 99 different nationalities. Most of these students come from government or private high schools where Arabic is the medium of instruction. Others come from American or British school systems in addition to international students. English is the language of instruction at AUS and students are required to have a minimum score of 80 on the Internet-based TOEFL (iBT) to join the university programs.

AUS gives a lot of attention to adopting latest pedagogies in Teaching and Learning at its classes in addition to using technology to enhance the learning experience. They offer great support towards applying new pedagogies and technologies that prompt active learning and critical thinking. By the end of the 2016-2017 academic year, AUS had created five classrooms that are set up specifically for active learning classes recognized as “Active Learning Spaces”. Those spaces involve round tables with chairs around them which make it suitable for students group work and group inquiry. Although the general teaching methodology may be considered to be lecturing, however active learning practices are widely adopted by teachers at AUS classes as the below review shows.

In Spring 2012, in a first-year general chemistry course “Chemistry and Everyday Life - CHM 103”, the instructor had adopted active learning strategies with the majority of classes being delivered as 50% activities and 50% lecturing while some classes delivered as 100% activities based on the class topics. The in-class group activities consisted of discussions, problem-solving sessions, student presentations, newspaper/magazine article critiques, and web searches. Less time was provided for lecturing and therefore students were asked to read the material before the class. Short graded quizzes were given to students at the beginning of the class to encourage them to come prepared. Students responded positively to the group work activities and favor more the group problem-solving sessions. The instructor reflected on the notable improvement of instructor/student and student/student interaction in the class [82]. Although the instructor did not refer to her class as flipped ones, the class setting is more like to be called a flipped classroom.

In 2012, a pilot study is conducted by the lead author of [83] on using iPads into “Pre-Calculus for Engineers - MTH 001”. The class was paperless and taught using iPads only. Multiple iPads applications were adopted to deliver the material and assessments in addition to collaborating during the class. The students’ survey indicated that using iPads was positively perceived by the majority of students regarding understanding the class content, classroom interactivity, and interest level. However, only 47% of participating students had reported on joining an iPad class in the future. As the authors noted, using iPad is not the norm in AUS or in UAE high-schools, and therefore students non preference for joining an iPad-based class is expected. However, we see that it would be worth it to conduct a pilot study on using the iPads partially for some classes and some activities.

In the electronic engineering class “Electronic I - ELE 241”, the instructor provided students with lecture capture after every class aiming to enhance their understanding of the course content. The instructor recorded every lecture using eBeam Edge System which turns the standard whiteboard into an interactive one and enables recording the interaction on the whiteboard along with the instructor sound but not the instructor himself. The system provides a superior quality video records that the instructor uploaded to students after every class through the Blackboard LMS. Through surveys and focus groups, it was found that students considered the lecture capture as an effective tool for many reasons but mainly for getting a better understanding of the course material. More mentioned benefits were about freeing students from taking much notes in the class and so concentrating more during the class lecture, filling the gap if a student misses some concepts or points during the lecture, in addition to being very helpful when students missed a class saving them from falling behind. However, students indicated that the availability of videos didn’t encourage them to skip a class. Further, all student noted their preference for other instructors to use lecture capture into their classes [84].

In Spring 2015, the lead author of [85] reviewed students’ preference of pre-class video type through a flipped class setting, with the aim of preparing to introduce flipped methodology into her future undergraduate mathematics classes. Three mathematics classes were involved in the study, two of them were for “Calculus for Engineers - MTH 103” and one class was for “Mathematics for Architects - MTH 111”. In the flipped class, the instructor provided students with pre-class videos to review the material before the class, making it clear for them that there will be no lecturing but rather activities based on the reviewed material. Three types of videos were selected by the instructor from YouTube with different presentation modes covering the same topic. The videos differ in length, visibility of teacher and amount of explanation details. Students were encouraged to watch the three videos but were expected to watch at least one of them. Students’ responses to the survey revealed that the highest preference percentage was for the longer videos with teacher visibility and more detailed explanation. Overall, students showed positive feedback about the use of pre-class videos and their usefulness. The instructor noted that students during the flipped class were motivated and sharing knowledge with each other.

Following the pilot study in [85], the lead author was teaching “Calculus for Engineers - MTH 103” during Fall 2015, and started to provide students with video records for all lectures as an optional learning tool [86]. The research aimed to track the students’ viewing behaviours, as the second preparation step for the lead author to flip her future mathematics classes. The recording was done with a camera mounted on the ceiling and moving as per the instructor motion. Videos were made available for students after the lecture through the LMS. Out of the 70 total enrolled students, 85% of the male students and 87% of the female ones had attempted to view the videos. Further, students from other sections asked the instructor and their friends about watching the videos. All students who filled the survey –total 65- agreed that videos were useful, and 93% of them reported viewing videos as a necessary support to enhance their learning. Students ranked “improving their understanding” as the most reason for watching the videos, followed by “reviewing for quizzes and exams”, “completing their notes” and finally “catching up after being absent”. Thus, similar to [84], the instructor noted that having access to recorded lectures did not encourage absenteeism.

Following up the work in [85] which shows that students preferred videos created by the instructor, and then the work in [86] which shows a high percentage of students views for the optional lecture records; the lead author of both works introduced the flipped classroom in her “Calculus for Engineers - MTH 103” class in Spring 2016 [87]. Recorded videos created earlier by the instructor in Fall 2015 [86] were edited and reused in Spring 2015 for the pre-class content material. The instructor informed the students about the flipped classroom approach making it clear for them that they had to watch the pre-class videos before the class so they are prepared to participate in group work or in-class problem-solving activities. The majority of the students liked the in-class group work activities for getting more practice and keeping the class away from being boring. However, although students liked the videos, they didn’t prefer to depend completely on the pre-class video to learn the material. Survey responses showed that 54% of the 28 participating students preferred the class format to be as 75% professor lecture and 25% group activities, followed by 21% preferring half distribution. No students reported for 100% in-class activities and only 7% reported a preference for 100% lecture. Thus, as the authors noted, the students still lack the confidence in their self-learning abilities to completely part with an instructor-led class, noting that the flipped classroom experience is new for many of the students joining AUS.

In 2012, a highlight of some teaching methodologies used in AUS classes is reported in a book titled “Enhancing Teaching and Learning in Higher Education in the United Arab Emirates” [88]. Through the fifteen chapters of the book where each chapter represents an AUS class; topics ranged from introducing a new active learning technique to examining the impact of new technology tool on the learning process.

Techniques used in classes involved using various active learning strategies such as the use of active-review sessions, visual lists, debates and group projects, adopting techniques to enhance learner autonomy, the use of in-class low stake formative assessments activities such as peer and self-evaluation exercises, the use of Personal Response Systems to encourage students participation, the use of lecture records, the use of interactive games to polish the imaginative skills of the students, combining traditional lecturing with individual and peer active learning activities such as crossword puzzles, true/false games, three-color problem solving, and homework assignment with oral conferences, adopting a Facebook group for online class discussions, adopting blogs and podcasts for group tasks, and finally using rubric-based approach for assessments.

In addition to the above published work about teaching and learning at AUS, instructors are working on adopting flipped learning in some of their courses. During years 2014-2018, some courses were flipped from colleges of sciences and engineering. Flipped courses that we were aware of during the writing of this thesis were “Calculus I” from college of Sciences for undergraduate students of engineering & sciences disciplines, “Management for Engineers”, “Financial Management for Engineers” and “Human Resources Management” from college of engineering for graduate students of Engineering Systems Management, in addition to “Analysis of Production Systems” from college of engineering for undergraduate students of industrial engineering.

Based on the above review of teaching and learning at AUS, there is an increased awareness and attention from instructors to adopt student-centered approaches. Some instructors had started to adopt the flipped learning pedagogy, while some others can be switching to the flipped classrooms easily as they are undertaking lecture record and active learning techniques along with traditional classes settings.

1.4. Flipped Learning at United Arab Emirates

In this section, we show an overview of higher education institutions applying flipped pedagogy in UAE other than AUS. The review revealed few related published works. The pedagogy is slowly finding its way into the higher education sector of UAE.

Engin and Donanci [89] reported on a project in which the flipped classroom approach is applied to aspects of academic writing at an English medium university in the UAE with female Emirati students. As for the pre-class activity, students were required to watch a short instructional video and complete the embedded tasks. Teachers prepared the videos and provided guidance through a step-by-step process. Findings indicated a positive response to the flipped approach. The majority of the students found the videos useful to their understanding, commenting that videos were clear, easy to review anytime and for many times in addition to finding the use of multi-media helpful to understand better. However, half of the students pointed out that they felt they needed the teacher to explain in the class. Despite that the class warm-up included discussing points explained in the video; the authors noted that students seem to want more detailed explanations by the teacher in the class. The authors concluded that the students are not yet ready for a complete flipped approach where all content is delivered through the video, and therefore a mixed approach of video and teacher input for content explanation would be more appropriate in their context.

In another UAE higher education institute: Higher Colleges of Technology – Dubai Women's College, the flipped classroom was adopted to teach vocabulary for foundation level 03 [90]. Teachers at the college created video modules for the students to review before the class and complete its embedded questions. Videos aimed to provide students with the base-line knowledge so that the teacher will utilize class time with related challenging activities to extend the students' understanding. Along with the flipped classroom settings, the spaced repetition technique was also implemented through using the iPad application "Anki". The technique is about increasing periods of time between reviews of material to ensure that the material moves from short-term to long-term memory. Thus, the iPad application provides each student with an individualized study program based on the spacing algorithm. The teacher mentioned that the flipped approach reduced the pressure that he usually feels from the very crowded curriculum, and allowed him to give more time for reading practices along with vocabulary development. He also noted that students felt very positively about the videos and enjoyed using them. However, the study lacks a formal assessment of students' perceptions.

Khodr and Waller [91] examined Engineering student responses for the introduction of flipped methodology at higher education institution in the northern region of UAE. Survey elements distributed during Fall 2015 with 50 students' responses revealed that students held positive impressions for the flipped class. In response to the perception that the implementation of flipped class would be an improvement for the university, students' responses fell between strongly agree and agree with a mean score of 4.44 out of 5-points likert scale. Positive comments were more predominant through open-ended questions. As noted by the authors, the most common positive themes centered on the flexibility of the flipped model to meet students' varied life and work schedules. On the other hand, authors also noted that students' comments indicated some concerns about reduced lecturing and increased self-study load. Using dimension reduction techniques, two underlying factors guiding the responses were identified; (1) the focus on the educational benefits of the methodology and (2) the instructional relevance of the flipped class approach.

Another study [92] surveyed 100 UAE students from multiple courses who had experienced flipped class in some of their courses to collect their perceptions for the flipped class. The survey consists of 14 questions based on 5 points Likert scale. 80% of the students reported that the flipped class is a better learning environment and that it helps in increasing their motivation for learning. 70% reported that flipped classroom strengthen their relationship with the teacher, and 80% reported that it provides a collaborative students' environment. In addition, 80% of the students reported that flipped classroom improves the quality of learning and provides a better understanding.

Thus, through the review of published work regarding adopting flipped pedagogy in UAE including AUS, we found that students are having a positive perception toward the use of pre-class videos and flexibility of the flipped model, however, students have some concerns regarding reduced lecturing.

Chapter 2. Problem Statement

American University of Sharjah pays a lot of attention to continuously improve the teaching and learning experience. AUS vision is to "be the region's leader in higher education, known for excellence and innovation in teaching, learning, research, and service." [93]. From this perspective, there are some individual initiatives by faculty members to apply flipped class at AUS at college of Engineering and college of Arts and Sciences. Up to Fall 2018, we are aware of four subjects from the college of Engineering being flipped where three of them are for graduate students in addition to two subjects being flipped at the college of Arts and Sciences for undergraduate students. Faculty members are adopting flipped methodology looking to engage students to be active learners in addition to free the class time for activities that will deepen the understanding of students and give them the chance for applied learning.

However, there is a lack of published studies that considers in a structured manner the impact of applying the flipped methodology in AUS or UAE higher education. Does the flipped pedagogy help, harm or make no difference to the students' learning experience? Specifically, how is the flipped methodology affecting the students' performance and how are the students perceiving it in comparison to the lecture-based method they are used to in this region. As shown in the introduction earlier, the flipped methodology is not yet very common in the UAE. Moreover, although many studies show a positive impact of the flipped methodology, the perceptions and effects of a learning pedagogy vary between cultures. Therefore, there is a need to identify how the flipped methodology is impacting the students in UAE region and how it can be structured to better fit the students and teachers considering the region's culture. Moreover, this study will investigate the reason contributing mostly to the impact of flipped method.

2.1. Research Objective

The objective of this research is to investigate the impact of flipped class on students' perceived learning experience at AUS. Furthermore, the research aims to provide a comparison to lecture-based class regarding both the students' perceived learning experience and academic performance. In addition, the study investigates the reason contributing mostly to the impact of flipped method. The study also intends to examine the current implementation of flipped pedagogy to explore effective strategies to guide its future adoption.

The outcome of this research will provide the AUS community with a first-hand insight into the impact of the implementation of the flipped pedagogy covering two aspects; students' perceptions and academic performance. Is the pedagogy worth pursuing? if so, then what are the enhancement areas that can be applied. As a result, this study will contribute positively to the wider continuous work to enhance teaching and learning at AUS. The following questions guided the study:

- How do the instructors implement the flipped method at AUS?
- What is the impact of the current implementation of the flipped method on students' perceived learning experience at AUS?
- What are the most contributing factors to the impact of the flipped method at AUS?
- What is the impact of the current implementation of the flipped method on students' academic performance at AUS?

2.2. Research Significance

As the flipped methodology has been implemented into AUS classes recently, there is a huge value to assess how this pedagogy is impacting the teaching and learning process. Assessing the current instances of flipped classes will help instructors in their future decisions regarding flipping and how this approach can be enhanced. Moreover, this is the first known study to investigate the impact of flipped methodology at AUS and in UAE higher education in a structured manner. In addition, as many studies reported the positive impact of flipped method, this study's target is to assess the reasons contributing mostly to the effectiveness of this method. This study will be valuable for instructors and educational leaders looking to implement the flipped methodology in AUS and UAE higher education as well. It will provide a first-hand insight into the impact of adopting the flipped methodology in the UAE region. Moreover, it will contribute to the literature of the flipped method experimental studies by showing an experimental study in a new region. Furthermore, data and results of this study may guide instructors about the design of the future flipped courses considering students feedback. Finally, findings of this study may help educational leaders in AUS and UAE in planning for an institutional-wide adoption of the flipped pedagogy.

This study also calls for continued studies that assess the teaching and learning process in a structured manner in UAE higher education institutions, where future suggestions can be data driven based on these studies. It also opens the doors for follow-up studies that would look into the impact of the flipped method after applying enhancements and considering students suggestions. In addition to calling for follow-up studies that could look into the continued impact of the flipped method; that is, monitoring students into the next courses and comparing those who passed the pre-course with a flipped setting to those with a non-flipped one.

2.3. Hypothesis

Following are the hypothesis of this research:

- H1: The flipped method will positively affect students' perceived learning experience.
- H2: The flipped method will positively affect students' academic performance.

2.4. Assumptions

In order to proceed in this research, some reasonable assumptions were made:

- The learning experience of lecture-based classes will be similar. This assumption will be checked also through statistical tests in order to process all related lecture-based classes as one group during the comparison of perceived learning experience.
- The learning experience of flipped classes will be similar. This assumption will be checked also through statistical tests in order to process all related flipped classes as one group during the comparison of perceived learning experience.

Chapter 3. Literature Review

In this chapter, the literature related to the research problem of "Investigating the impact of the flipped method on undergraduate and graduate students at AUS" will be reviewed covering the following:

- Design models and strategies for the flipped class in higher education
- Students' perceptions of the flipped method in higher education
- Instructors' perceptions of the flipped method in higher education
- Empirical Studies comparing the flipped method versus the lecture-based method in higher education

3.1. Design Models and Strategies for the Flipped Class in Higher Education

There is no single model for flipped classes. Different classes will have different structures, however, there are general design guidelines and strategies identified in the research to guide instructors into the flipped pedagogy approach. In this review, we presented the four pillars of F-L-I-P identified by the Flipped Learning Network (FLN) [15], the FLIPPED model proposed by [41] as a revision of the F-L-I-P schema, the nine design principles identified by [6] based on Revised Community of Inquiry framework in addition to ten design principles identified by [46] for mathematics flipped classes, based on qualitative synthesis of 61 related studies and quantitative meta-analysis of 21 related studies.

Flipped Learning Network [15] identified four pillars that must be adopted by instructors to create an engaged flipped learning experience. The F-L-I-P pillars are **F**lexible Environment, **L**earning Culture, **I**ntentional Content, and **P**rofessional Educator.

Flexible Environment refers to offering students various ways to learn the course content and demonstrate mastery. It also involves flexibility with students' assessments, timelines, and space arrangement to suit the group or individual work. **Learning Culture** refers to creating a learning environment where students are actively involved in constructing knowledge, evaluating their learning, and exploring topics to deep their understanding; in contrast to traditional teacher-centered model where teacher is the main source of information. **Intentional Content** refers to creating or using content designed with the flipped model in consideration; that is, the content will equip students with the conceptual understating and procedural fluency needed when they explore it by their own. The intentional content should provide students with needed knowledge so instructors can maximize the class time for active learning strategies. Finally, the **Professional Educator** refers to instructor's role as the essential ingredient for enabling flipped learning. Instructors needs to continuously observe students during the class, give them real feedback, and assess their work. In addition, the F-L-I-P model views the professional educator as being always active in collaborating with other educators to continuously improve the instruction in the flipped classrooms. Appendix A shows the checklist provided by FLN for each pillar to further direct the design of the flipped course.

The four pillars schema was revised by [41] proposing FLIPPED model by appending three additional letters to acronym F-L-I-P and changing the name of Learning Culture component to Learner-Centered Approach. The FLIPPED model components are therefore (Flexible Environment, Learner-Centered Approach, Intentional Content, Professional Educator, Progressive Networking Learning Activities, Engaging and Effective Learning Experiences, and Diversified and Seamless Learning Platforms). They reported that F-L-I-P schema by itself is inadequate for higher education due that it emphasis on the planning of content more than the delivery of activity, it lacks to include students' point of view, and it does not consider the computer learning platforms.

Progressive Networking Learning Activities refers to adopting concepts of "Learning by Doing" and "Learning by Networking" through delivering effective activities to create an activity-oriented flipped class. This component emphasizes the need for instructors to be familiar with activity-oriented classes and be well-trained in it. In addition to instructors being aware to apply different risk strategies at different stages of activity delivery, starting with low-risk activity strategies and moving gradually to high-risk activity strategies. This helps to reduce students' resistance to the new model.

The **Engaging and Effective Learning Experiences** component highlights the importance of the student-learning experience to the success of the flipped method, and that is should be well thought out by itself. The authors noted that getting professional educators is not enough as they can still fail in engaging students if the students' learning experience is neglected. The authors suggested that instructors stay aware of instructor behaviors' strategies identified by [94] in addition to Moore's Transactional Theory [95], stating that being aware of those together assists to provide "Engaging and Effective Experiences" in the flipped classroom.

The **Diversified and Seamless Platforms** component highlights the need for using digital platforms that provides flexible learning; that is, the class can be conducted anytime and anywhere. These platforms need to be diversified and support seamless learning.

The FLIPPED model was adopted by authors in a "Computer Network and Internet" flipped course environment to test its effectiveness. The class consists of 32 graduate students in a university in Taiwan in 2013. Students' survey and interview data reveal high satisfaction levels with the flipped model finding it more beneficial than the traditional one. Further, the system logs show increased attendance. The researchers noted that highly motivated students benefited more from the flipped approach and performed better than the non-motivated students. The researchers suggested deploying strategies to motivate students for self-directed home study in addition to enforcing students' commitments and giving attention to immediate feedback.

Nine design principles for flipped classrooms were identified by [6] through examining three flipped classrooms from different disciplines (Engineering, Social Studies, and Humanities) at University of Southern California. Different underlying pedagogies were used for the three classes (in-class problem solving for ENG, project-based learning for SOC and self-/co-regulated discussion for HUM). To examine the perceived learning experience and to guide the design principles, the RCOI instrument was used with two more instruments for 'Teaching Orientation' and technology use. Furthermore, open-ended questions, students' interviews, and instructors' interviews were adopted. Appling descriptive statistics, correlation-coefficient analysis for quantitative data in addition to coding qualitative data, the researchers Identified nine design principles for flipped classrooms as shown in Table 1. Three of those principles were adopted and validated from [51] (elements 1,2 & 7). Each of the design elements is linked to the RCOI construct presence that it emphasis.

Table 1: Nine design principles for flipped classrooms identified by [6]

Presence	Design Element	Description
Teaching Presence	1) Provide an incentive for students to prepare for class	Successful face-to-face activities in flipped classrooms require that students are prepared. Students can be motivated to do the pre-class preparation through weekly quizzes, giving low-stakes grades for commenting on the online watched material.
	2) Provide a mechanism to assess student understanding	Applying formative assessments (ex. Low-stakes simple quizzes) to ensure out-of-classroom activities and to help students preparing for in-class activities.
	3) Provide prompt/adaptive feedback on individual or group works.	Many students reported the need for more prompt feedback. Instructors are required to provide prompt/adaptive feedback with the aim to improve the group work and connect the in-class activities with out-of-class preparation.
Learner Presence	4) Provide enough time for students to carry out the assignments.	To promote the sense of learning self-regulation, students' needs to be given enough time to carry out assignments whether during the class or out of the class.
Social Presence	5) Provide facilitation for building a learning community.	Students value the in-class group work but face difficulties related to roles, level of participation, group dynamics, and grading. Thus, instructor role is to provide guidance on maintaining better group work and to facilitate building collaborative learning community.
	6) Provide technologies familiar and easy to access.	The use of familiar and easy to access technologies for delivery of online content and for flipped events. In addition to selecting technologies that emphasise the learning goals and encourage collaboration.
Cognitive Presence	7) Provide an opportunity for students to gain first exposure prior to class.	Providing pre-class learning materials that prepare students for in-class activities.
	8) Provide clear connections between in-class and out-of-class activities.	Pre- and in-class activities must be aligned to avoid students being distracted and not engaged. Alignment is crucial for students to achieve learning goals.
	9) Provide clearly defined and well-structured guidance.	Students require that flipped classroom activities are clearly defined and well-structured, so they know the specific goals they should achieve from these activities. This will focus their discussions and work and thus assist them in achieving learning goals.

Last but not least, ten design principles were identified by [46] for mathematics flipped classrooms, based on a qualitative synthesis of 61 related studies and quantitative meta-analysis of 21 related studies. Figure 3 shows the principles with a brief description of each. The principles were categorized into three categories, the transition to the flipped classroom (Principles 1 and 2), out-of-class learning design (Principles 3 to 5), and in-class learning design (Principles 6 to 10).

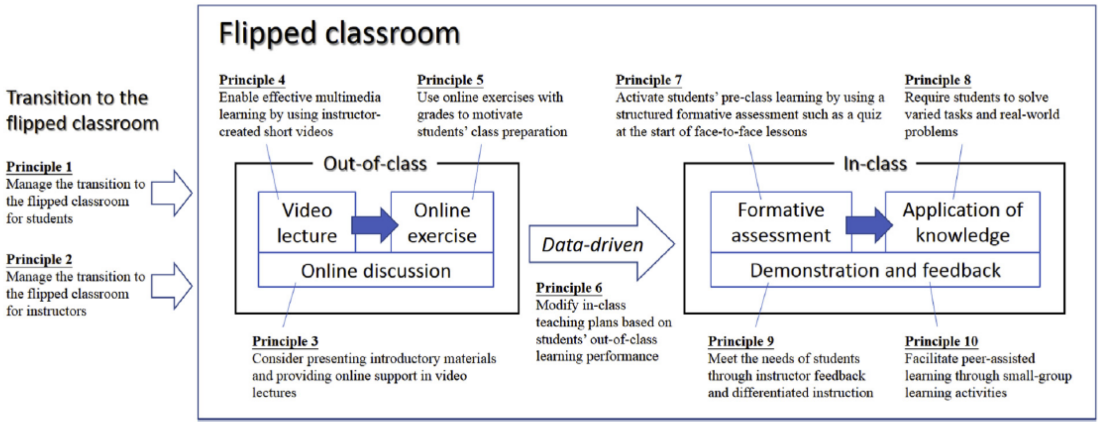

Figure 3: Ten design principles for mathematics flipped classrooms identified by [46]

3.2. Students' Perceptions of the Flipped Method in Higher Education

In this section, we reviewed students' perceptions toward flipped methodology in higher education institutions. The review is followed by a summary of identified benefits and challenges in addition to identified themes of open-ended responses.

At University of Hartford, students' perceptions were collected from five flipped Calculus I classes, accounting for 63 students [27]. Survey data revealed that 80% of students watched all the videos, and 74% of them indicated that videos helped them to better understand the material. Although note taking was not obligatory, 82% of students reported taking detailed notes while watching the videos. In two undergraduate flipped nutrition courses, where 142 students completed the survey voluntarily [37], 76% of students reported preferring watching videos over the face to face lectures, where 62% thought that videos helped them learn the material more effectively. Students commented on liking the ability to learn at their own pace and time. Further, 64% of students reported the preference to participate in the in-class activities for 2 classes rather than listening to instructor lecture for the same period. However, students showed concerns regarding the unavailability of the instructor to ask questions during the pre-class portion, and that other students did not prepare for the face to face activities.

In a study of partial flipped class in economics discipline [66] with 96 students responses, students also well-perceived the new method. 76% of students reported with "strongly agree" or "agree" on taking another course in a similar structure. In a Digital Circuit flipped course with 17 students [26], all students strongly agreed or agreed to enroll with higher level courses taught in a similar way. Similarly, with 100%, students reported that the pre-class video, in-class handouts, and interactive discussions helped them learn the course content.

In a computer engineering flipped course [96], students' perceptions were collected for three semesters of applying the flipped method. Students responses showed that they recognized the in-class activities to be the most effective components in the flipped class, rating it as 6.5 out of 7. They also found the pre-class activities to be effective but to a lesser degree counting for 5.48 out of 7. Similarly, in a linear algebra flipped course [97], students highly valued the in-class activities. Over 74% agreed that solving problems on the board helped them better remember the course material and was more fun than a traditional lecture. Almost 78% of students agreed that group work helped them to become socially more comfortable with their classmates, and over 70% agreed that explaining the problem to another student gave them a deeper understanding of it. Students' comments confirmed their self-report perceptions. The study showed that the students' in the flipped section had higher satisfaction compared to a non-flipped section of the same course.

Reidsema, Kavanagh, and Jolly [98] evaluated large flipped class of 1200 students in first year engineering course "Engineering Design and Innovation" at the University of Queensland using mixed method analysis. From the 30% of students who completed the survey, 73% of them rated the course as satisfactory (scale 3) or better on a scale from 1 to 5. Similar to [96], [97], students highly valued the in-class activities experience and reported that being able to work with other students is the greatest gain of the course. When students were asked about what was best at the course, the majority of students' comments were showing the identification of the value of the in-class activities, followed by the appreciation of guidance presence in the class, and learning more with teamwork. However, the difficulty of teamwork was also reported. Many students also reflected on the effects of the flipped model on their study habits and work, referring that the model pushed them to be more organized and improved their personal responsibility.

Students' perceptions about flipped instruction in a first-year general chemistry course with a large sample size of 334 students were collected in this study [17]. With a response rate of 82.92%, results showed that students' preference for the flipped instruction was somewhat mixed, with one-fifth of the student showing polarized feelings. Their ratings for the preference of the flipped instruction over the traditional one averaged 3.631 (SD = 1.538) on a 6-point scale. By considering demographic data, pre- and post- survey data and using OLS regression, it was found that students who were more motivated and academically well prepared reported higher rating for in-class quality and instruction clarity. Thus, it may show that they tend to be more receptive for the flipped instruction. Flexibility of studying at one's own time was at the top of the positive comments, while student resistance for the method as being not used to it and that they expect the instructor to lecture were at the top of the opposite comments. Similar to [17], students showed mixed responses in this study [25] with sophomores and juniors preferring the flipped model more than freshman and seniors. The study evaluated a school-wide implementation of flipped classes from multiple engineering majors ranging from first to senior years through the 2013-2014 school year with Over 1800 students.

Another school-wide flipped class evaluation is applied by [12] at the University of North Carolina for the school of pharmacy. In general, the model was preferable with conditions on its effective implementation. The study applied qualitative analysis to students' comments (n=6010) from evaluations of 10 flipped courses from year 1 and year 2 levels through 2012-2014, with aim of identifying the benefits and challenges of the flipped model as perceived by the students.

Two postgraduate courses were evaluated by [99] adopting flipped instruction with the 5E instructional model (Engage, Explore, Explain, Elaborate, and Evaluate). The study was applied at a Hong Kong university to postgraduate courses: Engaging Adult Learners (N=21) and E-Learning Strategies (N=26). Data were collected by distributing a 12 Likert-scale questionnaire and conducting semi-structured interviews. Results showed that students' attitudes toward the flipped class were positive. 92% of all participants agreed or strongly agreed that the flipped class is more engaging, and 95% reported to recommend the flipped class to their friends. 81% of the students reported that the flipped class provides more time to discuss issues and solve problems, and 80% perceived that the flipped approach improved their learning. Students liked watching videos lessons (83%), however, only 64% reported preference of video-recording lesson to traditional teacher instruction lesson. Qualitative data showed that the top three reasons for students' positive perceptions of the flipped class were, promoting more in-depth learning, cultivating self-directed learning, and improving peer communication and collaboration.

Sohrabi and Iraj [70] looked into perceptions of postgraduate students from two flipped sections of "Introduction to Big Data" course. The students in the two sections were demographically different in terms of age and work experience. Applying mixed method analysis, results showed that although the students in both groups were having different learning goals due to their demographics difference, mainly in their work experience, the flipped class has yet met their expectations to some extent.

The review shows that students in general have positive responses toward the flipped methodology, however, there are some challenges that they faced. The below section shows a summary points of students' perceptions as identified in the reviewed literature, classifying them into benefits and challenges views. We then showed the different themes coded from open-ended responses.

Identified benefits as reported by students in the reviewed literature are:

- The flexibility of the flipped model; ability to learn at student's own pace and time.
- Pre-class study helps to stay at the top of the material.
- Pre-class preparation helps in asking deep questions in the class time.
- The use of videos helps to learn the material more effectively in addition to the ability to play them multiple times to emphasise the concepts.
- In-class activities make the class more interactive, keeps it away from boring and provides higher engagement.
- Increased opportunities for applying concepts through in-class activities.

- Availability of instructor guidance and peer support through problem-solving and other in-class activities.
- Group work during the class helps students to become socially more comfortable with their classmates.
- In-class teamwork helps in learning more; explaining a problem to a classmate gives a deeper understanding of it.
- The flipped model helps students in improving personal responsibility and being more organized.
- Graduate students benefited from the increased chance to meet and talk to other working classmates and share workplace issues with instructor consultation.

Identified challenges as reported by students are:

- Unavailability of the instructor during the pre-class portion when students might need some help.
- Students who do not come prepared for the in-class activities are causing difficulties to those who prepared.
- Difficulties during the in-class teamwork.
- Difficulties to adapt to the new model.
- Class structure and expectations look unclear.
- The increase of work load for students.
- Difficult sections require much amount of time to be understood by students on their own.
- Poor quality of the online material makes it difficult to learn.
- Misalignments between in-class activities and the pre-class materials

Themes identified in open-ended responses are:

- Interaction (Student-Instructor), Class Preparation, Knowledge Gained, Engagement, Modeling/Problem Solving, Time commitment [96].
- Positive opinions, independent learning, negative opinions and confusion [70].
- **Benefits**: Video/Online Learning, Enhanced Learning or Learning Process, Alternative Use of Class Time, Specific to Course or Videos, Preparation/Engagement & Professional Behaviors, No Benefit or Neutral Result. **Suggestions/Drawbacks**: Specific to Course or Videos, In-Class Time,

Prepare/Equip & Incentivize Students to Flip, No Drawbacks or Neutral Result, Load/Burden/Stressors, Approach Differently, Video/Online Learning; Student Learning [25].

- **Overall course format**: Advantages of the flipped classroom model over the traditional lecture, Implementation issues. **Pre-class learning:** Benefits, Increased workload, Quality of pre-class learning materials. **In-class learning:** Alignment with pre-class learning, Role of the instructor [12].
- **Benefits:** *Sufficient time on task/practice:* More in-class time for important concepts/activities, On-demand accessibility of video lectures, The use of differentiated instructional activities. *Integrating new knowledge with existing beliefs:* Preparing students for class, Adjustment to teaching based on the pre-class analysis. *Real-time feedback:* Instructor feedback, Peer-assisted learning. **Challenges:** *Student-related challenges:* Unfamiliarity with flipped learning, Unpreparedness for pre-class learning tasks, Unable to ask questions during out-of-class learning, Unable to understand video content, Increased workload, Disengaged from watching videos. *Faculty challenges:* Significant start-up effort, Not accustomed to flipping, Ineffectiveness of using others' videos. *Operational challenges:* Instructors' lacking IT skills, Students' lacking IT resources [46].

3.3. Instructors’ Perceptions of the Flipped Method in Higher Education

In this section, we reviewed instructors’ perceptions toward flipped methodology in higher education institutions. The review is followed by a summary of identified benefits and challenges. It is to be noted that few studies assessed the perceptions of instructors regarding flipped methodology in higher education institutions.

“Faculty Focus”, a dedicated organization for higher education teaching strategies surveyed its readers to collect perceptions on the flipped method in the summer of 2014 [100]. 1,089 Faculty Focus readers completed the survey representing higher education institutions from the United States and Canada in addition to small number from other institutions abroad. 69.5% of the respondents tried flipping a course, class, period or activity, and plan to do it again, with another 5.49% who tried flipping but don’t plan to re-do it. Actual benefits noted by faculty who flipped: 74.9% saw greater student engagement, 80% said students are more collaborative, and 76.61% said that students ask more questions, while just over half (54.66%) reported on evidence of improved student learning. 70% of all respondents reported limited time as a frequent barrier for flipping, and more than 80% reported worries about student resistance.

Herreid and Schiller [42] investigated the implementation of the flipped methodology by STEM case teachers from the National Center for Case Study Teaching in Science Listserv. Teachers noted that students in the flipped classes were actively involved in the learning process and spending more time working with the scientific equipment available in the class. Techers also reported that with the flipped class, they had more time to spend with students in the class on authentic research, and that students who miss a class can still follow up by watching the videos. However, researchers identified two major challenges faced by the teachers during the implementation of the flipped approach. The first was students' resistance to the new approach, which let them to come unprepared to the class and as a result affects badly the in-class activities. To address this issue, teachers reported using short quizzes either online or in-class, targeting information from the pre-class material. The second was the significant amount of time required by teachers to prepare for the pre-class videos, where usually the quality of instructor's videos ends up being marginal. Adding to that, teachers reported difficulties in finding good quality videos that address their class needs.

Like the concerns faced by STEM teachers, an instructor at California State University Northridge reported on the much efforts needed to prepare for the pre-class instructional videos [30]. Applying the flipped approach to two classes of web design course, the instructor reported that it takes approximately 50 hours to produce 13.5 hours of videos instruction with its associated prep quizzes and serving websites. However, the instructor reported a significant decrease in the amount of time needed for preparation before each class meeting, in addition to notable reduction in repetitive instruction, relating this to the ability of students to replay videos as much as they need, and that students who miss a class were also easily directed to view its videos as well. Daily quizzes were noted to be a strong motivation for students to watch the videos. As when quizzes were stopped near the end of the semester, there was a decrement in students' engagement and attendance. The study also reported that the use of videos instruction was advantageous for the department to unique the core instruction of the courses regardless of the instructor, especially when many adjunct instructors are involved.

Another instructor teaching four flipped Calculus I classes at Appalachian State University during the full study year 2013 shared her experience in [62]. The essential factor for the instructor behind flipping was noting that her students were struggling in solving the homework. After flipping, she noted the ability to help students from their current understanding", that is; to continue the problems from the way they started thinking about it.

Post-course interviews were conducted with instructors to get their perceptions as part of evaluating a school-wide implementation of flipped classes for six courses from multiple engineering majors during 2013-2014 school year [25]. Another study [101] conducted a survey for teachers in the faculty of Arts (47 respondents) and interviewed them to gather their experiences and perceptions about flipped classroom and flexible assessment.

In overall, instructors' perceptions were positive rewarding the active learning at most. The below section shows a summary points of instructors' perceptions as identified in the reviewed literature, classifying them into benefits and challenges views.

Identified benefits as reported by instructors in the reviewed literature are:

- Greater student engagement
- Students are more confident to ask questions
- Students asking more questions
- Improved student learning
- Enhanced students' higher order thinking skills
- Students spending more time on authentic learning and research in the class
- Opportunity for students to do more problems solving in the class
- Students who miss a class can easily follow up
- The decrease in the amount of preparation needed for each class
- Reduction in repetitive instruction

- Ease revealing students' understanding and so probing them from their current understanding
- Ability to track cognitive development
- One-to-one in-class guidance for students
- Increased instructor-student interaction
- Better knowledge about the students' way of thinking
- Allow to unique the core instruction of the courses in a department

Identified challenges as reported by instructors are:

- Student resistance
- Students coming unprepared to the class and so can't participate in the class activities
- A significant amount of time is required to prepare for the pre-class videos
- Difficulties in finding good quality videos that address the class needs
- It requires a time commitment that would compromise research
- Some students struggle to engage in class activities

3.4. Empirical Studies Comparing the Flipped Method versus the Lecture-based Method in Higher Education

In this section, we reviewed recent studies applying empirical experiments to compare the flipped method to the traditional lecture-based method in higher education institutions. In the lecture-based class, lecturing covers most of the class time. It is to be noted that this review doesn't target studies comparing flipped instruction to active learning instruction.

In the empirical experiments, students in the flipped classes served as the treatment group, while students in the traditional classrooms served as the control group. Some experiments were done in a parallel matter; that is, the controlled and the treatment classes run at the same time. Other experiments were done in an unparallel matter where the flipped class is compared to a traditional one taught in the previous semester(s). Although applying a parallel experiment is usually seen as providing more control on the study, [68] reported that the separation of the control and the treatment groups by semester(s), eliminate the spillover effect related to the intervention that could occur when the same instructor is teaching both groups.

The majority of the studies looked into academic performance for comparison criterion. This includes assignments, course grades and/or exam grades. Three studies were found looking into perceived learning experience for comparison where one study adopted the Community of Inquiry (COI) framework and the other two used the College and University Classroom Environment Inventory (CUCEI). Some studies applied pre-/post- test experiments, but the majority only considered a post-test. The studies and their results are described in the remainder of this section.

A quasi-experimental design was applied by [102] to assess students on their perceived learning experiences adopting Community of Inquiry (COI) framework [103]. The experiment compared two flipped classes (IIS, ACI-II) offered in fall 2014 to two traditional ones (IIT, ACI-I) offered in the previous semester spring 2014. The compared courses were not the same but have a pre-requisite relation. Thus, students were nearly the same in the compared courses. The courses were offered at the Graduate School of Interpretation and Translation at Busan University of Foreign Studies. The COI instrument was distributed for both groups; the traditional and flipped groups, with a sample size of 45 students in each group.

The compared groups were ensured for homogenous where gender and age differences showed no statistical significance. The internal consistency of surveys was verified with a value greater than 0.9 Cronbach's alpha for all factors of COI in both classes. The two independent-samples t-test was applied for all factors to merge the data of the two flipped classes as one group and the two traditional classes as another group. Comparing the two groups using Wilcoxon Sign Rank test for TP and SP while using paired-samples t-test for CP, the flipped classes outperformed the traditional ones in terms of SP (0.6 difference, $p < 0.001$), then CP (0.29 difference, $p < 0.001$) and finally TP (0.11 difference, $p < 0.05$). As noted by the author, the significant change in SP shows that students in the flipped classes were projecting themselves more as the main agents, both socially and emotionally. The correlation analysis between the three factors of COI showed that TP and CP were directly correlated with SP ($r > 0.9$), concluding that much attention must be placed on strengthening the SP while designing and implementing the flipped classes.

Another study implementing quasi-experimental design and assessing student perceived learning experience was adapted by [69] but in a parallel manner. The study adopted the College and University Classroom Environment Inventory (CUCEI) [104] to record and compare students' perception of the flipped and traditional classes in an Operations Management classroom. The same instructor taught both sections in Fall 2013 for MBA students at a leading business school in New Delhi, India. Each section involved 25 students with even gender distribution. Students at both sections were asked to fill the CUCEI instrument at end of the semester twice to report their actual and preferred environment. The CUCEI assessment involves seven scales: personalization, involvement, student cohesiveness, equity, task orientation, innovation, and individualization. The Cronbach's alpha coefficients for all seven scales for both actual and preferred form of CUCEI were (0.63 – 0.92).

According to independent sample t-tests, students in the flipped class scored significantly higher than the students in the traditional class regarding actual responses of CUCEI on the scales of involvement ($p < 0.001$), task orientation ($p < 0.01$), and innovation ($p < 0.05$). For the preference responses of CUCEI, there was a significant difference on the scales of involvement ($p < 0.05$) and innovation ($p < 0.001$) with students in the flipped class scoring higher as well. Thus, as the author noted, the flipped instruction was perceived better by the students, and the lower mean score of task orientation may implies that students in introductory courses look for more structured format.

Pre-test/post-test quasi-experimental design was implemented by [7] during two years for Physics II course at Uludag University, Turkey. The traditional class was offered in the first year with 41 students while the flipped class was offered in the second year with 55 students. The same instructor taught both classes covering the same topics. The comparison measures involved final exam, homework completion rates and surveys' results from both classes. The exams for both classes were prepared with similar structure and level of difficulty, and their internal consistency were checked by other two instructors teaching the same course. Students were verified to have similar backgrounds level, as they did not show significant difference in their performance in the pre-test, physics I test, which is a pre-requisite taken by all students and taught by the same instructor with ($p = 0.25$) according to an independent sample t-test. Physics II final test was the post-test for this study. According to an independent sample t-test, students in the flipped class reported higher scores (51.40) on the final test compared to students in the traditional class (45.78) with ($t = -2.78$, $p < 0.05$).

The study also investigated the effect of homework completion rate on the course achievements using One-way ANOVA test for the traditional class and the non-parametric Kruskal Wallis ANOVA for the flipped class, where the students' weekly completion rates of homework were collected through a survey for both classes as per the following categories (80-100%), (60-80%), (40-60%), (20-40%), (less than 20%). The results revealed there was a linear relation between homework completion rate and rate of achievement in the flipped class but not in the traditional one. The study suggested that with a flipped classroom setting, the increase in doing in class homework will result in an increase in course achievements, reasoning this that students in the flipped class are more engaged in problem-solving by interacting with their peers and teacher in addition to participating more. These findings are similar to the findings of others [105] who also showed a strong correlation between grades of pre/in-class activities and course achievements in a flipped classroom.

Another study [26] applied the pre-test/post-test comparison experiment to a Digital Circuit course among two years. The course was taught in traditional method in the first year with 24 students while the flipped method was used in the second year with 17 students. The same instructor taught both courses while using the same textbook and similar homework and exams. To validate the comparability of both classes, GPA and composite ACT score of both groups were compared and found to be similar. The comparative measures were content coverage, exam performance and student's perception of the used teaching method. The core learning objectives were the same for both groups, however, the flipped one covered additional four objectives. This is consistent with [106] where they could cover two more topics in the flipped class. Exams performance included two midterms and final exam and they were written to be as similar as possible. Comparing exam performance between the two group, it was found that for all exams, the mean score increased in the flipped class while the standard deviation decreased. Furthermore, the score distribution range was significantly decreased. For the course score, the mean score, standard deviation, Min, Max for the traditional class were (79.72, 12.63, 44.98, 91.63) while for the flipped class they were (87.22, 8.28, 67.83, 95.82). According to one-way ANOVA at the 0.05 significance level, there was a statistical difference in the course score between the two classes (p = 0.04) with students in the flipped class scoring significantly higher. The comparison of the course grades distribution showed that the number of (A, A-, B+), (C-/D+) increased in the flipped class at the cost of (B, B-, C+), (E) grades respectively.

Furthermore, the study showed that students in the flipped class scored significantly higher in problems related to objectives associated with higher-order thinking, while there was no significant difference in performance on problems associated with lower order thinking. Thus, the study suggested that the flipped method enhances critical thinking and problem-solving skills or in other words, the higher-order skills. Similar findings were reported by [96] in the context of computer engineering course, where they showed using a variety of assessments that students' achievements aligned with lower-order learning outcomes have no significant difference between the flipped and traditional approaches, however, significant difference were found for achievements aligned with higher-order learning outcomes.

A partial flipped class was implemented by [107] for first-year introductory chemistry course in Fall 2015 and compared to a prior section of the same course taught in lecture-based format in Fall 2014 by the same instructor. The effective sample size was 223 students in the flipped class and 277 in the lecture-based one. The two classes were checked for equivalence based on demographics data, pre-college academic performance, and pre-survey. Measures involved exam performance, motivation, perceptions for the class quality in addition to overall score grade of subsequent chemistry course. Results showed that the flipped method did not impact exam performance according to two samples t-test ($p = 0.99$). However, students in the flipped class had significantly scored higher in the subsequent course in comparison to those in the lecture-based class ($p < 0.001$), with students of lower high school GPA benefiting more from the flipped instruction. The pre-survey motivation showed that students in the flipped class had lower motivation toward the class according to two samples t-test ($p = 0.03$), however, by the end of the quarter, students' motivation had improved and caught up with the motivation in the lecture-based class as shown by the two samples t-test ($p = 0.55$), which implies that the flipped method had improved the students' motivation. Regarding perceptions of class quality, students in the flipped class had reported significantly higher satisfaction on the three measures, instructional clarity ($p < 0.001$), overall instructor quality ($p < 0.001$), overall course quality ($p < 0.001$), compared to students in the lecture-based class.

A quasi-experimental design with partial flipped class was applied by [61] for Calculus II at University of Hartford. Both sections A, B were taught by the same instructor in the traditional manner for the first five weeks and up to the first exam. Then section B was flipped for the next five weeks up to the second exam. Comparing students' performance, both sections had similar average score and median on exam 1 while on exam 2 the mean score for students in the flipped section B was higher by five points and the median was also higher by seven points compared to the traditional section A. In addition, online homework scores for both sections were compared. The students' homework score percentages were similar for the units before the flip, however, after the flip, section B performed on the flipped units better than section A with four points higher (out of 100). Similar findings were reported by earlier study applying partial flip for one section in a comparison experiment [108].

Following up the experiment of partial flip at [61], authors adopted a large-scale parallel comparison experiment study for Calculus I undergraduate students at University of Hartford [27]. The experiment involved five flipped sections accounting for 63 students taught by four instructors following a similar structure, in comparison to five non-flipped sections accounting for 49 students taught by three instructors following also a similar structure. All sections were taught in the same semester adopting same material, assessments and common final exam that was graded by a group of participating faculties such as one instructor grade the same question for all students. Most of the students (approximately 60%) were from Engineering majors. Final exam and course grades were used for the comparison measures. The consistency of the students' conceptual understanding for Calculus was verified between both groups, as their results in the Pre-test 'Calculus Concept Inventory' did not show significant difference according to Mann-Whitney test ($p = 0.483$). According to a t-test with the assumption of unequal variance, students in the flipped group scored slightly significantly higher in the common final exam (74.9) compared to students in the non-flipped group (69.2) with ($p = 0.0496$). Furthermore, the DFW (grades of D, F, or withdrawals) rate in the flipped sections (25.7%) was lower than the non-flipped sections (33.3%). It was also lower than the historical Calculus I average DFW rate at the university which is approximately 30%. As the authors noted that although none of these differences are statistically significant, but they showed important improvements for a first-time large-scale adoption of the flipped pedagogy.

A follow-up study next semester was conducted on Calculus II students to check for any subsequent impact of the flipped pedagogy. Participants involved 42 students taken the flipped Calculus I course, and 40 students taken the non-flipped one. All Calculus II sections were taught in the non-flipped method. For the participating students, there was a significant difference in their Calculus I exam performance, where students enrolled in the flipped sections scored higher (3.14/4) compared to students who studied in the non-flipped sections (2.75/4) with (p = 0.027). The difference continued to Calculus II, as students who studied Calculus I with the flipped method scored significantly higher in the Calculus II final exam (3.20/4) compared to students who were not exposed to the flipped pedagogy (2.68/4) with (p = 0.008). Thus, the study suggested that the benefits from enrolling in a flipped course may extend to the following one. As the authors mentioned, these finding can have many explanations suggesting that the structure of the flipped class may have improved students' ability to learn, helped them to develop better out of class study habits and promoted their perseverance with problem-solving.

A quasi-experimental study is applied by [68] to compare the flipped instruction to the traditional one with a large sample size in the context of introductory accounting course for undergraduate students in a Canadian university. The lecture-based class was offered in winter 2010-2011 with 92 students while the flipped class was offered in winter 2013-2014 with 97 students. Both courses were taught by the same instructor using the same textbook and learning objectives. Furthermore, both classes showed similar age and gender profiles. According to Wilcoxon rank-sum test, the grades of final exam had improved in the flipped class reporting an average final grade of 66.2% versus 59.5% for the lecture-based class with (α = 0.01). The course grades improved as well, reporting average course grade of 70.7% for the flipped class versus 67.3% for the lecture-based class with (α = 0.05). As noted in the study that the change in assessments between the two groups may impacted the overall course grade; thus, this measure was used to provide additional insight noting that the assessments change was only for 20%-25% of the course. Furthermore, the study reported a higher percentage of students scoring above 50%, 80% in the flipped class in both final exam and overall course grades. Thus, the study suggested that the flipped classroom improves the student academic performance and lead to less failure rates and more student achieving high standing level in the course compared to the lecture-based class.

Another study with a large sample size was conducted by [17] in a parallel manner, comparing two sections of first-year general chemistry with 343 students enrolled in the lecture-based section and 334 students in the flipped section. Both sections were taught by the same instructor at a large public university in the western United States. Measures for comparison were exam performance and study time. Demographics of students including their majors, gender, study level, and ethnicity did not show major differences. Students study times were collected through mini-survey every week where students were reporting their pre-class study time and their post-class study time in the preceding week. Results showed that the overall out of class study time (pre-& post-class study time) was roughly the same at both sections. In overall, students in the flipped section were spending more time in the pre-class study time and less in the post-class. Therefore, the paper concluded that there is no need for adjusting the class time meetings for the flipped class by making it less in a response to mandatory pre-class study time.

According to two sample t-test, the flipped instruction had the strongest impact on the first midterm, diminished by the second midterm and rebound slightly with the final exam showing small but statistically significant effect (ES = 0.116, p = 0.132). The mean score for the final exam in the flipped section was 54.38 versus 49.90 for the lecture-based section. The effect size on the first midterm was twice of the final (ES = 0.202). The mean score for Midterm 1 in the flipped section was 43.9 versus 42.5 for the lecture-based section. Using OLS regression models, the results showed that the flipped instruction effect on the final exam, which was cumulative, was mainly due to its effect on the first midterm. The study concluded that the flipped instruction impact was more shown at the beginning but gradually diminished over time. Similar treatment-control experiment was implemented by [28] for a small size economics course with sample size of 31 in the flipped class and 35 in the traditional class, where they used t-tests and OLS regression model to assess the effect of flipping the class on students' first, second and final exams. However, results were in contrast to those found by [17]; as they showed that flipping had significant positive effects on the second and final exams but with no effect on the first exam. Researchers reasoned this to students being new to the flipped class environment.

Clark *et al.* [25] implemented a school-wide implementation of flipped classes for six courses from multiple engineering majors ranging from first to senior years through the 2013-2014 school year with Over 1800 students. They compared their results to lecture-based classes based on three criterions: Teaching Dimensions Observation Protocol (TDOP) to compare the student engagement and involvement during class, College and University Classroom Environment Inventory (CUCEI) to compare the learning environment, in addition to using assessments to compare students' achievements.

Regarding TDOP, two flipped courses (Statics/Mechanics and facility layout) were observed and compared to two pre-flip courses offered previously. Using Fisher's Exact test, results showed significant increases in the flipped courses ($p < 0.01$) in the percentages of small group work, student discussions, problem-solving, and instructor circulation to answer questions. For the other four flipped courses where there was no pre-flip data to use, TDOP results from those flipped classes were compared to a national TDOP study of 58 lecture-based STEM classes. The comparison showed that behaviors of interest such as problem-solving, small group work, individual active work, student discussion, and instructor coaching were significantly higher in the flipped classrooms ($p < 0.0001$).

Regarding CUCEI, survey results from the two flipped courses (Statics/Mechanics and facility layout) were compared to their pre-flip ones. Using t-tests for comparison, in Statics course, the CUCEI dimensions of student cohesiveness, individualization, involvement, and personalization were rated significantly higher in the flipped environment ($p < 0.0005$). In the facility layout course, the CUCEI dimensions of individualization and personalization had been also significantly improved in the flipped environment ($p < 0.0005$) besides the involvement dimension ($p = 0.002$).

Assessments, homework and/or exam scores were compared between four flipped courses and their pre-flipped ones offered in the previous semesters. For comparison, analysis of covariance was used with the pre-course cumulative GPA or SAT score as the covariate, or control variable. Comparison results were mixed. As for Introductory Engineering Programming and Mechanical Engineering Design courses there was no significant difference among the students' achievement between the flipped and non-flipped classes. While in the Bio-thermodynamics course, students in the flipped class performed significantly better in all four exam topics areas; concept mastery ($p = 0.004$), conservation of mass ($p < 0.0005$), conservation of energy ($p < 0.0005$), and gas expansion ($p < 0.0005$). The latter two topics were associated with large effect sizes, with Cohen's d values of 0.87 and 0.98, respectively. Further, in the Facility Layout/Material Handling course, students' performance significantly improved from the pre-flipped to the flipped course in homework assignment with average scores of 81% versus 89% respectively ($p < 0.0005$). The effect size was medium at d= 0.44.

Thus, the study concluded that the flipped class drove students' engagements and involvements, had a positive impact on the learning environment and led to similar or better students' achievements compared to the non-flipped class.

In summary, the reviewed literature showed that the results of the flipped classes were promising in comparison to the traditional ones. The most dominant comparison criterion was student performance, with the majority of studies comparing scores of exams and/or course grades by looking into average, standard deviation, range and distribution rates. The majority of the studies that compared student performance had reported enhanced performance for students in the flipped classroom. Only two of the studies [107], [25] covering three courses reported no statistical difference between the two classes models; flipped versus lecture-based. Other studies comparing the flipped class to active learning class had also shown no statistical difference in the student performance between the two class models [29], [109] but our comparison scope is highlighting the flipped versus lecture-based instruction. There were no studies found reporting lower performance for students in the flipped classroom.

Two of the studies compared student performance linked to the learning objectives [26], [96]. Both of those studies reported that students in the flipped class performed significantly higher in the problems associated with higher-order thinking while there was no difference in student performance with problems associated with lower-order thinking. One of the studies looked into the relation of assignments completion rate and rate of achievements, and it reported a linear relationship between the two rates in the flipped class but not the traditional one [7]. Similarly, another study also showed a strong correlation between grades of pre/in-class activities and course achievements in a flipped class [105]. Moreover, two of the studies looked into the effect of flipped instruction in the lecture-based post course and they reported that students exposed to flipped instruction in the pre-course performed better than those who were not [107], [27].

Three studies looked into comparing students' perceived learning experience with the following frameworks being adopted; COI, CUCEI, and TDOP [102], [69], [25]. All of these studies reported enhanced perceived learning experience in the flipped classroom in compare to the lecture-based ones.

Other comparison criteria involved content coverage and out-of-class study time, with two of the studies reporting more content coverage in the flipped class [26], [106], and one study reporting no difference for the overall study time (pre-& post-class study time) between the two models; flipped versus lecture-based [17].

To conclude, to the best of our knowledge, none of the studies had evaluated the flipped method in a structured manner in UAE higher education covering a large sample size or multiple classes. As shown in the rest of the sections, the above reviewed studies guided this research in investigating the impact of the flipped method on undergraduate and graduate students at AUS considering the perceived learning experience and the academic performance.

Chapter 4. Research Context

In 2017, seven flipped classes and eight lecture-based ones participated in this study. The flipped classes involve two undergraduate Calculus I classes taught by the same instructor in Spring 2017 (Cal_UG_Flip_A and Cal_UG_Flip_B), two undergraduate industrial engineering classes, "Analysis of Production Systems", taught by another instructor in Spring 2017 (Eng_UG_Flip_A) and Fall 2017 (Eng_UG_Flip_B), in addition to three graduate engineering classes from the engineering systems management (ESM) program taught by a third instructor. "Financial Management for Engineers" (Eng_G_Flip_A) was taught in Spring 2017. "Human Resources Management" (Eng_G_Flip_B) was taught in Fall 2017. "Management for Engineers" (Eng_G_Flip_C) was taught in Fall 2017. All of our flipped classes are considered of technical course nature except for the two graduate classes of "Human Resources Management" (Eng_G_Flip_B) and "Management for Engineers" (Eng_G_Flip_C), as they are of a conceptual course nature. Table 2 shows the list of flipped classes.

Four lecture-based undergraduate classes of Calculus I course were involved in this study. Those classes were taught by another two instructors, two sections each, in Spring 2017, the same semester the flipped classes were taught. The same instructor taught classes (Cal_UG_LB_C) and (Cal_UG_LB_D), while another one taught classes (Cal_UG_LB_E) and (Cal_UG_LB_F).

Regarding the engineering classes, there were no same courses offered in the lecture-based methodology to involve in the study and compare them to the flipped ones. Thus, similar lecture-based classes from the same program and of the same study level were involved to compare for the perceived learning experience, where the survey element was distributed. However, to compare for the academic performance, we referred to lecture-based courses that are the same as the flipped ones but offered earlier by the same instructor.

Thus, the engineering undergraduate lecture-based classes involved to compare them to the flipped classes of "Analysis of Production Systems" were "Facility Design and Operations" (Eng_UG_LB_C) and "Operations Research II" (Eng_UG_LB_D). Both classes were taught in Spring 2017 by another two instructors. To check for the academic performance, the data was collected from the lecture-based class “Analysis of Production Systems” offered in Fall 2015 by the same instructor offering the flipped ones.

For the graduate engineering courses, the lecture-based classes involved to compare them to the flipped technical class of “Financial Management for Engineers” (Eng_G_Flip_A) were “Introduction to Applied Operations Research” (Eng_G_LB_D) and “Advanced Engineering Economy” (Eng_G_LB_E). Both classes were taught in Spring 2017 by another two instructors. To check for the academic performance, the data was collected from the lecture-based class “Financial Management for Engineers” (Eng_G_LB_F) offered in Spring 2016 by the same instructor offering the flipped ones. For the conceptual graduate classes, there was no similar lecture-based classes to compare to them the students’ perceived experience. Thus, only the academic performance was compared to the lecture-based classes of same courses offered earlier by the same instructor in Fall 2015, “Human Resources Management” (Eng_G_LB_G), and “Management for Engineers” (Eng_G_LB_H).

Table 3 shows the list of lecture-based classes involved in this study, with the description of each class, and the type of impact analysis we are applying for each: perceived learning experience and/or academic performance.

Thus, one of the limitations of this study is the inability to fix all factors of instructor, teaching semester, and course during the comparison of flipped and lecture-based classes.

So, for the academic performance comparisons, the compared classes belong to the same course with similar or same assessments, but they were either offered in the same semester but with different instructors as in the mathematics undergraduate classes or they were offered by the same instructor but in different semesters as in the engineering classes.

For the perceived learning experience, the compared mathematics classes belong to the same course and taught in the same semester but by difference instructors, while for the engineering courses, the compared courses were not the same, nor were the instructors, but they were all offered in the same semester and belong to the same program. However, when it comes to the perceived learning experience, our study is comparing the flipped classes to multiple lecture-based classes. This multiple comparison assists to overcome the limitation we had of non-availability of a similar class taught by the same instructor, as our conclusion will be based on multiple comparisons. Rather, we argue that having a same class taught by the same instructor in two different methods might result in falling in bias due to the knowledge of the experiment. While in our data, instructors were not aware about the experiment until the end of the course, and everything was taught naturally.

We would like also to note that the comparison to the lecture-based classes is to provide an additional insight, while the main part of this study is to analyze the flipped data itself and compare it to each other and therefore draw a conclusion and recommendations based on it.

Table 2: List of flipped classes

Flipped Classes						
Course Name	Class (s) Code	College/ Department	Level	Semester	Instructor	Impact to measure
Calculus I	Cal_UG_Flip_A Cal_UG_Flip_B	Sciences/ Mathematics	UG	Spring 2017	A	Perceived learning experience – Academic performance
Analysis of Production Systems	Eng_UG_Flip_A Eng_UG_Flip_B	Engineering/ Industrial	UG	Spring 2017	B	Perceived learning experience – Academic performance
Financial Management for Engineers	Eng_G_Flip_A	Engineering/ Engineering Systems Management	G	Spring 2017	C	Perceived learning experience – Academic performance
Human Resources Management	Eng_G_Flip_B	Engineering/ Engineering Systems Management	G	Fall 2017	C	Perceived learning experience – Academic performance
Management for Engineers	Eng_G_Flip_C	Engineering/ Engineering Systems Management	G	Fall 2017	C	Perceived learning experience – Academic performance

Table 3: List of lecture-based classes

Lecture-based Classes						
Course Name	Class Code	College/ Department	Level	Semester	Instructor	Impact to measure
Calculus I	Cal_UG_LB_C Cal_UG_LB_D	Sciences/ Mathematics	UG	Spring 2017	D	Perceived learning experience – Academic performance
Calculus I	Cal_UG_LB_E Cal_UG_LB_F	Sciences/ Mathematics	UG	Spring 2017	E	Perceived learning experience – Academic performance
Facility Design and Operations	Eng_UG_LB_C	Engineering/ Industrial	UG	Spring 2017	F	Perceived learning experience
Operations Research II	Eng_UG_LB_D	Engineering/ Industrial	UG	Spring 2017	G	Perceived learning experience
Intro to Applied Operations Research	Eng_G_LB_D	Engineering/ Engineering Systems Management	G	Spring 2017	G	Perceived learning experience
Advanced Engineering Economy	Eng_G_LB_E	Engineering/ Engineering Systems Management	G	Spring 2017	H	Perceived learning experience
Analysis of Production Systems	Eng_UG_LB_E	Engineering/ Industrial	UG	Fall 2015	B	Academic performance
Financial Management for Engineers	Eng_G_LB_F	Engineering/ Engineering Systems Management	G	Spring 2016	C	Academic performance
Human Resources Management	Eng_G_LB_G	Engineering/ Engineering Systems Management	G	Fall 2015	C	Academic performance
Management for Engineers	Eng_G_LB_H	Engineering/ Engineering Systems Management	G	Fall 2015	C	Academic performance

4.1. Flipped Classes Description

For mathematics undergraduate classes, (Cal_UG_Flip_A and Cal_UG_Flip_B), students were given pre-class lecture-capturing videos that show the instructor explaining on the whiteboard. Videos were recorded from the previous semester by the instructor teaching both classes and uploaded to the LMS. They were edited to contain only the explanation of the concepts and all examples solving were excluded. Watching the videos was mandatory along with taking notes. During the class, the instructor checked for notes taking. Checking was done randomly and more at the beginning of the semester. Following that, a short lecture is given to review the concepts that students viewed in the pre-class video. Then students will set for group problem solving following a handout sheet. The group consists of 2-3 members formed as per the students' selection. During the problem-solving activity, the instructor walks and stops by the groups to answer questions, correct concepts, and sometimes devote a student to explain a solution or contribution to the class. By the end of the class, the instructor might do a wrap up to provide feedback and correct misunderstandings noted during the group problem-solving. Students were given weekly quizzes, in addition to one midterm and one final. There was no graded homework, but students were given recommended problems to solve out of the class time, where only the final answer was shared with them. Students were advised to approach the instructor through office hours for assistance in solving those problems.

In the engineering undergraduate flipped classes, students were given the lecture notes and sometimes online related videos to prepare for the class and take notes. All needed material is posted on the LMS one week ahead of the flipped session. Students were also advised to read from the textbook and an e-book summary. Classes that cover the beginning of a new chapter are only flipped, counting for seven sessions. That is, students need to do preparation on the theoretical aspects of the course. At the beginning of the class, a low-stakes quiz is given to check for the students' preparation. The quiz involves multiple choice and/or open-ended questions. The class time is then divided as the following, group discussion between students, followed by class discussion with the instructor and finally a wrap-up lecture that may involve new material. Students might sit for a problem-solving in the flipped sessions but more in the non-flipped ones as they cover the technical parts. Problem-solving is done in groups or individual matter, where problems were projected on the class board. There were seven graded assignments for after-class time and one group project. Furthermore, students were given a lot of none-graded exercises to solve on their own and practice. The course involved one midterm and one final.

In the engineering graduate flipped classes, students were only given the lecture notes to prepare for the class. The material was sent by email one week before the flipped session with further instructions about the next flipped session or a motivational message. All classes were flipped for the graduate courses. At the beginning of the class, a low-stakes multiple choice quiz is given to students to check for the pre-class preparation. The class time is then divided as the following, group discussion between students, followed by a mini-lecture on the pre-class material along with class discussion. Finally, a group workshop is given to students to work on collaborating with each other and with the instructor. The workshop is a practical application of the pre-class material and students were given a handout that describes it. For some classes, students were asked to bring their laptops to explore more information that is needed for the workshop. In many cases, the workshop is part of the final class project as all the flipped graduate courses involved in this study were project-based. There was no homework assigned. The course had one midterm and the final was the class project, where students submit a progress report of it during the middle of the semester.

4.2. Lecture-based Classes Description

In all the lecture-based classes involved in our study, students were not required to prepare before the class but were encouraged to do so. During the class, the major class time is devoted to the instructor to explain the concepts and solve examples. However, all our instructors emphasized on engaging students and requesting interaction from them. This involved asking students questions to enable a class discussion, in addition to giving them problems to solve in the class individually or sometimes in groups as the time allows. When problems were given, instructors check for the solution provided by the students, and then share the correct one through the whole class using the projector and the whiteboard. Looking into the content delivery style, all the classes, except for (Cal_UG_LB_C) and (Cal_UG_LB_D), adopted the projector to present the course notes and explain through them along with using the whiteboard. For the mathematics undergraduate classes (Cal_UG_LB_C) and (Cal_UG_LB_D), the instructor had only used the whiteboard to explain the concepts. Thus, definitions and concepts were written on the whiteboard by the instructor. Looking into the assessments, students in the mathematics undergraduate lecture-based classes were given weekly quizzes to ensure that they are studying on the go. There was no homework or course project, however, students were given a list of recommended problems to solve out of the class time, where only the final answer is shared with them. Students were advised to approach their instructor through office hours for assistance in solving those problems. The course involves one midterm and one final. For the engineering undergraduate lecture-based classes, quizzes and assignments were used to ensure that students are studying on the go. The courses had one group project, one midterm and one final. For the engineering graduate lecture-based classes, quizzes were used to ensure that students are studying on the go. Assignments were considered as a bonus instead of a requirement. The courses had one group project, one midterm and one final.

Chapter 5. Methodology

This research utilized mixed methods to evaluate the impact of the flipped method on students' perceived learning experience and their academic performance. Both quantitative and qualitative methods were used. Instructor interviews were carried out to look at how instructors are implementing the flipped classes, in addition to observing challenges and benefits. Furthermore, similar lecture-based classes were investigated to provide an additional insight into the impact of flipped method through comparing both teaching methodologies using a post-test quasi-experimental design with a control group. The Revised Community of Inquiry framework (RCOI) was adopted as the underlying factor to assess students' perceptions of their learning experience in addition to custom created factors. Furthermore, open-ended questions were adopted to get additional insight into the students' perceptions of each of the learning experiences they have gone through. Course grades were used to evaluate academic performance. To achieve the objectives of this research, the steps stated below were followed:

- Step 1: Conducting a literature review on empirical studies comparing flipped instruction versus lecture-based method in higher education, students' and instructors' perceptions of flipped method in higher education, in addition to design models and strategies for flipped classes in higher education. The review assisted in identifying the methodologies to apply empirical studies in addition to showing existing themes about students' and instructors' perceptions that help guide analyzing the data.
- Step 2: Collecting the students' perceptions of the perceived learning experience for flipped and lecture-based classes based on RCOI framework.
- Step 3: Collecting demographic data of students involved in the study per each course. Data is collected in anonymous matter from the registration and involves course grade, CGPA, class year, and gender.
- Step 4: Analyzing the demographic data of students for merging related classes into one group to ease analysis.

Step 5: Analyzing the demographic data of students for testing group equivalence between comparable classes; flipped versus lecture-based ones.

Step 6: Analyzing the students' responses of the survey elements in the flipped classes and compare the results to each other.

Step 7: Analyzing the students' responses of the survey elements, and data of course grades and compare the results between flipped and lecture-based classes.

Step 8: Concluding about the impact of flipped method on students' perceived learning experience and academic performance and provide a comparison to the lecture-based results.

5.1. Data Collection

5.1.1. Instructor interview. Instructor interviews were conducted in order to gather how instructors are flipping their classes at AUS, in addition to collecting the identified benefits and challenges. The framework used for the interview is shown in Appendix B.

5.1.2. Student survey. Student survey elements were developed to collect the students' perceptions of flipped and lecture-based classes adopting RCOI framework. Each survey consisted of demographic questions, RCOI framework items, custom created self-report items, in addition to open-ended questions. The name of the construct being measured is not mentioned in the surveys to avoid bias that could occur if students were aware of what we are measuring. The aim is to let students reflect their feelings and be themselves. Survey elements are shown in Appendix C and Appendix D.

Survey elements for the flipped class consisted of eight parts. Parts I-IV forms the RCOI items updated as per the need. Part V consists of custom questions to measure the impact of pre-class preparation on in-class understanding and participation, In-class construct. Part VI consists of custom questions to measure the impact of pre-class preparation on study load, Study Load construct. Part VII consists of custom questions to check for study practices. Part VIII consists of open-ended questions. Parts I-VI were developed using five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Survey elements for lecture-based classrooms consisted of seven parts. Parts I-IV forms the RCOI items updated as per the need. Part V consists of custom questions to check for in-class understanding and participation with the absence of pre-class preparation. Part VI consists of custom questions to check for study practices. Part VII consists of open-ended questions. Parts I-V were developed using five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The survey items divisions, for flipped and lecture-based class, showing the name of the constructs is shown in Appendix E.

For the RCOI framework statements, items of teaching (10 items), social (6 items) and cognitive presence (9 items) were adopted from the COI instrument [110] which was developed by a group of researchers working with the COI framework. The COI instrument was validated [103], [111] through factor analysis as a valid measure for cognitive, social and teaching presence. Items to measure learning presence (7 items) were adopted from [6], which had been developed in reference to the scheme proposed by [75]. The construct includes items from the Self-Regulation section of the Motivated Strategies for Learning Questionnaire [112] in addition to items from the Metacognitive Self-Regulation questionnaire [113].

Much attention has been made to the adoption of COI framework in online and blended learning environment [76], [77], [75], [103], [111] where the presence of these elements became more challenging with the absence or reduction of face-to-face medium and existence of text-based or technology-medium communication. The COI instrument includes some elements related to online learning components. In a similar way, the learning presence construct suggested by [75] was with greater attention toward the online learning environment.

Therefore, to ensure the validity of using the developed measure, the COI [110] instrument and Learning Presence measure [75], [6] were reviewed by two expert instructors from AUS and updated as needed for this research context, which involves flipped (blended) and traditional learning environment. Noting that, Community of Inquiry concept and learner self-regulation (Learning Presence) are valid for any learning environment and are based on learning theories. Origins of the Community of Inquiry concept can be found in [79]. Learning theories about learner self-regulation can be found in [114], [115]. In addition, in both classes' settings, students are working in groups on their course projects or case studies seeking information through online resources by their own and communicating through a technology-based and face-to-face medium. Students also retrieve the course content and assessments through an LMS or email medium. So, the online learning component exists in both studied methodologies and all four constructs are valid for the creation of a successful learning experience.

An approval to distribute the survey elements was firstly obtained from the Institutional Review Board (IRB). The survey instruments were then distributed to all involved courses that were offered in Spring 2017 and Fall 2017 to include them in the analysis related to the perceived learning experience. Surveys were distributed in a paper format at the class and administrated by the researcher. Students were briefed about the research objective and their participation was voluntary.

5.1.3. Course grades. For courses that are involved in the analysis of academic performance, demographics data of students were collected from the registration involving gender, class year, pre-course CGPA in addition to the grade of the course that is involved in the academic performance analysis.

5.2. Data Analysis

In this section, we show the procedures followed in analyzing the collected data to achieve the objectives of this research.

5.2.1. Implementation of flipped classes at AUS. Instructor interviews were used in order to identify how instructors are flipping their classes at AUS in addition to coding the benefits and challenges they observed.

5.2.2. Perceived learning experience. The survey element was used to collect the perceived learning experience of flipped and lecture-based classrooms.

As shown in Appendix C and Appendix D, surveys consist of quantitative and qualitative data. Each will be analyzed differently. For the quantitative data, descriptive statistics and suitable statistical tests were applied to check for validity of merging the responses of related flipped classes as one group and the responses of related lecture-based classes as another group. Then, descriptive statistics, internal consistency testing, group equivalence testing, inferential statistics and hypothesis testing were carried out using suitable software to analyze and interpret the data. In the end, data were reported for each flipped group and compared to each other providing a conclusion about how the flipped method impacted the perceived learning experience of the students. Furthermore, the responses in the flipped classes were compared to the similar lecture-based classes providing an additional insight into the impact of flipped method on the students' perceived learning experience.

Figure 4 shows an overview of the data analysis process followed when comparing groups or classes for the asked items in the survey. For ordinal data, Mann-Whitney U test was used. For continuous data, both parametric and non-parametric tests were carried out and compared then interpreted in case of differences. For comparison of two continuous variables, two independent-samples t-test and Mann-Whitney U test were applied. While for comparing more than two continuous variables, One-Way ANOVA and Kruskal Wallis tests were used, followed up by Games-Howell and Fisher post-hoc parametric tests and Kruskal Wallis Multiple Comparison test that adopts Dunn's test. Games-Howell post hoc test was used when equality of variances is violated. The rule followed in case of differences between the parametric and non-parametric tests was checking for assumptions, so if the normality or equality of variances were violated then the non-parametric test results will be considered. Anderson-Darling test was used to check for normality, and Levene's test was used to check for equality of variances. For comparison of categorial variables, Chi-Square test was used. In few cases where the expected cell counts were small, then Fisher's Exact test was applied. For correlations, Spearman and Goodman-Kruskal's gamma tests were adopted.

For the constructs of TP, CP, SP, LP, In-class and Study Load, the scoring of each of the asked items within the construct were averaged per each student response to come out with a final score regarding the measured construct. This final score was used in the comparison tests.

The qualitative data were coded to identify themes in students' perceptions that can further elaborate on their self-report responses and to support the conclusion on how the flipped method impacts the perceived learning experience of the students.

5.2.3. Academic performance. Course letter grades were used to look into the impact of the flipped method on the academic performance in comparison to the lecture-based learning.

The demographics data of students were analyzed to check for group equivalence between the comparable classes; flipped versus lecture-based ones. Then, descriptive statistics, inferential statistics and hypothesis testing were carried out to analyze and interpret the data and to look for any statistical differences on the course grades between the flipped and lecture-based classes. The letter course grades were translated to their equivalent GPA points number, and therefore the data analysis workflow followed was as per Figure 4, ordinal data. The equivalent GPA points of letter grades as per AUS are shown in Appendix H. Furthermore, the failure rates (grades of D, F, or withdrawals) were reported for the flipped and lecture-based classes and interpreted. We also wanted to compare the course grade performance by categorizing the participants as per gender (Female, Male) and pre-class CGPA (low, high), however, the sample size tends to be very low per each category, and very unequal between the compared classes, so we ended up considering the whole class.

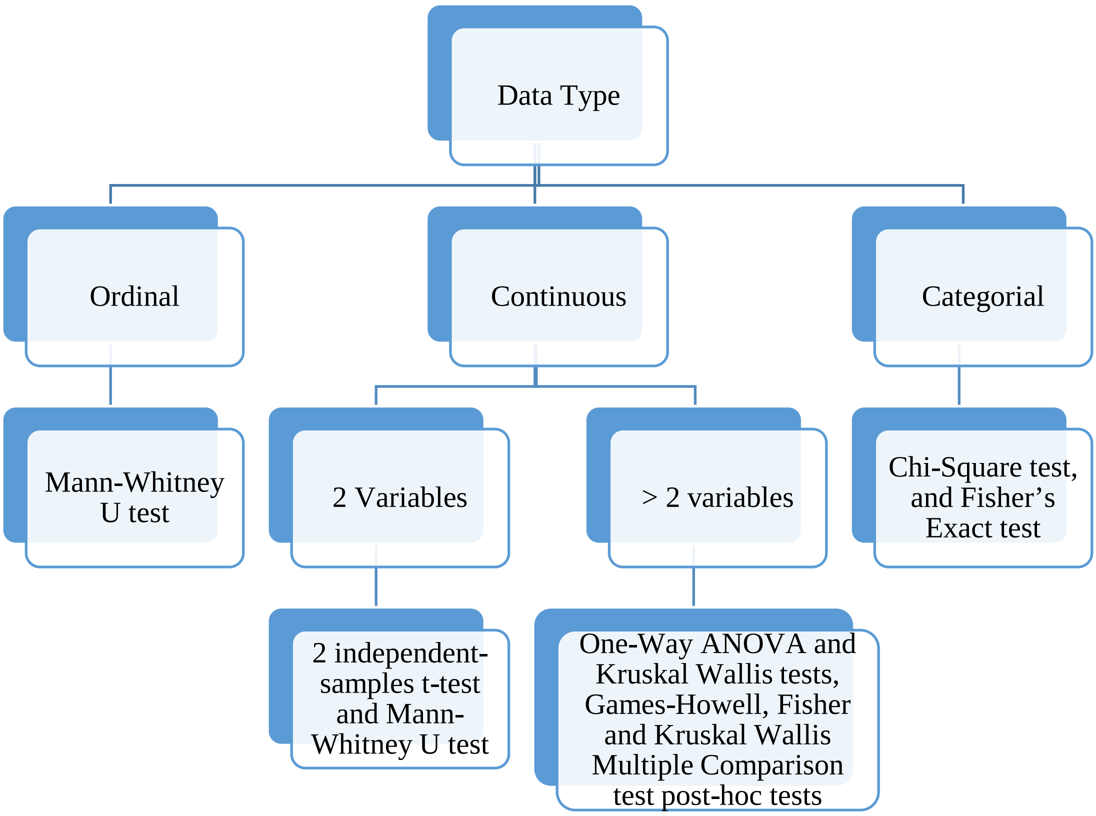

Figure 4: Data Analysis Workflow

Chapter 6. Results and Analysis

This chapter presents the results and analysis of the survey distributed to flipped and lecture-based classes along with the results and analysis of course grades data collected from the Registration.

The analysis was performed to the flipped classes comparing them to each other to examine the impact of the current implementation of the flipped method on students' perceived learning experience and to investigate the most contributing factors to the flipped method. Following that, the flipped classes were compared to their similar lecture-based classes, to provide an additional insight on the impact of the flipped method on the students perceived learning experience, in addition to providing a comparison for the academic performance.

6.1. Comparison of Individual Classes within Flipped and Lecture-based Groups: Check for Merge

Similar to [6], [102], we investigated the differences of flipped classes according to the RCOI constructs in order to check for validity of merging them as one group to simplify further analysis. The same investigation was also applied to the lecture-based classes to merge them as another group.

However, we had initially divided our classes such as we only investigated the merge of related classes. Our divisions were: "Mathematics undergraduate classes", "Engineering undergraduate classes", and "Engineering graduate classes". Noting that, all our examined mathematics classes were for the same course "Calculus I". Furthermore, all our examined engineering undergraduate classes were from the Industrial Engineering program. In addition, all our examined engineering graduate classes were from the Engineering Systems Management program. Following, we show the investigation of merge and further analysis as per the mentioned three divisions.

6.1.1. Mathematics undergraduate classes. As shown before in Table 2 and Table 3, there are two flipped and four lecture-based classes for course "Calculus I".

Three different instructors taught two sections each. The flipped classes (Cal_UG_Flip_A, Cal_UG_Flip_B) were taught by the same instructor. A second instructor taught the lecture-based classes (Cal_UG_LB_C, Cal_UG_LB_D), and a third instructor taught the lecture-based classes (Cal_UG_LB_E, Cal_UG_LB_F). Thus, in this section, we are investigating to merge the data of the two flipped classes (Cal_UG_Flip_A and Cal_UG_Flip_B) as one group, and the data of the lecture-based classes (Cal_UG_LB_C, Cal_UG_LB_D, Cal_UG_LB_E and Cal_UG_LB_F) as another group.

As shown in Table 4, normality was not validated for all RCOI data of mathematics undergraduate classes. However, homogeneous of variances was validated for the data to be checked for merge as shown in Table 5 as *p*-value was greater than 0.05 for all tests results.

Table 4: RCOI Normality test results for mathematics undergraduate classes: before merge

Construct	Cal_UG_ Flip_A	Cal_UG_ Flip_B	Cal_UG_ LB_C	Cal_UG_ LB_D	Cal_UG_ LB_E	Cal_UG_ LB_F
TP	Not normal ($p < 0.005$)*	Not normal ($p < 0.005$)*	Normal ($p = 0.156$)	Not normal ($p = 0.006$)*	Normal ($p = 0.137$)	Normal ($p = 0.299$)
SP	Not normal ($p = 0.026$)*	Normal ($p = 0.484$)	Normal ($p = 0.598$)	Not normal ($p<0.005$)*	Not Normal ($p = 0.016$)*	Normal ($p = 0.070$)
CP	Normal ($p = 0.136$)	Normal ($p = 0.653$)	Normal ($p = 0.241$)	Normal ($p = 0.341$)	Normal ($p = 0.426$)	Normal ($p = 0.161$)
LP	Normal ($p = 0.523$)	Normal ($p = 0.533$)	Normal ($p = 0.332$)	Not normal ($p = 0.029$)*	Normal ($p = 0.530$)	Normal ($p = 0.551$)

* $p < 0.05$

Table 5: RCOI Levene's test results for mathematics undergraduate classes: before merge

RCOI Construct	*p*-value (Cal_UG_Flip_A&B)	*p*-value (Cal_UG_LB_C&D&E&F)
TP	0.272	0.265
SP	0.459	0.492
CP	0.845	0.794
LP	0.253	0.604

According to the parametric test, two independent-samples t-test, and the non-parametric test, Mann-Whitney U test, there is no significant difference between the flipped classes (Cal_UG_Flip_A) and (Cal_UG_Flip_B) for all RCOI constructs, as *p*-value was greater than the alpha value of 0.05 as shown in Table 6. Therefore, we can safely merge the two flipped classes as one group “Cal_UG_Flip_GI” for further review.

Table 6: RCOI 2 independent samples t-test and Mann-Whitney U test between the two flipped mathematics undergraduate classes: before merge

Construct	**Cal_UG_Flip_A**			**Cal_UG_Flip_B**			***t (p)* A & B**	***W (p)* A & B**
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*		
TP	26	4.66 ± 0.40	4.80	27	4.62 ± 0.53	4.90	0.36 (0.718)	696.00 (0.918)
SP	26	3.76 ± 0.789	4.00	27	3.74 ± 0.68	3.67	0.14 (0.89)	723.50 (0.707)
CP	26	4.12 ± 0.74	4.11	27	3.90 ± 0.71	4.00	1.03 (0.306)	760.00 (0.305)
LP	26	4.04 ± 0.62	4.07	27	3.97 ± 0.51	4.00	0.45 (0.654)	734.00 (0.574)

Table 7 shows the descriptive statistics for the four mathematics undergraduate lecture-based classes involved in this study. Looking into comparison results, lecture-based classes showed significant difference in teaching presence according to both the parametric test, One-Way ANOVA (p = 0.030), and the non-parametric test, Kruskal Wallis (p = 0.021) as shown in Table 8. Furthermore, the learning presence was significantly different according to One-Way ANOVA (p = 0.043), and slightly according to Kruskal Wallis test (p = 0.081). Those differences in TP and LP seem to be affected by the different instructors and students.

Thus, we looked into grouping the lecture-based classes as per the instructor as the following; "Cal_UG_LB_GII" for classes (Cal_UG_LB_C and Cal_UG_LB_D), "Cal_UG_LB_GIII" for classes (Cal_UG_LB_E and Cal_UG_LB_F). Looking into comparison results presented in Table 9, there was no significant difference between the classes of Cal_UG_LB_GII: (Cal_UG_LB_C and Cal_UG_LB_D), for all RCOI constructs as p values were greater than the alpha value of 0.05. Similarly, there was no significant difference between the classes of Cal_UG_LB_GIII: (Cal_UG_LB_E and Cal_UG_LB_F), for all RCOI constructs.

Table 7: RCOI Descriptive Statistics of lecture-based mathematics undergraduate classes: before merge

Construct	Cal_UG_LB_C			Cal_UG_LB_D			Cal_UG_LB_E			Cal_UG_LB_F		
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*
TP	23	4.39 ± 0.41	4.30	26	4.42 ± 0.58	4.55	21	4.03 ± 0.42	4.00	16	4.13 ± 0.61	4.10
SP	23	3.86 ± 0.54	4.00	26	3.69 ± 0.74	3.50	21	3.34 ± 0.84	3.33	16	3.59 ± 0.89	3.67
CP	23	3.86 ± 0.48	3.78	26	3.73 ± 0.59	3.61	21	3.64 ± 0.48	3.67	15	3.74 ± 0.58	3.89
LP	23	4.07 ± 0.44	4.14	26	4.198 ± 0.54	4.00	21	3.79 ± 0.46	3.86	15	4.03 ± 0.49	4.00

Table 8: RCOI One-way ANOVA test and Kruskal Wallis test for the lecture-based mathematics undergraduate classes: before merge

Construct	***f (p)*** **Cal_UG_LB_C&D&E&F**	***H (p)*** **Cal_UG_LB_C&D&E&F**
TP	3.13 (0.030)*	9.71 (0.021)*
SP	1.85 (0.145)	4.46 (0.216)
CP	0.60 (0.618)	2.51 (0.473)
LP	2.83 (0.043)*	6.72 (0.081)

* $p < 0.05$

Table 9: RCOI 2 independent samples t-test and Mann-Whitney U test between mathematics undergraduate lecture-based classes taught by the same instructor: before merge

Construct	***t (p)*** **Cal_UG_LB_C&D**	***W (p)*** **Cal_UG_LB_C&D**	***t (p)*** **Cal_UG_LB_E&F**	***W (p)*** **Cal_UG_LB_E&F**
TP	-0.22 (0.824)	550.00 (0.621)	-0.55 (0.588)	366.50 (0.325)
SP	0.92 (0.361)	640.50 (0.190)	-0.88 (0.387)	364.00 (0.287)
CP	0.80 (0.426)	634.00 (0.240)	-0.55 (0.589)	372.50 (0.618)
LP	-0.88 (0.382)	551.50 (0.643)	-1.48 (0.149)	344.00 (0.155)

Thus, as shown above, in our study, there was no significant difference between the mathematics undergraduate classes taught by the same instructor for all RCOI constructs. The merged data to be considered for further analysis is shown in Table 10.

Table 10: Mathematics undergraduate classes: after merge

Group Name	Teaching method	Merged Classes
Cal_UG_Flip_GI	Flipped	Cal_UG_Flip_A and Cal_UG_Flip_B
Cal_UG_LB_GII	Lecture-based	Cal_UG_LB_C and Cal_UG_LB_D
Cal_UG_LB_GIII	Lecture-based	Cal_UG_LB_E and Cal_UG_LB_F

6.1.2. Engineering undergraduate classes. As shown before in Table 2 and Table 3, there are two flipped engineering undergraduate classes that are related to the same course "Analysis of Production Systems" and taught by the same instructor on following semesters, Spring 2017 (Eng_UG_Flip_A) and Fall 2017 (Eng_UG_Flip_B).

Two lecture-based engineering undergraduate classes were involved in this study. (Eng_UG_LB_C: "Facility Design and Operations") and (Eng_UG_LB_D: "Operations Research II"). Both lecture-based classes were taught in Spring 2017 by two instructors. All involved engineering undergraduate classes, flipped and lecture-based, are year three classes from the industrial engineering program.

As shown in Table 11, normality was validated for all RCOI constructs of flipped classes but not for the lecture-based ones. However, homogeneous of variances was validated for the data to be checked for merge as shown in Table 12 as *p*-value was greater than 0.05 for all the tests results.

Table 11: RCOI Normality test results for engineering undergraduate classes: before merge

Construct	Eng_UG_Flip_A	Eng_UG_FLip_B	Eng_UG_LB_C	Eng_UG_LB_D
TP	Normal ($p = 0.175$)	Normal ($p = 0.605$)	Not Normal (p<0.005)**	Not Normal (p<0.005)
SP	Normal ($p = 0.088$)	Normal ($p = 0.700$)	Not Normal ($p = 0.022$)*	Normal ($p = 0.307$)
CP	Normal ($p = 0.217$)	Normal ($p = 0.549$)	Not Normal (p<0.005)*	Normal ($p = 0.052$)
LP	Normal ($p = 0.103$)	Normal ($p = 0.062$)	Normal ($p = 0.262$)	Not Normal ($p = 0.033$)

* $p < 0.05$

Table 12: RCOI Levene's test results for engineering undergraduate classes: before merge

Construct	*p*-value (Eng_UG_Flip_A & B)	*p*-value (Eng_UG_LB_C & D)
TP	0.266	0.079
SP	0.063	0.318
CP	0.856	0.539
LP	0.828	0.111

Looking into the comparison results of the RCOI constructs between the two flipped engineering undergraduate classes, Eng_UG_Flip_A and Eng_UG_Flip_B, presented in Table 13, according to two independent samples t-test, only the CP showed a significant difference as *p*-value was equal to 0.05. Furthermore, the *p*-value for SP comparison was not very high ($p = 0.094$). While Mann-Whitney U test shows slightly higher *p* values (CP: $p = 0.076$, SP: $p = 0.194$). Given that normality and equivalent of variances are met, then we are considering the results of the parametric test.

No significance difference was shown for TP and LP according to both the parametric test, two independent-samples t-test, and the non-parametric test, Mann-Whitney U test. Considering that the response rate for class Eng_UG_Flip_B was low (40.54%: 15 out of 37) and that the same course is taught by the same instructor, while all other RCOI constructs did not show a difference, then we can say that it is safe to merge the data and consider them as one group (Eng_UG_Flip_GI) for further review.

Table 13: RCOI 2 independent samples t-test and Mann-Whitney U test between engineering undergraduate flipped classes: before merge

Construct	Eng_UG_Flip_A			Eng_UG_Flip_B			*t (p)* A & B	*W (p)* A & B
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*		
TP	29	3.869 ± 0.674	3.80	15	3.54 ± 0.89	3.60	1.37 (0.177)	702.50 (0.219)
SP	29	4.12 ± 0.59	4.00	15	3.74 ± 0.88	3.83	1.71 (0.094)	705.00 (0.194)
CP	29	3.82 ± 0.74	3.78	15	3.33 ± 0.78	3.33	2.02 (0.050)	724.50 (0.076)
LP	29	3.96 ± 0.48	4.14	15	3.86 ± 0.51	3.86	0.59 (0.557)	692.00 (0.331)

On the other hand, engineering undergraduate lecture-based classes showed significant difference in teaching and cognitive presences according to both the parametric test, two independent-samples t-test, and the non-parametric test, Mann-Whitney U test as the *p* values were less than 0.05 as shown in Table 14. Those differences in TP and CP look to be affected by the different instructors and different class activities. Thus, the engineering undergraduate lecture-based classes cannot be merged, and each class will be considered by itself for further analysis.

Table 14: RCOI 2 independent samples t-test and Mann-Whitney U between engineering undergraduate lecture-based classes

Construct	**Eng_UG_LB_C**			**Eng_UG_LB_D**			***t (p)*** **C & D**	***W (p)*** **C & D**
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*		
TP	23	4.70 ± 0.40	4.90	24	4.10 ± 0.85	4.400	3.05 (0.004)*	704.00 (0.001)*
SP	23	4.11± 0.90	4.33	24	3.76 ± 0.69	3.67	1.51 (0.139)	640.50 (0.060)
CP	23	4.40 ± 0.66	4.33	24	3.46 ± 0.81	3.56	4.35 (0.000)*	746.50 (0.000)*
LP	23	4.04 ± 0.67	4.00	24	3.79 ± 0.49	3.86	1.48 (0.147)	623.50 (0.128)

* $p < 0.05$

6.1.3. Engineering graduate classes. As shown before in Table 2 and Table 3, there are three flipped engineering graduate classes that are taught by the same instructor. “Financial Management for Engineers” (Eng_G_Flip_A), taught in Spring 2017. “Human Resources Management” (Eng_G_Flip_B), taught in Fall 2017. “Management for Engineers” (Eng_G_Flip_C) taught in Fall 2017.

Two lecture-based engineering graduate classes were involved in this study. “Intro to Applied Operations Research” (Eng_G_LB_D), taught in Spring 2017. “Advanced Engineering Economy” (Eng_G_LB_E) taught in Spring 2017. Each of the lecture-based classes were taught by a different instructor. All involved engineering graduate classes, flipped and lecture-based, are from the Engineering Systems Management program.

As shown in Table 15, normality was not validated for all engineering graduate RCOI data. However, homogeneous of variances was validated for the data to be checked for merge as shown in Table 16, as p-value was greater than 0.05 for all tests results.

Table 15: RCOI Normality test results for engineering graduate classes: before merge

Construct	Eng_G_Flip_A	Eng_G_Flip_B	Eng_G_Flip_C	Eng_G_LB_D	Eng_G_LB_E
TP	Normal (p = 0.08)	Normal (p = 0.478)	Not Normal (p = 0.01)	Normal (p = 0.787)	Normal (p = 0.650)
SP	Not Normal (p = 0.014)*	Not Normal (p = 0.013)*	Normal (p = 0.484)	Normal (p = 0.063)	Not Normal (p = 0.008)*
CP	Normal (p = 0.382)	Normal (p = 0.475)	Not Normal (p = 0.014)*	Normal (p = 0.669)	Normal (p = 0086)
LP	Normal (p = 0.137)	Normal (p = 0.334)	Normal (p = 0.823)	Normal (p = 0.544)	Normal (p = 0.455)

* $p < 0.05$

Table 16: RCOI Levene's test results for engineering graduate classes: before merge

Construct	*p*-value Eng_G_Flip_A & B & C	*p*-value Eng_G_LB_D & E
TP	0.392	0.452
SP	0.579	0.553
CP	0.502	0.788
LP	0.642	0.500

Table 17 shows the descriptive statistics for the three flipped engineering graduate classes involved in this study. Looking into the comparison results of the RCOI constructs between the three flipped engineering graduate classes presented in Table 18, teaching and cognitive presences showed statistically significant difference according to both the parametric test, One-Way ANOVA (TP: p = 0.007, CP: p = 0.042), and the non-parametric test, Kruskal Wallis (TP: p = 0.016, CP: p = 0.021). While the social and learning presences did not show a statistical difference according to both One-Way ANOVA test (SP: p = 0.147, LP: p = 0.124), and Kruskal Wallis test (SP: p = 0.226, LP: p = 0.153).

Table 17: RCOI Descriptive Statistics of flipped engineering graduate classes: before merge

Construct	Eng_G_Flip_A			Eng_G_Flip_B			Eng_G_Flip_C		
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*
TP	11	4.06 ± 0.41	4.00	11	4.42 ± 0.34	4.30	26	4.52 ± 0.41	4.55
SP	11	3.83 ± 0.60	4.00	11	4.29 ± 0.42	4.00	26	4.10 ± 0.55	4.17
CP	11	3.91 ± 0.42	3.89	11	4.19 ± 0.60	4.00	26	4.38 ± 0.49	4.22
LP	11	3.64 ± 0.65	3.43	11	3.96 ± 0.51	4.00	26	4.05 ± 0.52	4.07

Table 18: RCOI One-way ANOVA test and Kruskal Wallis test between flipped engineering graduate classes: before merge

Construct	***F* (*p*-value)** **Eng_G_Flip_A & B & C**	***H* (*p*-value)** **Eng_G_Flip_A & B & C**
TP	5.53 (0.007)*	8.33 (0.016)*
SP	2.00 (0.147)	2.98 (0.226)
CP	3.42 (0.042)*	7.70 (0.021)*
LP	2.19 (0.124)	3.76 (0.153)

* $p < 0.05$

To identify the groups that are significantly different from each other, post hoc test analysis was conducted involving both parametric Fisher test, in addition to the non-parametric Kruskal Wallis Multiple Comparison test.

As shown in Table 19, the graduate conceptual classes (Eng_G_Flip_B and Eng_G_Flip_C) showed very similar class experiences for all RCOI constructs with *p* values > 0.05 according to both the parametric and the non-parametric post hoc tests.

However, the graduate technical class (Eng_G_Flip_A) was different from each of the other classes. Where TP was statistically significant between class Eng_G_Flip_A and Eng_G_Flip_B according to Fisher test ($p = 0.037$) and Kruskal Wallis Multiple Comparison test ($p = 0.056$), in addition to SP showing slightly significant difference according to Fisher test ($p = 0.054$) and according to Kruskal Wallis Multiple Comparison test ($p = 0.089$). While TP and CP showed statistical significance difference between class Eng_G_Flip_A and Eng_G_Flip_C according to Fisher test (TP: $p = 0.002$, CP: $p = 0.013$) and Kruskal Wallis Multiple Comparison test (TP: $p = 0.004$, CP: $p = 0.006$).

This result is expected due to the difference of the courses nature, as courses (Eng_G_Flip_B, Eng_G_Flip_C) are conceptual ones while (Eng_G_Flip_A) is more of a technical course and is considered to be different from the usual ESM courses.

Thus, for further analysis for flipped engineering graduate classes, class (Eng_G_Flip_A) will be considered by itself, while classes (Eng_G_Flip_B, Eng_G_Flip_C) are merged as Eng_G_Flip_GI.

Table 19: Fisher post-hoc test and Kruskal Wallis Multiple Comparison test results between flipped engineering graduate classes: before merge

Construct	*t (p)* Eng_G_ Flip_B&A	*Z (p)* Eng_G_ Flip_B&A	*t (p)* Eng_G_ Flip_C&A	*Z (p)* Eng_G_ Flip_C&A	*t (p)* Eng_G_ Flip_C&B	*Z (p)* Eng_G_ Flip_C&B
TP	2.15 (0.037)*	1.91 (0.056)	3.32 (0.002)*	2.87 (0.004)*	0.76 (0.449)	0.607 (0.544)
SP	1.98 (0.054)	1.69 (0.089)	1.39 (0.171)	1.26 (0.208)	-0.96 (0.343)	0.75 (0.452)
CP	1.32 (0.195)	1.38 (0.169)	2.60 (0.013)*	2.76 (0.006)*	1.04 (0.304)	1.13 (0.261)
LP	1.38 (0.174)	1.28 (0.199)	2.09 (0.043)*	1.93 (0.053)	0.45 (0.658)	0.41 (0.682)

* $p < 0.05$

On the other hand, there was no significant difference between the two lecture-based engineering graduate classes (Eng_G_LB_D) and (Eng_G_LB_E) for all RCOI constructs, as *p* values were greater than the alpha value of 0.05, according to both the parametric two independent samples t-test and the non-parametric Mann-Whitney U test as presented in Table 20. However, to avoid comparison of unequal sample sizes, we are not merging the two lecture-based classes, and instead comparing the reported students' perceptions in the flipped technical class (Eng_G_Flip_A) to each of the two technical lecture-based classes.

Table 20: RCOI Descriptive Statistics, 2 independent samples t-test and Mann-Whitney U test between engineering graduate lecture-based classes

Construct	Eng_G_LB_D			Eng_G_LB_E			*t (p)* D & E	*W (p)* D & E
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*		
TP	10	4.22 ± 0.51	4.25	16	4.37 ± 0.43	4.35	-0.80 (0.431)	123.00 (0.542)
SP	10	3.88 ± 0.71	3.50	16	4.10 ± 1.01	4.42	-0.60 (0.554)	113.50 (0.266)
CP	10	4.03 ± 0.67	3.94	16	3.89 ± 0.74	3.83	0.50 (0.619)	143.00 (0.691)
LP	10	3.79 ± 0.73	3.79	16	3.95 ± 0.63	3.93	-0.60 (0.556)	125.00 (0.615)

6.2. Participants

Participants of this research involved students from the flipped and lecture-based classes, in addition to the three instructors who taught the flipped classes. All participants were from AUS. Participating students involved were undergraduate students form the college of Arts and Sciences, Department of Mathematics, undergraduate students from the college of Engineering, Department of Industrial Engineering, in addition to graduate students from the college of Engineering, Department of Engineering Systems Management. Thus, all students were from STEM majors.

This section presents students' participants as per the merged data decided in the previous section. Furthermore, homogeneous of compared flipped and lecture-based groups is checked by looking into demographics data of pre-course CGPA, gender, age and level of study. Pre-course CGPA and gender data were collected from the registration office in anonymous manner. Those data are for all students enrolled in participating courses whether the students have filled the survey or not, as some students were not available at the survey distribution time. Furthermore, students who filled the survey were asked to report their demographic data. We are presenting in this section demographics data for the whole class and for the respondents. When it comes to the comparison of the academic performance, then homogenous of groups should consider the whole class. While for the survey comparison, it makes more sense to check homogenous of groups considering respondents. However, as respondents might not answer the demographic questions, we are assuming that if the homogeneous of groups was verified for the whole class then it will be verified considering only respondents. This is valid because we are having high response rate ranging from (62.86%) to (96.63%).

6.2.1. Flipped classes. Table 21 shows demographics for all students in the involved flipped classes as retrieved from the registration department. While Table 22 shows the demographics of the students who responded to the survey.

Participants in the flipped classes were 179 students, consisting of 125 undergraduate students and 54 graduates. Number of respondents to the survey was 145, consisting of 97 undergraduate students and 48 graduates. This results in 81.01% response rate in total, 77.60% response rate for undergraduate classes, and 88.88% response rate for graduate classes. The most majority of undergraduate participants from mathematics classes (Cal_UG_Flip_GI) were freshman. While the undergraduate participants from the engineering classes (Eng_UG_Flip_GI) were mostly juniors. The age of the undergraduate participants ranged from 17 to 22, and for the graduate participants from 23 to 30. For the undergraduate mathematics classes, males were nearly double of females, while for the undergraduate engineering classes, females were nearly double of males. Gender distribution in the graduate classes was nearly equal.

Table 21: Demographics of all students in the flipped classes

Factor		Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
Total		55	70	13	41
Pre-course CGPA	Mean	2.72	2.74	3.49	2.652
	Median	2.65	2.63	3.44	3.300
	N/A*	7	-	-	-
Gender	Female	17	45	8	22
	Male	38	25	5	19

Table 22: Demographics of respondents in the flipped classes

Factor		Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
Total	Enrolled	55	70	13	41
	Responded	53	44	11	37
	Response%	93.36%	62.86%	84.62%	90.24%
Pre-course CGPA	Mean	2.985	2.798	3.47	3.42
	Median	2.91	2.65	3.48	3.45
	N/A	16	8	5	11
Gender	Female	15	29	6	21
	Male	36	15	4	15
	N/A	2	-	1	1
Age	17-22	46	40	-	1
	23-30	-	-	10	30
	N/A	7	4	1	6
Class Year	Freshman	41	-	-	-
	Sophomore	5	2	-	-
	Junior	4	35	-	-
	Senior	1	6	-	-
	Master	-	-	11	37
	N/A	2	1	-	-

6.2.2. Mathematics undergraduate classes (flipped versus lecture-based classes). Participants in the mathematics undergraduate classes were 55 students in the flipped group and 104 students in the lecture-based groups. Number of respondents to the survey was 53 in the flipped group Cal_UG_Flip_GI (96.63% response rate), 49 in the lecture-based group Cal_UG_LB_GII (87.50% response rate), and 37 in the lecture-based group Cal_UG_LB_GIII (77.08% response rate). The majority of the participants were freshman and males were nearly double that of females (see Table 23 and Table 24).

Checking homogenous of the compared classes, the flipped group (Cal_UG_Flip_GI) versus each of the lecture-based groups (Cal_UG_LB_GII and Cal_UG_LB_GIII), results were similar considering both all students and only respondents. Considering all students (Table 23), there was no statistical difference regarding pre-class CGPA, according to two independent samples t-test for both comparisons of (GI&GII: p = 0.887, GI&GIII: p = 0.547), and according to Mann-Whitney U test for both comparisons (GI&GII: p = 0.818, GI&GIII: p = 0.465). Similarly considering only the respondents (Table 24), there was no statistical difference regarding the pre-class CGPA according to two independent samples t-test and Mann-Whitney U test as p values were greater than 0.05. Thus, homogeneous of pre-class CGPA is verified.

For the rest categorial data of gender, age and level of study, Chi-Square test was used. As shown in Table 23 and Table 24, the p-value in all our comparisons was greater than 0.05. Therefore, gender, age and level of study carry no statistical difference between the flipped group and each of the lecture-based groups, considering both demographics of all students and only respondents. Thus, the homogenous of compared groups is verified for further analysis.

Table 23: Demographics of all students in the mathematics undergraduate classes

Factor		**Cal_UG_Flip_GI**	**Cal_UG_LB_GII**	**Cal_UG_LB_GIII**	***W(p) or $x^2(p)$*** **GI & GII**	***W(p) or $x^2(p)$*** **GI & GIII**
Pre-course CGPA	Mean	2.72	2.74	2.64	-0.14 (0.887)	0.61 (0.547)
	Median	2.65	2.69	2.50	3040.50 (0.818)	2971 (0.465)
	N/A*	7	5	8	-	-
Gender	Female	17	20	15	0.591	0.970
	Male	38	36	33		

* Some students are in their first semester and has no pre-course CGPA

Table 24: Demographics of respondents in the mathematics undergraduate classes

Factor		Cal_UG_Flip_GI	Cal_UG_LB_GII	Cal_UG_LB_GIII	t(p) or $x^2(p)$ GI & GII	t(p) or $x^2(p)$ GI & GIII
Total	Enrolled	55	56	48	-	-
	Responded	53	49	37		
	Response%	96.63%	87.50%	77.08%		
Pre-course CGPA	Mean	2.99	3.02	2.73	-0.93 (0.357)	0.87 (0.389)
	Median	2.91	3.00	2.80	1314.00 (0.332)	1132.50 (0.512)
	N/A	16	11	16	-	-
Gender	Female	15	17	14	0.571	0.356
	Male	36	32	22		
	N/A	2	-	1		
Age	17-22	46	45	33	-	-
	N/A	7	4	4		
Class Year	Freshman	41	44	34	0.367*	0.393**
	Sophomore	5	4	2		
	Junior	4	1	-		
	Senior	1	-	-		
	N/A	2	-	1		

* Excluding Senior

** Excluding Junior & Senior

6.2.3. Engineering undergraduate classes (flipped versus lecture-based classes). Participants from the engineering undergraduate classes were 70 students from the flipped classes and 58 students from the lecture-based ones. Number of respondents to the survey was 44 students (62.86% response rate) in the flipped group Eng_UG_Flip_GI, 23 students in the lecture-based class Eng_UG_LB_C (79.31% response rate) and 24 students in the lecture-based class Eng_UG_LB_D (82.76% response rate). The most majority of participants were juniors or seniors (see Table 25 and Table 26).

Checking homogenous of the compared classes, the flipped group (Eng_UG_Flip_GI) versus each of the lecture-based classes (Eng_UG_LB_C and Eng_UG_LB_D), results were similar considering both all students and only respondents. Considering all students (Table 25), there was no statistical difference regarding pre-class CGPA, according to two independent samples t-test for both comparisons of (GI&C: $p = 0.435$, GI&D: $p = 0.676$), and according to Mann-Whitney U test for both comparisons (GI&C: $p = 0.606$, GI&D: $p = 0.428$). Similarly considering only the respondents (Table 26), there was no statistical difference regarding the pre-class CGPA according to two independent samples t-test and Mann-Whitney U test as p values were greater than 0.05. Thus, homogeneous of pre-class CGPA is verified.

All participants were aged between 18 and 23, thus age didn't carry any statistical difference between the flipped and lecture-based classes. Gender and class year carry no statistical differences comparing the flipped group (Eng_UG_Flip_GI) to the lecture-based class (Eng_UG_LB_D), according to Chi-Square test, as p-value was greater than 0.05 considering all students for gender or only respondents for gender and class year (see Table 25 and Table 26). However, gender and class year showed statistical differences comparing the flipped group (Eng_UG_Flip_GI) to the lecture-based class (Eng_UG_LB_C), according to Chi-Square test, as p-value was less than or equal to 0.05 considering all students for gender or only respondents for gender and class year (see Table 25 and Table 26). However, considering that the courses offered in the flipped classes (Eng_UG_Flip_GI) and the lecture-based class (Eng_UG_LB_C) are year three courses, and are usually taken by juniors or seniors, then the class year difference is not a major factor to consider. Furthermore, the gender distribution difference by itself is not a major factor to consider, since the pre-class CGPA and age were homogenous, in addition to the class year being in the norm range of compared courses, which is juniors or seniors. Thus, we can say that the homogeneous of the compared engineering undergraduate classes is verified for further analysis.

Table 25: Demographics of all students in the engineering undergraduate classes

Factor		**Eng_UG_Flip_GI**	**Eng_UG_LB_C**	**Eng_UG_LB_D**	***W(p) or t(p) or $x^2(p)$*** **GI & C**	***W(p) or t(p) or $x^2(p)$*** **GI & D**
Total		70	29	29	-	-
Pre-course CGPA	Mean	2.74	2.66	2.78	0.78 (0.435)	-0.42 (0.676)
	Median	2.63	2.63	2.73	3567.50 (0.606)	3396.50 (0.428)
Gender	Female	45	11	18	5.797 (0.016)	0.044 (0.835)
	Male	25	18	11		

Table 26: Demographics of respondents in the engineering undergraduate classes

Factor		Eng_UG_Flip_GI	Eng_UG_LB_C	Eng_UG_LB_D	*W(p) or t(p) or x^2(p)* GI & C	*W(p) or t(p) or x^2(p)* GI & D
Total	Enrolled	70	29	29	-	-
	Responded	44	23	24		
	Response%	62.86%	79.31%	82.76%		
Pre-course CGPA	Mean	2.798	2.74	2.85	0.45 (0.656)	-0.43 (0.666)
	Median	2.65	2.67	2.74	1005.50 (0.783)	991.00 (0.555)
	N/A	8	5	4	-	-
Gender	Female	29	9	12	3.753 (0.053)	0.805 (0.370)
	Male	15	13	10		
	N/A	-	1	2		
Age	18-23	40	19	21	-	-
	N/A	4	4	3		
Class Year	Freshman	-	-	-	22.986 (0.000)*	1.488 (0.475)
	Sophomore	2	-	1		
	Junior	35	5	16		
	Senior	6	16	6		
	N/A	1	2	1		

* Excluding Sophomore

6.2.4. Engineering graduate classes (flipped versus lecture-based classes). For the graduate engineering classes, the flipped technical class (Eng_G_Flip_A) is to be compared to each of the lecture-based technical classes (Eng_G_LB_D) and (Eng_G_LB_E). While for the flipped conceptual classes (Eng_G_Flip_GI), there was no lecture-based conceptual classes to compare the learning experience to them.

Participants from the engineering graduate technical classes were 13 students in the flipped class (Eng_G_Flip_A), 11 students in the lecture-based class (Eng_G_LB_D), and 23 students in the lecture-based class (Eng_G_LB_E). Number of respondents to the survey was 11 students (84.62% response rate) in the flipped class (Eng_G_Flip_A), 10 students (90.91% response rate) in the lecture-based class (Eng_G_LB_D), and 16 students (69.57% response rate) in the lecture-based class (Eng_G_LB_E) (see Table 27 and Table 28).

Checking homogenous of the compared classes, the flipped class (Eng_G_Flip_A) versus each of the lecture-based classes (Eng_G_LB_D and Eng_G_LB_E), results were similar considering both all students and only respondents. Considering all students (Table 27), there was no statistical difference regarding pre-class CGPA, according to Mann-Whitney U test for both comparisons (A&D: $p = 0.146$, A&E: $p = 0.947$), and according to two independent samples t-test for comparison of (A&E: $p = 0.974$). The result of two independent samples t-test for comparison of (A&D: $p = 0.023$) is not valid as the quality of variances is violated, and thus the Mann-Whitney U test results is considered. Similarly considering only the respondents (Table 28), there was no statistical difference regarding the pre-class CGPA according to two independent samples t-test and Mann-Whitney U test as p values were greater than 0.05 (Table 28). Thus, homogeneous of pre-class CGPA is verified.

All participants were aged between 22 and 32, thus age didn't carry any statistical difference between the flipped and lecture-based classes. Homogenous of gender distribution was not verified for both comparisons of flipped class (Eng_G_Flip_A) to each of the lecture-based classes (Eng_G_LB_D) and (Eng_G_LB_E) considering both all students or only respondents, the p values of the Chi-Square tests were less than or almost equal to 0.05 (see Table 27 and Table 28). However, the gender distribution difference by itself is not a major factor to consider, since the pre-class CGPA and age were homogenous, Thus, we can say that the homogeneous of compared engineering graduate classes is verified for further analysis.

Table 27: Demographics of all students in the engineering graduate classes

Factor		**Eng_G_Flip_A**	**Eng_G_LB_D**	**Eng_G_LB_E**	***t (p) or W(p) or x^2(p)*** **A & D**	***t (p) or W(p) or x^2(p)*** **A & E**
Total		13	11	23	-	-
Pre-course CGPA	Mean	3.49	1.95	3.49	2.69 (0.023)**	-0.03 (0.974)
	Median	3.44	3.25	3.40	188.00 (0.146)	243.00 (0.947)
Gender	Female	8	2	5	4.608 (0.032)*	5.702 (0.017)*
	Male	5	9	18		

* $p < 0.05$, ** Equality of variance is violated

Table 28: Demographics of respondents in the engineering graduate classes

Factor		Eng_G_Flip_A	Eng_G_LB_D	Eng_G_LB_E	***t(p) or W(p) or x^2(p)* A & D**	***t(p) or W(p) or x^2(p)* A & E**
Total	Enrolled	13	11	23	-	-
	Responded	11	10	16		
	Response%	84.62%	90.91%	69.57%	-	-
Pre-course CGPA	Mean	3.47	3.63	3.53	-0.73 (0.491)	-0.33 (0.746)
	Median	3.48	3.78	3.6	27.00 (0.519)	57.50 (0.680)
	N/A	5	7	2	-	-
Gender	Female	6	2	3	3.333 (0.068)	4.626 (0.031)
	Male	4	8	13		
	N/A	1	-	-		
Age	22-32	10	9	12	-	-
	N/A	1	1	4		
Class Year	Master	All	All	All	-	-

6.3. Reliability of Survey

Internal consistency was assessed according to Cronbach's alpha to check for reliably of survey items to measure the same construct they are designed for. Table 29 and Table 30 show the Cronbach's alpha values and number of items per each construct for flipped and lecture-based classes. The Cronbach's alpha value for most of the constructs was greater than or equal to 0.7, the minimum accepted alpha value. For learning presence, the value in the lecture-based classes (Cal_UG_LB_GIII) and (Eng_UG_LB_D) were 0.6486 and 0.5862, which is considered to be questionable to poor. However, given that the LP items are adopted from COI framework which has proven reliability, in addition that alpha values for all other eight groups were greater than 0.7, then these poor values can be ignored and might be affected by some random responses by students. For the study load construct, Cronbach's alpha value for undergraduate mathematics flipped class (Cal_UG_Flip_GI) is 0.6753, which is accepted as it is almost equal to 0.7. The value for the undergraduate engineering flipped class (Eng_UG_Flip_GI) is 0.5603, which is considered to be poor. Omitting item SL1 for this factor in this group, increases the internal reliability to 0.7407, therefore this will be taken into consideration in the analysis. However, given that for other three flipped classes, the Cronbach's alpha value of study load construct was greater or almost equal to 0.7, then we can safely verify the reliability of the construct. Thus, as per the above discussion, internal reliability for each construct is verified for flipped and lecture-based classes.

Table 29: Reliability of survey constructs - Flipped classes

Construct	**No. of Items**	**Cal_UG_Flip_GI**		**Eng_UG_Flip_GI**		**Eng_G_Flip_A**		**Eng_G_Flip_GI**	
		N	*Alpha*	*N*	*Alpha*	*N*	*Alpha*	*N*	*Alpha*
TP	10	53	0.9172	44	0.9201	11	0.7387	37	0.8741
SP	6	53	0.7658	44	0.8904	11	0.8523	37	0.7838
CP	9	53	0.8918	44	0.9206	11	0.7374	37	0.8777
LP	7	53	0.7104	44	0.6917	11	0.7696	37	0.7037
In-class	7	52	0.8803	44	0.9151	11	0.7376	37	0.8398
Study load	3	52	0.6753	43	0.5603	11	0.7680	37	0.8334

Table 30: Reliability of survey constructs - lecture-based classes

Construct	**No. of Items**	**Cal_UG_LB_GII**		**Cal_UG_LB_GIII**		**Eng_UG_LB_C**		**Eng_UG_LB_D**		**Eng_G_LB_D**		**Eng_G_LB_E**	
		N	*Alpha*	*N*	*Alpha*	*N*	*Alpha*	*N*	*Alpha*	*N*	*Alpha*	*N*	*Alpha*
TP	10	49	0.9008	37	0.8529	23	0.9334	24	0.9497	10	0.8162	16	0.7922
SP	6	49	0.8190	37	0.9102	23	0.8997	24	0.7957	10	0.8322	16	0.9706
CP	9	49	0.7995	36	0.7874	23	0.9153	24	0.8933	10	0.9074	16	0.8670
LP	7	49	0.7173	36	0.6486	23	0.8224	24	0.5862	10	0.8218	16	0.7678

6.4. Preparation – Lecture-based classes

Students in the lecture-based classes were asked if they had prepared for the surveyed course as instructors usually provide the students with a pre-class reading material and encourage them students to prepare without it being mandatory. Thus, we checked for the pre-class preparation to see if we need to consider it in our analysis. The item asked was Study4: "For this class, I usually prepared.", where students selected one of the following choices, "As early as possible after the class time", "As early as possible before the class time", or "Only few days before the midterm or quiz". 16.28% of students in the mathematics undergraduate classes reported doing the pre-class preparation as presented in Figure 5. The percentage was 10.64% in the engineering undergraduate classes as shown in Figure 6, and 30.77% in the engineering graduate classes as shown in Figure 7. Those percentages do not raise any concern in our comparisons to the flipped classes as they do not represent majority.

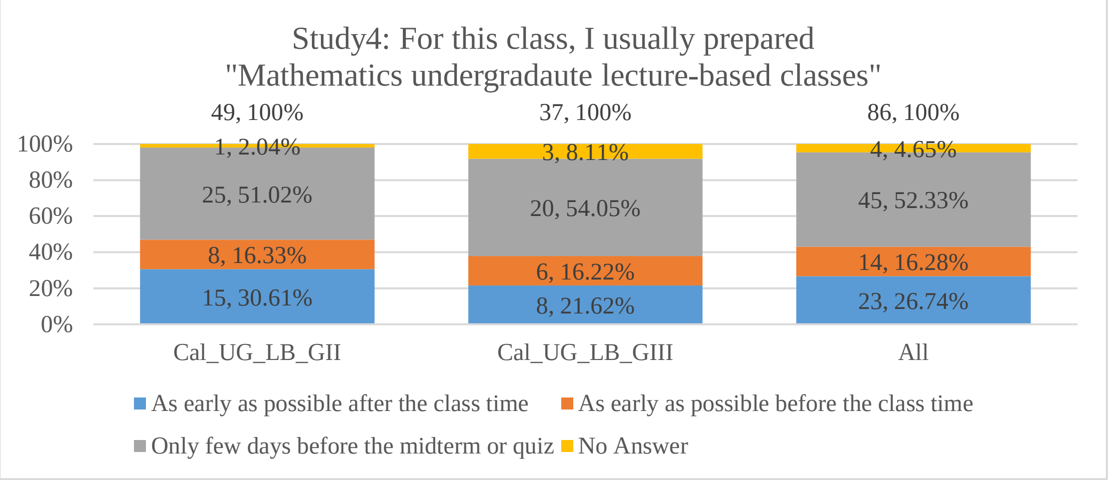

Figure 5: Students' responses for preparation time (Study4) – Mathematics undergraduate lecture-based classes

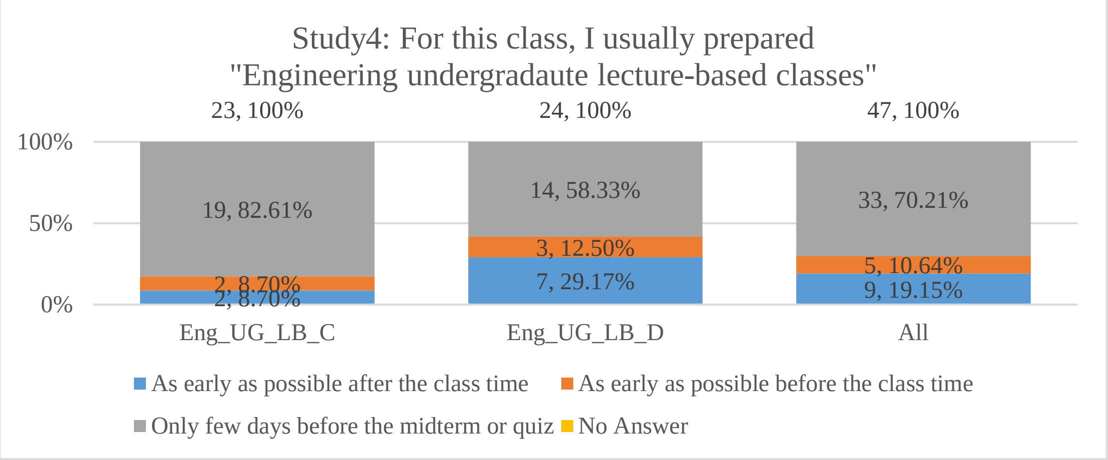

Figure 6: Students' responses for preparation time (Study4) – Engineering undergraduate lecture-based classes

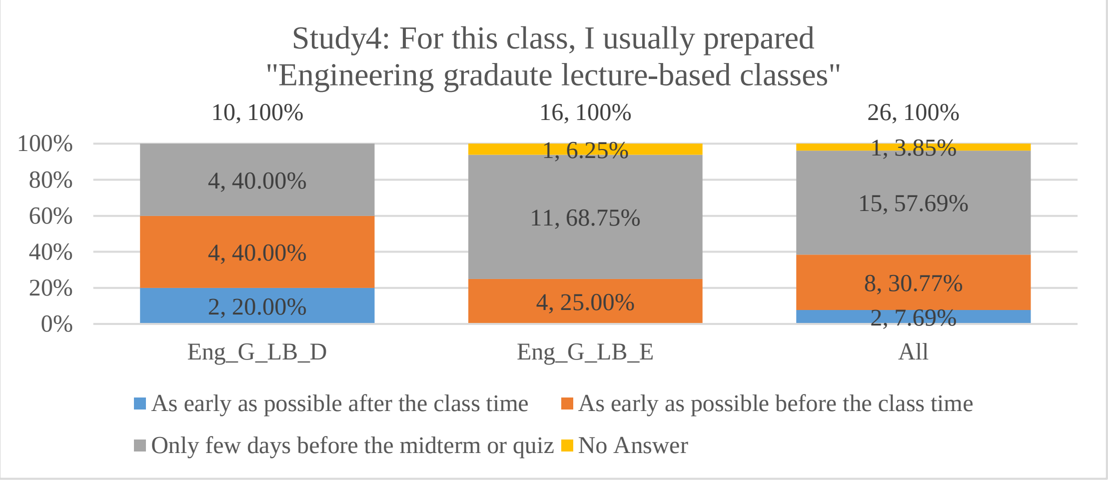

Figure 7: Students' responses for preparation time (Study4) – Engineering graduate lecture-based classes

6.5. Survey Analysis – Flipped classes

6.5.1. RCOI constructs. Overall, students' perceptions of the flipped class experience were positive for both undergraduate and graduate flipped classes according to their responses to RCOI constructs as shown in Table 31.

In the undergraduate mathematics classes Cal_UG_Flip_GI, teaching presence had the highest level of satisfaction (Mean: 4.63 out of 5, Median: 4.90 out of 5), followed by cognitive presence (4.00, 4.11), learning presence (4.00, 4.00) and finally social presence (3.75, 3.83). In the undergraduate engineering classes Eng_UG_Flip_GI, social presence had the highest level of satisfaction (3.996, 4.00), followed by learning presence (3.92, 4.00), teaching presence (3.76, 3.80) and finally cognitive presence (3.65, 3.78). While in all our graduate engineering classes Eng_G_Flip_A and Eng_G_Flip_GI, the highest level of satisfaction was for teaching presence followed by cognitive presence, social presence and finally learning presence.

Table 31: Descriptive statistics of RCOI in flipped classes

Construct	Cal_UG_Flip_GI			Eng_UG_Flip_GI			Eng_G_Flip_A			Eng_G_Flip_GI		
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*
TP	53	4.63 ± 0.47	4.90	44	3.76 ± 0.76	3.80	11	4.06 ± 0.41	4.00	37	4.49 ± 0.39	4.50
SP	53	3.75 ± 0.73	3.83	44	3.996 ± 0.72	4.00	11	3.83 ± 0.60	4.00	37	4.16 ± 0.52	4.17
CP	53	4.00 ± 0.72	4.11	44	3.65 ± 0.78	3.78	11	3.91 ± 0.42	3.89	37	4.32 ± 0.52	4.22
LP	53	4.00 ± 0.56	4.00	44	3.92 ± 0.50	4.00	11	3.64 ± 0.65	3.43	37	4.02 ± 0.51	4.00

The presences of RCOI constructs were statistically compared between the two flipped groups of the undergraduate level, mathematics (Cal_UG_Flip_GI) and engineering (Eng_UG_Flip_GI) using two independent samples t-test and Mann-Whitney U test. Similarly, the RCOI presences were compared between the technical graduate class (Eng_G_Flip_A) and the conceptual graduate group (Eng_G_Flip_GI).

The test results for the normality assumption are shown in Table 32. Normality was validated for LP in all the flipped classes. TP normality was violated in classes Cal_UG_Flip_GI and Eng_G_Flip_GI. SP normality was violated in class Eng_G_Flip_A. Finally, CP normality was violated in group Eng_G_Flip_GI. Table 33 verifies the equality of variances between the undergraduate flipped classes for SP, CP and LP, but not for TP according to Levene's test. Thus, for TP, the results of the non-parametric Mann-Whitney U test will be considered for the analysis. For graduate classes, equality of variances is verified for all RCOI constructs.

Table 32: Normality test results of RCOI for flipped classes

Construct	Cal_UG_Flip_G I	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
TP	Not Normal ($p < 0.005$)*	Normal ($p = 0.081$)	Normal ($p = 0.08$)	Not normal ($p < 0.005$)*
SP	Normal ($p = 0.207$)	Normal ($p = 0.101$)	Not Normal ($p = 0.014$)*	Normal ($p = 0.328$)
CP	Normal ($p = 0.09$)	Normal ($p = 0.421$)	Normal ($p = 0.382$)	Not normal ($p = 0.042$)*
LP	Normal ($p = 0.282$)	Normal ($p = 0.052$)	Normal ($p = 0.137$)	Normal ($p = 0.810$)

* $p < 0.05$

Table 33: RCOI Levene's test results between compared flipped classes

Construct	***p*-value** **Cal_UG_Flip_GI & Eng_UG_Flip_GI**	***p*-value** **Eng_G_Flip_A & Eng_G_Flip_GI**
TP	0.007*	0.780
SP	0.922	0.623
CP	0.596	0.470
LP	0.387	0.263

* $p < 0.05$

As presented in Table 34, according to the parametric two independent samples t-test, teaching and cognitive presences were statistically significantly higher in the undergraduate mathematics flipped classes Cal_UG_Flip_GI (TP: 4.63 ± 0.47, CP: 4.00 ± 0.72) in compare to the undergraduate engineering flipped ones Eng_UG_Flip_GI (TP: 3.76 ± 0.76, CP: 3.65 ± 0.78), with *p* values of (TP: 0.000, CP: 0.025), and 95% confidence intervals for mean difference as (TP: 0.62 - 1.14, CP: 0.04 - 0.65). Similarly, the non-parametric Mann-Whitney U test shows that teaching and cognitive presences were statistically significantly higher in the undergraduate mathematics flipped classes Cal_UG_Flip_GI (TP: 4.90, CP: 4.11) in compare to the undergraduate engineering flipped ones Eng_UG_Flip_GI (TP: 3.80, CP: 3.78), with *p* values of (TP: 0.000, CP: 0.022), and 95% confidence intervals for median difference as (TP: 0.7 - 1.1, CP: 0.00

- 0.67). Despite that students in the undergraduate mathematics flipped classes were mostly freshmen, while students in the undergraduate engineering flipped ones were mostly juniors. On the other hand, social and learning presences showed no significant difference.

Table 34: RCOI 2 independent samples t-test and Mann-Whitney U test between undergraduate flipped classes

Construct	***t (p)*** **95% CI** **Cal_UG_Flip_GI &** **Eng_UG_Flip_GI**	**W (*p*)** **95%CI** **Cal_UG_Flip_GI &** **Eng_UG_Flip_GI**
TP	6.70 (0.000)* (0.62, 1.14)	3379.50 (0.000)* (0.7 1.10)
SP	-1.68 (0.096) (-0.54, 0.05)	2374.000 (0.105) (-0.50, -0.00)
CP	2.27 (0.025)* (0.04, 0.65)	2914.00 (0.022)* (0.00, 0.67)
LP	0.68 (0.496) (-0.14, 0.29)	2670.00 (0.598) (-0.14, 0.29)

* $p < 0.05$

Comparing the technical graduate class Eng_G_Flip_A and the conceptual graduate classes Eng_G_Flip_GI as presented in Table 35. According to the parametric two independent samples t-test, teaching and cognitive presences were significantly higher in the conceptual graduate classes Eng_G_Flip_GI (TP: 4.49 ± 0.39, CP: 4.32 ± 0.52) in compare to the technical graduate class Eng_G_Flip_A (TP: 4.06 ± 0.41, CP: 3.91 ± 0.42), with *p* values of (TP: 0.002, CP: 0.021), and 95% confidence intervals for mean difference as (TP: 0.17 - 0.7, CP: 0.07, 0.76).

Similarly, the non-parametric Mann-Whitney U test showed that teaching and cognitive presences were statistically significantly higher in the conceptual graduate classes Eng_G_Flip_GI (TP: 4.50, CP: 4.22) in compare to the technical graduate class Eng_G_Flip_A (TP: 4.00, CP: 3.89), with *p* values of (TP: 0.005, CP: 0.012), and 95% confidence intervals for median difference as (TP: 0.1 - 0.8, CP: 0.11 - 0.89).

Learning presence was slightly significantly higher in the conceptual graduate classes as well with *p*-value of 0.045 and 0.060 according to both parametric and non-parametric tests. Social presence did not show a significant difference.

Table 35: RCOI 2 independent samples t-test and Mann-Whitney U test between graduate flipped classes

Construct	*t* (*p*) 95% CI Eng_G_Flip_A & Eng_G_Flip_GI	W (*p*) 95% CI Eng_G_Flip_A & Eng_G_Flip_GI
TP	-3.25 (0.002)* (-0.71, -0.17)	155.50 (0.005)* (-0.8, -0.1)
SP	-1.76 (0.085) (-0.696, 0.05)	207.00 (0.123) (-0.67, 0.00)
CP	-2.40 (0.021)* (-0.76, -0.07)	166.50 (0.012)* (-0.89, -0.11)
LP	-2.06 (0.045) (-0.76, -0.01)	192.50 (0.060) (-0.86, 0.00)

* $p < 0.05$

Following the comparison of the reported learning experience within each study level, undergraduate and graduate, the data were grouped as per the course nature and the use of pre-class video to check for differences in the learning experience.

Thus, our data resulted in three groups. The first is “Technical-Video” group which involved classes of technical course nature with pre-class video provided, that is the undergraduate mathematics classes “Cal_UG_Flip_GI”. The second is “Technical” group which involved classes of technical course nature without providing a pre-class video component. This group covers the undergraduate engineering classes “Eng_UG_Flip_GI” and the graduate technical class “Eng_G_Flip_A”. The data for this group was checked for validity of merge as shown in Table 36, as no significant difference was found for all RCOI constructs according to both the parametric two independent samples t-test and the non-parametric Mann-Whitney U test. The third is “Conceptual” group which involved classes of conceptual course nature without providing a pre-class video component, that is the graduate conceptual classes “Eng_G_Flip_GI”.

Table 37 shows the descriptive statistics for responses to RCOI constructs in the flipped classes grouped as per the course nature and the use of pre-class video.

Table 36: RCOI Levene's test results, 2 independent samples t-test, and Mann-Whitney U test between technical flipped classes

Construct	*p*-value (Leven's test) Eng_UG_Flip_GI & Eng_G_A	*t (p)* Eng_UG_Flip_GI & Eng_G_A	W (*p*) Eng_UG_Flip_GI & Eng_G_A
TP	0.072	-1.25 (0.218)	1168.00 (0.180)
SP	0.586	0.69 (0.490)	1263.50 (0.509)
CP	0.076	-1.04 (0.305)	1187.00 (0.348)
LP	0.280	1.64 (0.107)	1303.50 (0.134)

Table 37: Descriptive statistics of RCOI in flipped classes after grouping as per course nature and the use of pre-class video

Construct	Technical-Video Cal_UG_Flip_GI			Technical Eng_UG_Flip_GI & Eng_G_Flip_A			Conceptual Eng_G_Flip_GI		
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*
TP	53	4.63 ± 0.47	4.90	55	3.82 ± 0.71	3.90	37	4.49 ± 0.39	4.50
SP	53	3.75 ± 0.73	3.83	55	3.96 ± 0.69	4.00	37	4.16 ± 0.52	4.17
CP	53	4.00 ± 0.72	4.11	55	3.71 ± 0.73	3.78	37	4.32 ± 0.52	4.22
LP	53	4.00 ± 0.56	4.00	55	3.87 ± 0.54	4.00	37	4.02 ± 0.51	4.00

The reported learning experience is compared across the three groups using One-Way ANOVA and Kruskal Wallis tests. Normality test results for "Technical-Video" group and "Conceptual" group can be viewed in Table 32 as they represent classes "Cal_UG_Flip_GI" and "Eng_G_Flip_GI" sequentially. For the "Technical" group, normality was verified for CP (p = 0.131) and LP (p = 0.177), but not for TP (p = 0.008) and SP (p = 0.014). Equality of variances is violated in TP (p = 0.012), while verified for SP (p = 0.119), CP (p = 0.117), and LP (p = 0.791) according to Levene's test.

Table 38 shows the comparison results. There was a significant difference across the compared flipped groups in terms of teaching (p = 0.000), social (p = 0.017, p = 0.022) and cognitive (p = 0.000) presences, while learning presence did not show any significant difference (p = 0.310, p = 0.438).

Table 38: RCOI One-way ANOVA and Kruskal Wallis tests between the flipped classes after grouping as per course nature and the use of pre-class video

Construct	*F* (*p*-value)	*H* (*p*-value)
TP	26.00 (0.000)*	44.08 (0.000)*
SP	4.19 (0.017)*	7.67 (0.022)*
CP	9.22 (0.000)*	17.96 (0.000)*
LP	1.18 (0.310)	1.65 (0.438)

*$p < 0.05$

To identify the groups that are significantly different from each other, post hoc test analysis was conducted involving both parametric Games-Howell and Fisher tests, in addition to the non-parametric Kruskal Wallis Multiple Comparison.

As shown in Table 39, according to the parametric post hoc tests analysis, Games-Howell and Fisher tests, teaching presence was significantly higher in the flipped classes of "Technical-Video" (p = 0.000) and "Conceptual" (p = 0.000) groups, compared to the "Technical" group. The reported mean values were 4.63 ± 0.47, 4.49 ± 0.39 and 3.82 ± 0.71 sequentially. The 95% confidence interval for mean differences between the "Technical" and and "Technical-Video" groups was 0.55 to 1.10, while it was 0.40 to 0.95 between the "Technical" and "Conceptual" groups. Figure 8 illustrates the differences of means for TP across the three flipped groups.

Cognitive presence was significantly higher in the "Conceptual" group in comparison to both the "Technical-Video" group (p = 0.029, 95% CI: 0.03 – 0.61), and "Technical" group (p = 0.000, 95% CI: 0.33 – 0.91). Furthermore, cognitive presence was significantly higher in "Technical-Video" group in comparison to "Technical" group (p = 0.025, 95% CI: 0.04 – 0.56). The mean values for the groups were, "Conceptual": 4.32 ± 0.52, "Technical-Video": 4.00 ± 0.72, "Technical": 3.71 ± 0.73. Figure 9 illustrates the differences of means for CP across the three flipped groups.

Social presence was significantly higher in the "Conceptual" group with a mean value of 4.16 ± 0.52 in comparison to "Technical-Video" group with a mean value of 3.75 ± 0.73 (p = 0.005, 95% CI: 0.13 – 0.69).

Table 39: RCOI Games-Howell and Fisher post-hoc tests results between the flipped classes after grouping as per course nature and the use of pre-class video

Group	**TP Games-Howell t (*p*)**	**SP Fisher t (*p*)**	**CP Fisher t (*p*)**	**LP Fisher t (*p*)**
Technical - Conceptual	-5.88 (0.000)* (-0.95, -0.40)	-1.37 (0.173) (-0.47, 0.09)	-4.27 (0.000)* (-0.91, -0.33)	-1.33 (0.184) (-0.38, 0.07)
Technical-Video – Conceptual	1.58 (0.259) (-0.07, 0.36)	-2.87 (0.005)* (-0.69, -0.13)	-2.21 (0.029)* (-0.61, -0.03)	-0.18 (0.860) (-0.25, 0.21)
Technical-Video - Technical	7.12 (0.000)* (0.55, 1.10)	-1.68 (0.096) (-0.47, 0.04)	2.26 (0.025)* (0.04, 0.56)	1.28 (0.204) (-0.07, 0.34)

*$p < 0.05$

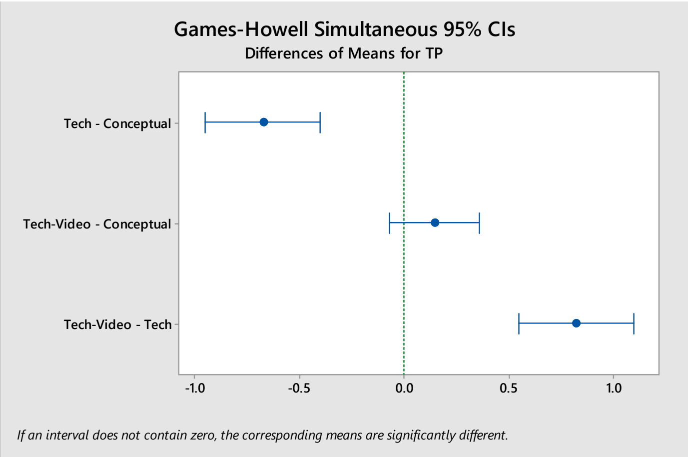

Figure 8: Games-Howell test results for 95% CI differences of means for TP between the flipped classes after grouping as per course nature and the use of pre-class video.

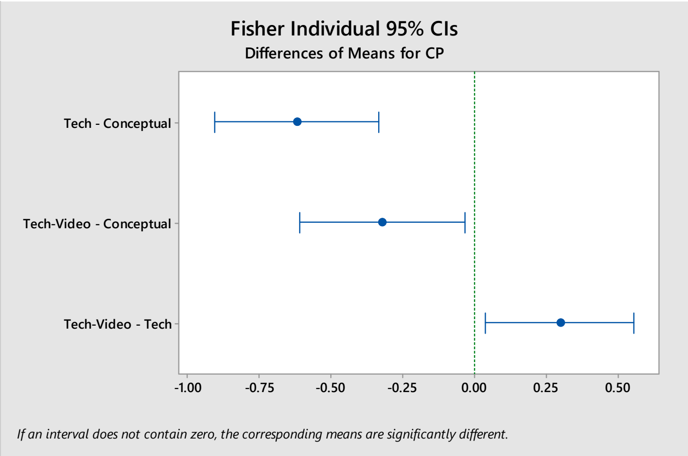

Figure 9: Fisher test results for 95% CI differences of means for CP between the flipped classes after grouping as per course nature and the use of pre-class video.

The non-parametric post hoc tests analysis, Kruskal Wallis Multiple Comparison, presented in Table 40, gives similar results to the parametric ones. Teaching presence was significantly higher in the flipped classes of “Technical-Video” (*p* = 0.000) and “Conceptual” (*p* = 0.000) groups in comparison to the “Technical” group. The reported median values were 4.90, 4.50 and 3.90 sequentially. The 80.53% confidence interval for median differences between the “Technical” and “Technical-Video” groups was 0.73 to 1.2, while it 0.31 to 0.9 between the “Technical” and “Conceptual” groups. Figure 10 illustrates the Kruskal Wallis Multiple Comparison test results for TP across the three flipped groups.

Cognitive presence was significantly higher in the “Conceptual” group in comparison to both the “Technical-Video” group (*p* = 0.034, 80.53% CI: 0 – 0.44), and “Technical” group (*p* = 0.000, 80.53% CI: 0.33 – 0.77). Furthermore, cognitive presence was significantly higher in “Technical-Video” group in comparison to “Technical” group (*p* = 0.022, 80.53% CI: 0.11 – 0.55). The median values of CP for the groups were, “Conceptual”: 4.22, “Technical-Video”: 4.11, “Technical”: 3.78. Figure 11 illustrates the Kruskal Wallis Multiple Comparison test results for CP across the three flipped groups.

Social presence was also significantly higher in the “Conceptual” group with a median value of 4.17 in comparison to the “Technical-Video” group with a median value of 3.83 (*p* = 0.006, 80.53% CI: 0 – 0.66).

Table 40: RCOI Kruskal Wallis Multiple Comparison test results between the flipped classes after grouping as per course nature and the use of pre-class video

Construct	TP Z (*p*)	SP Z (*p*)	CP Z (*p*)	LP Z (*p*)
Technical - Conceptual	4.42 (0.000)* (-0.9, -0.31)	1.35 (0.177) (-0.33, 0)	4.21 (0.000)* (-0.77, -0.33)	1.12 (0.265) (-0.29, 0.13)
Technical-Video – Conceptual	1.37 (0.172) (0.03, 0.69)	2.75 (0.006)* (-0.66, 0)	2.13 (0.034)* (-0.44, 0)	0.15 (0.881) (-0.28, 0.28)
Technical-Video - Technical	6.40 (0.000)* (0.73, 1.2)	1.57 (0.118) (-0.33, 0)	2.29 (0.022)* (0.11, 0.55)	1.07 (0.287) (-0.14, 0.29)

$*p < 0.05$

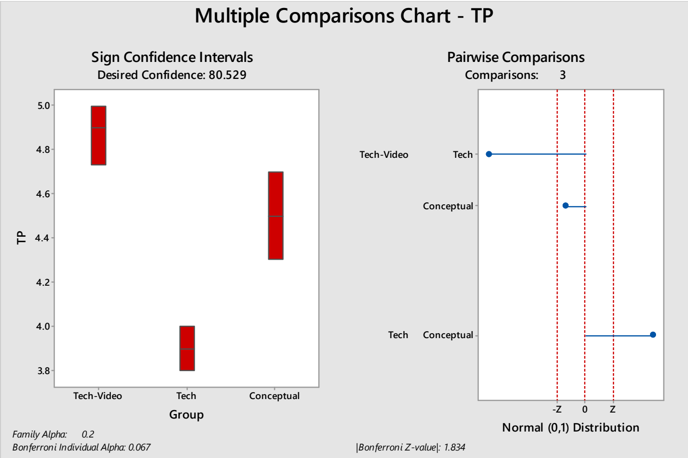

Figure 10: Kruskal Wallis Multiple Comparison test results showing 80.53% CI for median values of TP between the flipped classes after grouping as per course nature and the use of pre-class video.

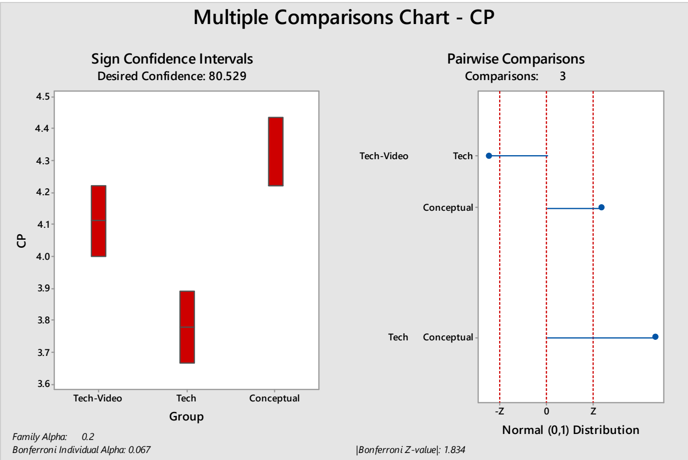

Figure 11: Kruskal Wallis Multiple Comparison test results showing 80.53% CI for median values of CP between the flipped classes after grouping as per course nature and the use of pre-class video.

To get a better understanding of students’ responses to the RCOI constructs, we determined the satisfaction rate for each individual item asked in the survey. The satisfaction rate is considered to be the percentage of the positive responses, strongly agree and agree. According to our data, we set up a threshold value at 60%, where we considered that lower satisfaction rates are relatively low and need attention for future deployment of the flipped method.

Table 41 shows the satisfaction rates for teaching presence items in all flipped classes. Students in all the flipped classes reported that their instructors had properly communicated the course topics and goals, and encouraged them to participate in discussions and to explore new concepts in the course (satisfaction rate is ≥ 72.73% to the items TP1, TP2, TP7). However, students in the engineering undergraduate classes (Eng_UG_Flip_GI) show the need for clearer communication of important due dates/time frames for learning activities (satisfaction rate is 43.18% to the item TP4), in addition to more instructor guidance in the class toward understanding the course topics (satisfaction rate is 52.27% to the item TP5). Further, they highly sought feedback to help them toward a better understanding of the course (satisfaction rate is 34.09% to the item TP10). Engineering graduate students in class (Eng_G_Flip_A) showed a little need for clearer instructions on how to participate in the in-class activities (satisfaction rate is 54.54% to the item TP3). The teaching presence was highly acknowledged in the mathematics undergraduate classes (Cal_UG_Flip_GI) and engineering graduate classes of a conceptual nature (Eng_G_Flip_GI), as positive responses were ≥ 86.48% for all teaching presence items.

Table 41: Satisfaction rates (Top 2 boxes score) of TP items for flipped classes

TP Item	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
TP1	53 100%	33 75.00%	8 72.72%	37 100%
TP2	52 98.11%	37 84.09%	10 90.91%	36 97.3%
TP3	50 94.33%	32 72.73%	6 54.54%*	36 97.3%
TP4	51 96.23%	19 43.18%*	9 81.81%	36 97.29%
TP5	50 94.34%	23 52.27%*	9 81.82%	36 97.3%
TP6	48 90.56%	33 75.00%	10 90.91%	37 100%
TP7	47 88.68%	40 90.91%	9 81.81%	36 97.29%
TP8	49 92.45%	29 65.91%	10 90.91%	32 86.48%
TP9	49 92.45%	31 70.45%	10 90.91%	36 97.29%
TP10	48 90.56%	15 34.09%*	9 81.81%	35 94.6%

* Percentage < 60%

Table 42 shows the satisfaction rates for social presence items in all the flipped classes. Students in all the engineering classes, both undergraduate and graduate reported that the flipped class promoted open communication, interaction, cohesion and a sense of belonging in the course, as positive responses were ≥ 63.63% for all social presence items. However, students in the mathematics undergraduate classes felt the need to improve upon the creation of a collaborative cohesion learning environment, so that students will have a stronger feeling of belonging to the course (satisfaction rate is 56.61% to the item of SP1), will be able to form better impressions about each other's (satisfaction rate is 52.83% to the item of SP2), and feel comfortable to disagree with each other's (satisfaction rate is 50.95% to the item of SP5).

Table 42: Satisfaction rates (Top 2 boxes score) of SP items for flipped classes

SP Item	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
SP1	30 56.61%*	33 75.00%	8 72.73%	28 75.67%
SP2	28 52.83%*	36 81.82%	8 72.73%	30 81.08%
SP3	45 84.9%	30 68.18%	9 81.82%	32 86.48%
SP4	41 77.36%	38 86.37%	9 81.81%	34 91.9%
SP5	27 50.95%*	32 72.73%	7 63.63%	33 89.19%
SP6	33 62.26%	31 70.46%	7 63.64%	31 83.79%

* Percentage < 60%

Table 43 shows the satisfaction rates for cognitive presence items in all the flipped classes. Students in all classes agreed that in-class discussions and reflections had helped them in the understanding of the fundamental concepts (satisfaction rates ≥ 70.46% to the item of CP7 in all classes). Students in the mathematics undergraduate classes (Cal_UG_Flip_GI) and in the engineering graduate conceptual classes (Eng_G_Flip_GI) highly reported on the usefulness of learning activities in constructing solutions and explanations (satisfaction rates ≥ 84.91% to the item of CP6). The usefulness of the in-class learning activities was reported to a lesser degree in the engineering graduate technical class (Eng_G_Flip_A) with satisfaction rate as 64%. However, the satisfaction rates of cognitive presence were relatively low in the engineering undergraduate classes (Eng_UG_Flip_GI) (52.27% - 70.46%). Engineering undergraduate students in our study had a need to have in-class activities that will increase their interest in the course (satisfaction rate is 52.27% to the item CP1) and help them more in constructing solutions (satisfaction rate is 56.81% to the item CP6). Furthermore, students in the engineering graduate technical class (Eng_G_Flip_A) reported lower satisfaction rates (54.55% - 100%) in comparison to those in the engineering graduate conceptual classes (Eng_G_Flip_GI) (72.97% - 94.59%). Students in the engineering graduate technical class (Eng_G_Flip_A) reported relatively low on ability to apply what was learned in a broader area (satisfaction rate is 54.55% to the item CP9). However, that maybe because of the nature of the course rather than the in-class activities, as the course is somehow different from the program theme as it is more about financial investments where all students are engineers and did not take a financial course previously.

Table 43: Satisfaction rates (Top 2 boxes score) of CP items for flipped classes

CP Item	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
CP1	38 71.7%	23 52.27%*	9 81.82%	33 89.19%
CP2	33 62.26%	27 61.36%	9 81.82%	31 83.78%
CP3	38 71.7%	26 59.09%*	8 72.72%	27 72.97%
CP4	38 71.7%	28 63.63%	7 63.63%	32 86.49%
CP5	44 83.02%	28 63.63%	10 90.91%	32 86.49%
CP6	45 84.91%	25 56.81%*	7 63.63%	35 94.59%
CP7	40 75.48%	31 70.46%	11 100%	35 94.59%
CP8	33 62.27%	28 63.64%	8 72.73%	32 86.49%
CP9	36 67.92%	28 63.63%	6 54.55%*	33 89.19%

* Percentage < 60%

Table 44 shows the satisfaction rates for learning presence items in all flipped classes. The satisfaction rates were relatively low in the engineering graduate technical class (Eng_G_Flip_A) (27.27% - 81.82%). Students had a slight need to advance evaluating their learning (satisfaction rate is 54.54% to the item LP2), adapting to the course structure needs (satisfaction rate is 54.54% to the item LP3) and self-identifying what is needed to be done to learn (satisfaction rate is 54.54% to the item LP6). Students also showed a great need to advance goal settings to direct their learning (satisfaction rate is 27.27% to the item LP1). However, this very low satisfaction maybe again reasoned that the nature of the course is different from the students' backgrounds, as it is a financial course while they are all from an engineering background. On the other hand, mathematics undergraduate students (Cal_UG_Flip_GI), engineering undergraduate students (Eng_UG_Flip_GI), and students in the graduate conceptual courses (Eng_G_Flip_GI) showed a better self-regulation of their learning, as positive responses were ≥ 60% for all learning presence items.

Table 44: Satisfaction rates (Top 2 boxes score) of LP items for flipped classes

LP Item	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
LP1	39 73.58%	31 70.45%	3 27.27%*	22 59.46%*
LP2	33 62.26%	35 79.55%	6 54.54%*	28 75.67%
LP3	41 77.36%	38 86.36%	6 54.54%*	27 72.98%
LP4	38 71.7%	38 86.36%	9 81.82%	33 89.19%
LP5	39 73.59%	29 65.91%	8 72.72%	34 91.89%
LP6	36 67.93%	32 72.72%	6 54.54%*	27 72.98%
LP7	43 81.13%	39 88.63%	8 72.72%	31 83.78%

* Percentage < 60%

To examine the association among RCOI constructs, Spearman's correlation coefficient analyses were conducted for all the flipped classes as shown in Table 45 - Table 48. The Spearman's correlation coefficient measures the extent to which two variables tend to change together in a linear or monotonic relationship. The correlation values were significant between the four constructs of RCOI (TP, SP, CP and LP) for all the flipped classes ranging from 0.161 to 0.707, except for the engineering graduate technical class (Eng_G_Flip_A), where all correlation values were insignificant. This can be attributed to the small sample size of 11 students. However, for the other flipped classes of Cal_UG_Flip_GI, Eng_UG_Flip_GI and Eng_G_Flip_GI, cognitive presence was at the heart of the strongest correlations with the other constructs of teaching, social and learning presences, with correlation values ranging from 0.528 to 0.707, and p-value < 0.01.

Table 45: Spearman correlation coefficient among RCOI constructs: Cal_UG_Flip_GI

RCOI Construct	TP	SP	CP	LP
TP	1	0.311*	0.664**	0.505**
SP		1	0.590**	0.349*
CP			1	0.543**
LP				1

* $p < 0.05$; ** $p < 0.001$

Table 46: Spearman correlation coefficient among RCOI constructs: Eng_UG_Flip_GI

RCOI Construct	TP	SP	CP	LP
TP	1	0.464*	0.691**	0.420*
SP		1	0.707**	0.456*
CP			1	0.586**
LP				1

* $p < 0.01$, ** $p < 0.001$

Table 47: Spearman correlation coefficient among RCOI constructs: Eng_G_Flip_A

RCOI Construct	TP	SP	CP	LP
TP	1	-0.179	-0.125	0.159
SP		1	0.342	-0.346
CP			1	-0.049
LP				1

Table 48: Spearman correlation coefficient among RCOI constructs: Eng_G_Flip_GI

RCOI Construct	TP	SP	CP	LP
TP	1	0.521**	0.633***	0.333*
SP		1	0.528**	0.161*
CP			1	0.588***
LP				1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.5.2. In-Class understanding and participation construct. Seven self-report questions were asked to students in the flipped classes to check the impact of enforcing the pre-class preparation on students' in-class understanding and participation. Furthermore, students were asked to explain their selection regarding their self-report for confidence level about asking questions during the class. Table 49 shows the questions asked to the flipped classes regarding the in-class understanding and participation construct.

Table 49: Items of In-class understanding and participation construct – flipped classes

Item code	Item
In-class1	**38.** The pre-class preparation helps me better understand the course materials in compare to other courses.
In-class2	**39.** The pre-class preparation makes me more engaged and less bored in the class time in compare to other courses.
In-class3	**40.** The pre-class preparation inspired me to ask more deep questions about this course in compare to other courses.
In-class4	**41.** I felt the flipped methodology helps me develop the knowledge of the course material gradually in a better way in comparison with lecture-based methodology.
In-class5	**42.** The pre-class preparation helps me better participate and ask questions at the class in compare to my participation in other courses?
In-class6	**43.** At the class time, I feel confident asking questions about the lecture topic. Please explain briefly your selection.
In-class7	**44.** Generally, at the end of the class, you feel you have understood everything

Students overall agreed about the usefulness of pre-class study in enhancing the in-class understanding and participation in both undergraduate and graduate flipped classes as shown in Table 50. The highest satisfaction was reported by students in the engineering graduate conceptual classes (Eng_G_Flip_GI) with values of (mean: 4.34 out of 5, median: 4.43 out of 5), followed by mathematics undergraduate classes (Cal_UG_Flip_GI) with values of (4.25, 4.5), then the engineering graduate technical class (Eng_G_Flip_A) with values of (3.86, 3.86), and finally the least satisfaction was reported by students in the engineering undergraduate classes (Eng_UG_Flip_GI), with values of (3.39, 3.43).

Table 50: Descriptive statistics of In-class construct in flipped classes

Construct	**Cal_UG_Flip_GI**			**Eng_UG_Flip_GI**			**Eng_G_Flip_A**			**Eng_G_Flip_GI**		
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*
In-class	52	4.25 ±0.74	4.50	44	3.39 ±0.99	3.43	11	3.86 ±0.16	3.86	37	4.34 ±0.51	4.43

The reported satisfaction for the In-class construct was statistically compared between the two flipped groups of the undergraduate level, mathematics (Cal_UG_Flip_GI) and engineering (Eng_UG_Flip_GI) using two independent samples t-test and Mann-Whitney U test. Similarly, the comparison was checked between the technical graduate class (Eng_G_Flip_A) and the conceptual graduate group (Eng_G_Flip_GI). Assumption test for normality is shown in Table 51. Normality was validated for (Eng_UG_Flip_GI) and (Eng_G_Flip_A), but not for (Cal_UG_Flip_GI) and (Eng_G_Flip_GI).

Table 51: Normality test results of In-class construct in flipped classes

Construct	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
In-Class	Not Normal (p<0.005)*	Normal (p = 0.272)	Normal p = 0.384)	Not Normal (p = 0.011)*

* $p < 0.05$

As presented in Table 52, equality of variance was validated for the comparison between the undergraduate classes with *p*-value of 0.052. According to the parametric two independent samples t-test, satisfaction regarding the In-class construct, usefulness of pre-class preparation for students' in-class understanding and participation, was statistically significantly higher in the undergraduate mathematics flipped classes (4.25 ± 0.74) in compare to the undergraduate engineering flipped ones (3.39 ± 0.99), with *p*-value of 0.000, and 95% confidence intervals for mean difference as (0.51 - 1.21). Similarly, the non-parametric Mann-Whitney U test showed that the satisfaction regarding the In-class construct was statistically significantly higher in the undergraduate mathematics flipped classes (4.50) in comparison to the undergraduate engineering flipped ones (3.43), with *p*-value of 0.000, and 95% confidence intervals for median difference as (0.43 - 1.14).

Table 52: In-class Levene's test results, 2 independent samples t-test, and Mann-Whitney U test between undergraduate flipped classes

Construct	***p*-value (Leven's test)** **Cal_UG_Flip_GI &** **Eng_UG_Flip_GI**	***t (p)*** **95% CI** **Cal_UG_Flip_GI &** **Eng_UG_Flip_GI**	**W (*p*)** **95% CI** **Cal_UG_Flip_GI &** **Eng_UG_Flip_GI**
In-class	0.052	4.87 (0.000)* (0.51, 1.21)	3114.00 (0.000)* (0.43, 1.14)

* $p < 0.05$

Comparing the technical graduate class (Eng_G_Flip_A) and the conceptual graduate classes (Eng_G_Flip_GI) as presented in Table 53, equality of variance was validated with *p*-value of 0.957. According to the parametric two independent samples t-test, the satisfaction for the In-class construct was statistically significantly higher in the conceptual graduate classes (4.34 ± 0.51) in comparison to the technical graduate class (3.86 ± 0.16), with *p*-value of 0.008, and 95% confidence intervals for mean difference as (0.13 - 0.84). Similarly, the non-parametric Mann-Whitney U test showed that the satisfaction regarding the In-class construct was statistically significantly higher in the conceptual graduate classes (4.43) in comparison to the technical graduate class (3.86), with *p*-value of 0.00, and 95% confidence intervals for the median difference as (0.14 - 1).

Table 53: In-class Levene's test results, 2 independent samples t-test, and Mann-Whitney U test between graduate flipped classes

Construct	*p*-value (Leven's test) Eng_G_Flip_A & Eng_G_Flip_GI	*t (p)* 95% CI Eng_G_Flip_A & Eng_G_Flip_GI	W (*p*) 95% CI Eng_G_Flip_A & Eng_G_Flip_GI
In-class	0.957	-2.76 (0.008)* (-0.84, -0.13)	159.00 (0.007)* (-1, -0.14)

* $p < 0.05$

The reported satisfaction regarding the In-class construct was also compared across the flipped classes grouping them as per the course nature and the use of pre-class video. The classes for "Technical" group, the undergraduate engineering classes "Eng_UG_Flip_GI" and the graduate technical class "Eng_G_Flip_A", were validated for merge as no significant difference was found for the In-class construct according to both the parametric two independent samples t-test and the non-parametric Mann-Whitney U test as shown in Table 54.

Table 54: In-class Levene's test results, 2 independent samples t-test, and Mann-Whitney U test for technical flipped classes (Eng_UG_Flip_GI) & (Eng_G_A)

Construct	*p*-value (Leven's test) Eng_UG_Flip_GI & Eng_G_A	*t (p)* Eng_UG_Flip_GI & Eng_G_A	W (*p*) Eng_UG_Flip_GI & Eng_G_A
In-class	0.072	-1.25 (0.218)	1168.00 (0.180)

Table 55 shows the descriptive statistics for responses to In-class construct in flipped classes grouped as per the course nature and the use of pre-class video. The reported satisfaction for In-class construct was compared across the three groups using One-Way ANOVA and Kruskal Wallis tests. Normality test results for "Technical-Video" group and "Conceptual" group were violated as shown before in Table 51, where those groups represent classes "Cal_UG_Flip_GI" and "Eng_G_Flip_GI" sequentially. For the "Technical" group, normality was verified with ($p = 0.080$). As shown in Table 56, equality of variances is violated as *p*-value is 0.007, less than alpha value of 0.05, thus, the non-parametric test results are considered more valid. According to the Kruskal Wallis test, the reported In-class satisfaction was significantly different across the compared flipped groups with (p = 0.000). Same p-value was reported with One-way ANOVA test.

Table 55: Descriptive statistics of In-class construct in flipped classes after grouping as per course nature and the use of pre-class video

Construct	**Technical-Video Cal_UG_Flip_GI**			**Technical Eng_UG_Flip_GI & Eng_G_Flip_A**			**Conceptual Eng_G_Flip_GI**		
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*
In-class	52	4.25 ± 0.74	4.50	55	3.48 ± 0.93	3.57	37	4.34 ± 0.51	4.43

Table 56: One-way ANOVA test and Kruskal Wallis test for In-class construct in flipped classes after grouping as per course nature and the use of pre-class video

Construct	***p*-value (Leven's test) All FC**	***F* (*p*-value) All FC**	***H* (*p*-value) All FC**
In-class	0.007*	17.12 (0.000)*	29.17 (0.000)*

* $p < 0.05$

According to the parametric Games-Howell post hoc tests analysis presented in Table 57, the students' reported satisfaction for usefulness of pre-class preparation on in-class understanding and participation was statistically significantly higher in the flipped classes of "Technical-Video" (p = 0.000) and "Conceptual" (p = 0.000) groups, compared to the "Technical" group. The reported mean values were 4.25 ± 0.74, 4.34 ± 0.51and 3.48 ± 0.93 sequentially. The 95% confidence interval for mean differences between the "Technical" and "Technical-Video" groups was 0.38 to 1.15, while it was 0.50 to 1.22 between the "Technical" and "Conceptual" groups. Figure 12 illustrates the differences of means for In-class construct across the three flipped groups.

The non-parametric post hoc tests analysis, Kruskal Wallis Multiple Comparison test, presented in Table 57, gives similar results to the parametric one. Students' reported satisfaction for In-class construct was statistically significantly higher in the flipped classes of "Technical-Video" (p = 0.000) and "Conceptual" (p = 0.000) groups, in comparison to the "Technical" group. The reported median values were 4.50, 4.43 and 3.57 sequentially. The 80.53% confidence interval for median differences between the "Technical" and "Technical-Video" groups was 0.55 to 1.14, while it was 0.29 to 1.14 between the "Technical" and "Conceptual" groups. Figure 13 illustrates the Kruskal Wallis Multiple Comparison test results for In-class construct across the three flipped groups.

Thus, students in the flipped classes of a technical course nature with pre-class video material, or a conceptual course nature with the pre-class reading material similarly view the usefulness of pre-class material and statistically more than the students in the technical course nature with the pre-class reading material.

Table 57: Games-Howell and Kruskal Wallis Multiple Comparison tests results of In-class construct in flipped classes after grouping as per course nature and the use of pre-class video

Group	In-class Games-Howell t (*p*) 95% CI	In-class Kruskal Wallis Multiple Comparison Z (*p*) 80.53% CI
Tech - Conceptual	-5.71 (0.000)* (-1.22, -0.50)	4.53 (0.000)* (-1.14, -0.29)
Tech-Video – Conceptual	-0.73 (0.747) (-0.41, 0.22)	0.30 (0.763) (-0.16, 0.43)
Tech-Video - Tech	4.74 (0.000)* (0.38, 1.15)	4.64 (0.000)* (0.55, 1.14)

* $p < 0.05$

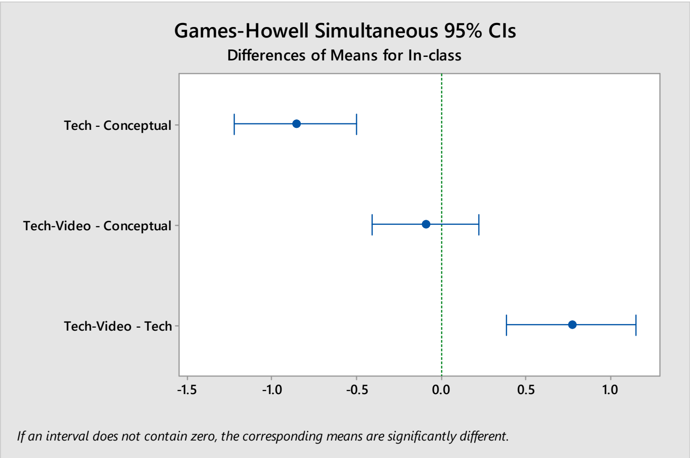

Figure 12: Games-Howell test results for 95% CI differences of means for In-class construct between the flipped classes after grouping as per course nature and the use of pre-class video.

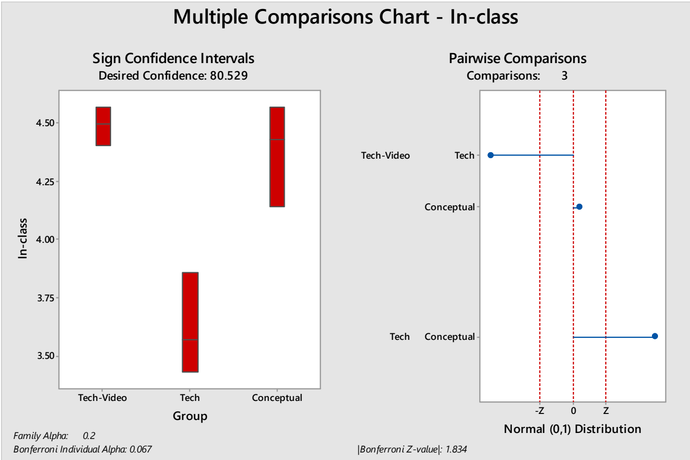

Figure 13: Kruskal Wallis Multiple Comparison test results showing 80.53% CI for median values of In-class between the flipped classes after grouping as per course nature and the use of pre-class video.

Satisfaction rates results confirm the earlier observations, where low satisfaction rates were noted in the technical classes with the absence of a pre-class video, Eng_UG_Flip_GI and Eng_G_Flip_A, but not in the other classes of "Conceptual" and "Technical-video" category, that is, Cal_UG_Flip_GI and Eng_G_Flip_GI, as presented in Table 58.

In particular, students in the undergraduate technical classes (Eng_UG_Flip_G) showed low satisfaction regarding the usefulness of pre-class preparation for all asked items except for item In-class2. Thus, this shows a concern about the pre-class material, and that it may need to be re-designed. Students in the graduate technical class (Eng_G_Flip_A) reported low on In-class7 (Generally, at the end of the class, you feel you have understood everything) with a satisfaction rate of 54.55%.

Thus, despite the students being satisfied with the rest of items regarding the usefulness of pre-class preparation in enhancing participation during the class, students are lacking understanding of the material properly, and thus this raises a concern on re-designing the pre-class material to ensure better understanding for the students.

Table 58: Satisfaction rates (Top 2 boxes score) of In-class items for flipped classes

Item	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
In-class1	45 84.90%	21 47.73%*	8 72.73%	36 97.3%
In-class2	40 75.50%	31 70.45%	10 90.91%	35 94.6%
In-class3	36 68.00%	23 52.27%*	8 72.72%	34 91.89%
In-class4	40 75.50%	26 59.09%*	9 81.82%	34 91.9%
In-class5	37 69.80%	21 47.73%*	8 72.72%	35 94.59%
In-class6	38 71.70%	26 59.09%*	9 81.82%	33 89.19%
In-class7	45 84.90%	16 36.36%*	6 54.55%*	32 86.49%

* Percentage < 60%

Students were asked to explain their self-reporting of the confidence level to ask questions in the class. The question asked was In-class6: "At the class time, I feel confident asking questions about the lecture topic. Please explain briefly your selection.". Figure 14 shows students self-report responses for the In-class6 item.

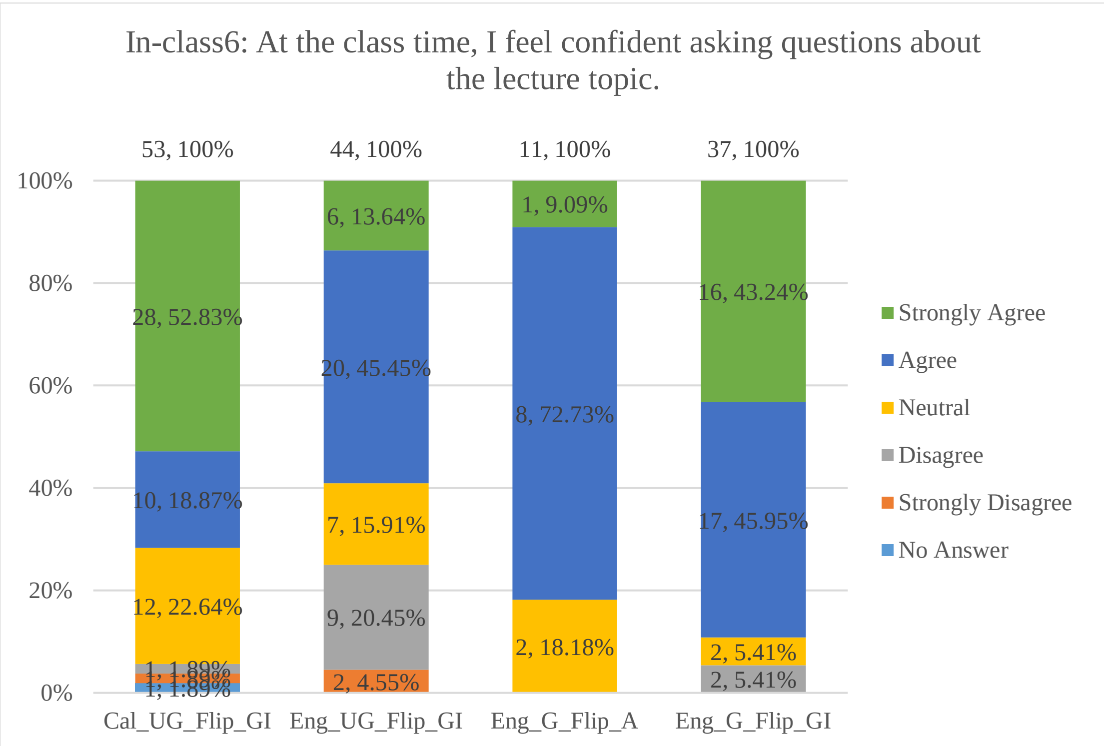

Figure 14: Students' responses to in-class confidence to ask questions (In-class6) – Flipped Classes

Their responses were coded into two classifications for each group. Students who responded with Agree or Strongly Agree as reasons of high confidence and those who responded with Neutral, Disagree or Strongly Disagree as reasons of low confidence.

In total, 73.10% of students responded with Strongly Agree or Agree. Reasons identified for high confidence levels to ask questions in the flipped classes are summarized in Table 59. As the table shows, few students explained their reasons (20.00% of total respondents from all the flipped classes). The main theme for the high confidence of asking questions for students in the flipped classes was the pre-class study as reported by (Cal_UG_Flip_GI: 18.86%, Eng_UG_Flip_GI: 4.55%, Eng_G_Flip_GI: 16.51%). Students commented that due to the preparation before the class, asking questions is easier as they know what area they need help with. However, this reason was mentioned more by students in the technical class with pre-class video, and students in the conceptual classes with the absence of the pre-class video. However, it was mentioned by only two students from the technical classes with the absence of pre-class video. This may raise a concern about the helpfulness of text-based pre-class material for technical classes. Our claim for this concern is weak due that most students not giving any explanations. Another shown theme reported to a lesser degree (4.14% of participating students) referred to the engaging and friendly class. Three students commented that professor welcomes questions. Another three students reasoned their confidence to ask in-class questions to simply feeling comfortable. Table 150 in Appendix F shows unedited quoted comments from students regarding high confidence to ask in-class questions in flipped classes.

On the other hand, 26.21% of total students responded with low confidence to ask questions in the class, reporting as Neutral, Disagree or Strongly Disagree, but they did not comment much about the reasons as shown in Table 60. Only 9 students, 3.45% of total respondents from all flipped classes, mentioned the reason for their selection of low confidence to ask in-class questions.

In the undergraduate flipped mathematics classes, only two students mentioned that they “just don’t ask questions in the class”, one student said, “I prefer asking during the office hour”, and interestingly one student said that “he understands clearly from the videos that he did not need to ask that much”. In the engineering undergraduate flipped classes, four students responded with community concerns as follows: "I sometimes feel the prof will judge me if the question is too silly", "some students do not like it when others keep asking questions, so I try to not ask and instead search it online but it's not very helpful.", "I'm shy", "the class environment is stiff and tense". One student mentioned that "Honestly, sometimes I don't know what to ask even though I know there is for sure some concepts that I don't really understand". No student in the graduate classes had reported their reasons. In addition, due to the low number of responses, there is no theme to consider regarding reasons of low confidence to ask questions in the flipped classes.

Table 59: Reasons identified for high confidence level of asking in-class questions – flipped classes

Identified Reason	Cal_UG _Flip_GI	Eng_UG _Flip_GI	Eng_G _Flip_A	Eng_G _Flip_GI	Total
N	53	44	11	37	145
Pre-class study	10 18.86%	2 4.55%	- -	5 13.51%	17 11.72%
class environment	1 1.89%	1 2.27%	1 9.09%	3 8.11%	6 4.14%
professor welcomes questions	1 1.89%	2 4.55%	- -	- -	3 2.07%
I am comfortable to ask	- -	3 6.82%	- -	- -	3 2.07%
NA	26 49%	18 40.91%	8 72.73%	26 70.27%	78 53.79%

Table 60: Reasons identified for low confidence level of asking in-class questions – flipped classes

Identified Reason	Cal_UG _Flip_GI	Eng_UG _Flip_GI	Eng_G _Flip_A	Eng_G _Flip_GI	Total
N	53	44	11	37	145
I don't ask in-class questions	3 5.66%	- -	- -	- -	3 2.07%
I did not need to ask that much due to Pre-class study	1 1.89%	- -	- -	- -	1 0.69%
Community concerns	- -	4 9.09%	- -	- -	4 2.76%
I don't know what to ask	- -	1 2.27%	- -	- -	1 0.69%
NA	10 18.86%	13 29.55%	2 18.18%	4 10.81%	29 20.00%

6.5.3. Study load construct.

Five questions were asked to students in the flipped classes to check the impact of the flipped methodology on the students' study load. As shown in Table 61, three of those questions (SL1, SL2, SL3) are self-report Likert questions, and two of them are open-ended questions (SL4, SL5). As shown in the literature review, one of the main challenges reported by the students in the flipped classes was the increased study load and stress [12] [17] [91]. However, students also reported that the flipped methodology due to the pre-class component, had helped them to stay at the top of the material [12]. In other words, we assume that it helps in distributing the study load and reducing the stress before the exams. Thus, our questions in this survey were to check the usefulness of the flipped methodology in reducing the study load and stress.

Table 61: Items of study load construct – flipped classes

Item code	Item
SL1	**45.** I felt the pre-class preparation distribute the study load of this course over the semester but didn't create extra study load for me in total?
SL2	**46.** Studying for the midterm/final exam of this course requires me less efforts in compare to other courses?
SL3	**47.** Studying for the midterm/final exam of this course, I was more confident and less stressful in compare to other courses?
SL4	**53.** In average, how many hours do you spend in preparing ahead for this class? (open-ended)
SL5	**55.** In your opinion, what is the accepted number of courses to be taken in the flipped methodology in the same semester? Select from (1, 2, 3, 4, 5, 6, 7, 8, all courses). Describe the reason of your selection. (open-ended)

For each student response, the scoring of the self-report items were averaged to come out with a final score regarding the measured construct of "impact of flipped methodology on reducing the study load and stress". Students' agreement to the usefulness of the flipped methodology on reducing the study load and stress was neutral ranging from (mean: 2.24 out of 5, median: 2.00 out of 5) to (mean: 3.82 out of 5, median: 4.00 out of 5) as shown in Table 62.

The highest agreement was reported by the students in the engineering graduate conceptual classes (Eng_G_Flip_GI) with values of (mean: 3.82, median: 4.00), followed by mathematics undergraduate classes (Cal_UG_Flip_GI) with values of (mean: 3.76, median: 3.83), then engineering graduate technical class (Eng_G_Flip_A) with values of (mean: 3.27, median: 3.67), and finally the least satisfaction was reported by students in the engineering undergraduate classes (Eng_UG_Flip_GI), with values of (mean: 2.24, median: 2.00).

Table 62: Descriptive statistics of study load construct in flipped classes

Construct	Cal_UG_Flip_GI			Eng_UG_Flip_GI			Eng_G_Flip_A			Eng_G_Flip_GI		
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*
Study Load	51	3.76 ±0.91	3.83	43	2.24 ±0.82	2.00	11	3.27 ±0.92	3.67	37	3.82 ±0.98	4.00

The reported satisfaction for study load construct was statistically compared between the two flipped groups of undergraduate level, mathematics (Cal_UG_Flip_GI) and engineering (Eng_UG_Flip_GI) using two independent samples t-test and Mann-Whitney U test. Similarly, the comparison was checked between the technical graduate class (Eng_G_Flip_A) and the conceptual graduate group (Eng_G_Flip_GI). Assumption test for normality is shown in Table 63. Normality was validated for all our classes except for Eng_G_Flip_GI.

Table 63: Normality test results of study load construct for flipped classes

Construct	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
Study Load	Normal ($p = 0.05$)	Normal ($p = 0.195$)	Normal ($p = 0.098$)	Not Normal ($p = 0.044$)*

* $p < 0.05$

As presented in Table 64, equality of variance was validated for comparing the undergraduate classes with *p*-value of 0.451. According to the parametric two independent samples t-test, satisfaction regarding the study load construct, that is, agreement for usefulness of flipped methodology on reducing the study load and stress, was statistically significantly higher in the mathematics undergraduate flipped classes (3.76 ± 0.91) in compare to engineering undergraduate flipped ones (2.24 ± 0.82), with *p*-value of 0.000, and 95% confidence intervals for mean difference as (1.16 - 1.87). Similarly, according to the non-parametric Mann-Whitney U test, satisfaction regarding the study load construct, was statistically significantly higher in the mathematics undergraduate flipped classes (3.83) in compare to the engineering undergraduate flipped ones (2.00), with *p*-value of 0.000, and 95% confidence intervals for median difference as (1.33 - 2).

Table 64: Study load Levene's test results, 2 independent samples t-test, and Mann-Whitney U test between undergraduate flipped classes

Construct	***p*-value (Leven's test) Cal_UG_Flip_GI & Eng_UG_Flip_GI**	***t (p)* 95% CI Cal_UG_Flip_GI & Eng_UG_Flip_GI**	**W (*p*) 95% CI Cal_UG_Flip_GI & Eng_UG_Flip_GI**
Study Load	0.451	8.47 (0.000)* (1.16, 1.87)	3351.50 (0.000)* (1.33, 2)

* $p < 0.05$

Comparing the technical graduate class (Eng_G_Flip_A) and the conceptual graduate classes (Eng_G_Flip_GI) as presented in Table 65. Equality of variance was validated with *p*-value of 0.831. According to two independent samples t-test, the satisfaction for the study load construct was slightly significantly higher in the conceptual graduate classes (3.82 ± 0.98) in comparison to the technical graduate class (3.27 ± 0.92), with *p*-value of 0.105, and 95% confidence intervals for mean difference as (0.12 - 1.21). Similarly, according to the non-parametric Mann-Whitney U test, the satisfaction for the study load construct was slightly significantly higher in the conceptual graduate classes (4.00) in comparison to the technical graduate class (3.67), with *p*-value of 0.085, and 95% confidence intervals for mean difference as (0 - 1.33).

Table 65:Study load Levene's test results, 2 independent samples t-test, and Mann-Whitney U test between graduate flipped classes

Construct	***p*-value (Leven's test) Eng_G_Flip_A & Eng_G_Flip_GI**	***t (p)* 95% CI Eng_G_Flip_A & Eng_G_Flip_GI**	**W (*p*) 95% CI Eng_G_Flip_A & Eng_G_Flip_GI**
Study Load	0.831	-1.65 (0.105) (-1.21, 0.12)	199.50 (0.085) (-1.33, 0.00)

The reported satisfaction regarding the study load construct was checked for comparison across the flipped classes as per the course nature and the use of pre-class video. However, the classes for "Technical" group, the undergraduate engineering classes "Eng_UG_Flip_GI" and the graduate technical class "Eng_G_Flip_A", were not validated for merge according to both the parametric two independent samples t-test and the non-parametric Mann-Whitney U test as the *p* values of the two tests were less than 0.05 as shown in Table 66. Therefore, the comparison as per the course nature and the use of pre-class video is not valid to be applied.

Table 66: Study load Levene's test results, 2 independent samples t-test, and Mann-Whitney U test for technical flipped classes (Eng_UG_Flip_GI) & (Eng_G_A)

Construct	***p*-value (Leven's test) Eng_UG_Flip_GI & Eng_G_Flip_A**	***t (p)* Eng_UG_Flip_GI & Eng_G_Flip_A**	**W (p) Eng_UG_Flip_GI & Eng_G_Flip_A**
Study Load	0.542	-3.65 (0.001)*	1044.50 (0.003)*

* $p < 0.05$

Looking into satisfaction rates, that is, the percentages of responses with strongly agree or agree, it is notable that the agreements for item of SL1 was scoring the highest in compare to SL2 and SL3 for the three engineering groups (Eng_UG_Flip_GI, Eng_G_Flip_A and Eng_G_Flip_GI) as shown in Table 67. For group Eng_UG_Flip_GI, agreement for SL1 was 16% more than the next highest agreement item. The difference range was 19% for classes Eng_G_Flip_A and Eng_G_Flip_GI. This shows that for those groups, which has in common the absence of pre-class videos, students are in more agreement that the flipped method is distributing the study load over the semester (SL1), in comparison to agreeing that it makes studying for major exams effortless (SL2) and less stressful (SL3).

Students in the engineering undergraduate classes (Eng_UG_Flip_GI) showed notably very low satisfaction regarding the usefulness of flipped methodology on reducing the study load and stress, as the satisfaction rates were 27.27% for SL1 and 11.36% for SL2 and SL3. Thus, this calls for attention to the engineering undergraduate flipped classes design, as undergraduates of mathematics classes showed significantly higher satisfaction. For other classes, either both or one of the items of studying for major exams, SL2 and SL3, were reported with satisfaction less than the threshold 60%.

Table 67: Satisfaction rates (Top 2 boxes score: Strongly Agree - Agree) of study load items for flipped classes

Item	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
SL1	36 67.92%	12 27.27%*	8 72.73%	31 83.78%
SL2	31 58.49%*	5 11.36%*	5 45.45%*	24 64.87%
SL3	36 67.92%	5 11.36%*	6 54.54%*	20 54.05%*

* Percentage < 60%

In order to accommodate for low reliability in the engineering undergraduate classes (Eng_UG_Flip_GI) regarding study load items, which was 0.5603 as shown in Table 29, which was mainly due to item of SL1, as explained before in section 6.3, we checked if there is any statistical difference, among satisfaction responses between the three study load items (SL1, SL2, SL3) for each class using Kruskal Wallis and the post hoc test Kruskal Wallis multiple comparisons test.

As shown in Table 68 and Table 69, the responses to study load items were significantly different in classes (Eng_UG_Flip_GI) and (Eng_G_Flip_GI) according to Kruskal Wallis test. For classes (Eng_UG_Flip_GI), responses to SL1 were significantly higher in comparison to SL2 with a *p*-value of 0.013. While for classes (Eng_G_Flip_GI), responses to SL1 were significantly higher in comparison to SL3 with a *p*-value of 0.018. However statistically, there is no thematic observation regarding agreement to SL1 in comparison to SL2 and SL3. Thus, the three items can be considered as one construct including SL1.

Table 68: Kruskal Wallis test between responses to study load items for flipped groups

Items	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI
Study Load Items (SL1, SL2, SL3)	0.40 (0.817)	6.19 (0.045)*	1.16 (0.559)	5.75 (0.056)

* $p < 0.05$

Table 69: Kruskal Wallis Multiple Comparison tests between responses to study load items for flipped groups (Eng_UG_Flip_GI and Eng_G_Flip_GI)

Items	Eng_UG_Flip_GI	Eng_G_Flip_GI
SL2 – SL1	2.48758 (0.013)*	1.48632 (0.137)
SL3 – SL1	1.31607 (0.188)	2.37282 (0.018)*
SL3 – SL2	1.17151 (0.241)	0.886508 (0.375)

* $p < 0.05$

Students were asked to report the number of hours they spend in preparing ahead for the flipped class, that is, the number of hours needed for the pre-class component. Some students reported an exact number of hours (ex. two hours), while others provided a range (ex. two to three hours), thus we had coded all the comments accordingly into ranges.

As shown in Figure 15 - Figure 18, the highest mentioned duration for our groups was either spending two to three hours as reported by 37.70% of the respondents in group Cal_UG_Flip_GI and 40.54% of the respondents in group Eng_G_Flip_GI, or one to two hours as reported by 36.36% of the respondents in group Eng_UG_Flip_GI and 36.36% of the respondents in the class Eng_G_Flip_A.

The next mentioned duration was one to two hours for (Cal_UG_Flip_GI, 28.30%) and (Eng_G_Flip_GI, 27.03%), two to three hours for class (Eng_G_Flip_A, 27.27), and three to four hours for (Eng_UG_Flip_GI, 15.91%).

Thus, the duration to prepare for the pre-class component in all participating classes is centralized around one to four hours. Some students from each examined group reported on spending less than an hour (Cal_UG_Flip_GI: 15.10%, Eng_UG_Flip_GI: 6.82%, Eng_G_Flip_A: 18.18%, Eng_G_Flip_GI: 8.11%), while few students, total three, reported on spending more than four hours (Eng_UG_Flip_GI: 1 student, Eng_UG_Flip_GI: 2 students).

Few students, total four, reported on not preparing before the class, the “none” response. Despite that the pre-class preparation was a must, thus few students were not doing it.

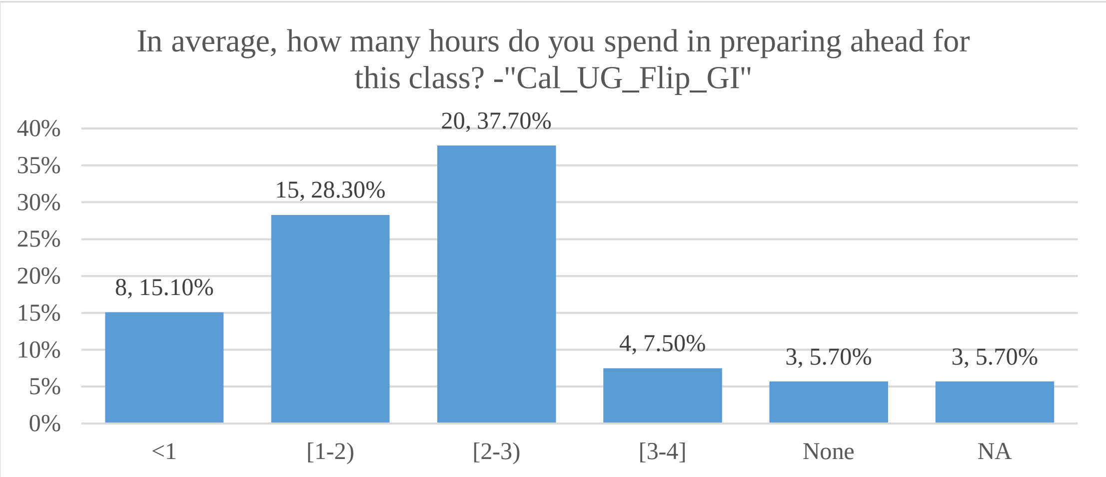

Figure 15: Number of hours needed for the pre-class component - Cal_UG_Flip_GI

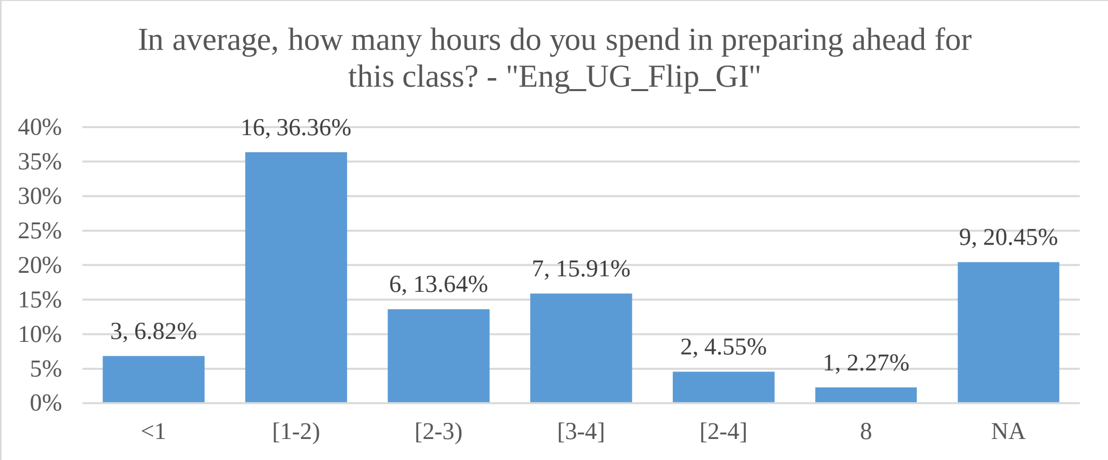

Figure 16: Number of hours needed for the pre-class component - Eng_UG_Flip_GI

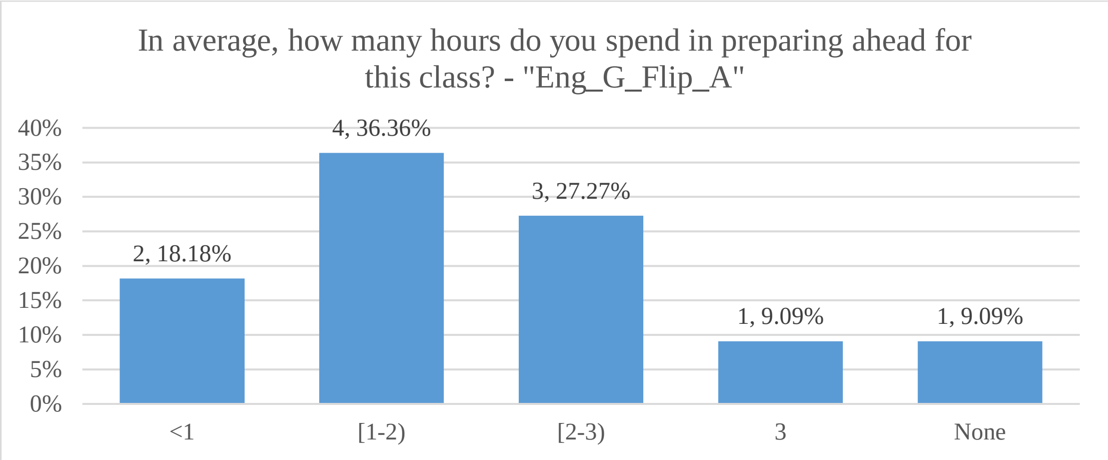

Figure 17: Number of hours needed for the pre-class component - Eng_G_Flip_A

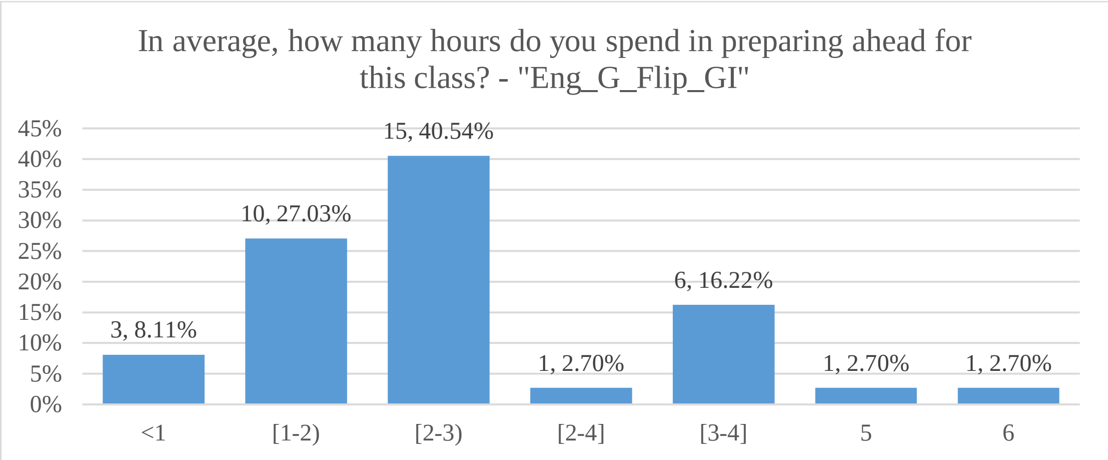

Figure 18: Number of hours needed for the pre-class component - Eng_G_Flip_GI

Students were also asked to report the accepted number of courses to be taken in the flipped methodology in the same semester. Their responses were analyzed according to study level as undergraduate or graduate as the study load is different. For undergraduate, the usual number of courses per semester is six or seven courses, while for graduate it is two courses for part-time students, usually full-time employees, and three courses for full-time students, usually non-working or teaching assistant students. Responses of students were either reporting a solid number, like commenting “three courses”, or giving options, like commenting “two or three courses”. Thus, we coded the students’ comments into a solid number of courses, that is, we wanted to report how many students agreed on accepting a specific number of courses. Therefore, if a student commented with “two or three courses”, we count plus one for the “2” courses category and another plus one for the “3” courses category.

Coded responses of undergraduate students are shown in Figure 19 and Figure 20. For undergraduate mathematics classes “Cal_UG_Flip_GI”, the three most accepted number of courses were, two courses, three courses and all courses. The agreement percentages for each response sequentially were 28.30%, 24.53% and 15.09%. On the other hand, for undergraduate engineering classes “Eng_UG_Flip_GI”, the three most accepted number of courses were, three courses, two courses and one course, with agreement percentages as 27.27%, 25.00%, and 22.73% sequentially. Thus, for both undergraduate groups, the common accepted number of courses to be taken with the flipped methodology in the same semester is three or two courses, with nearly 25% agreement for each choice in each group.

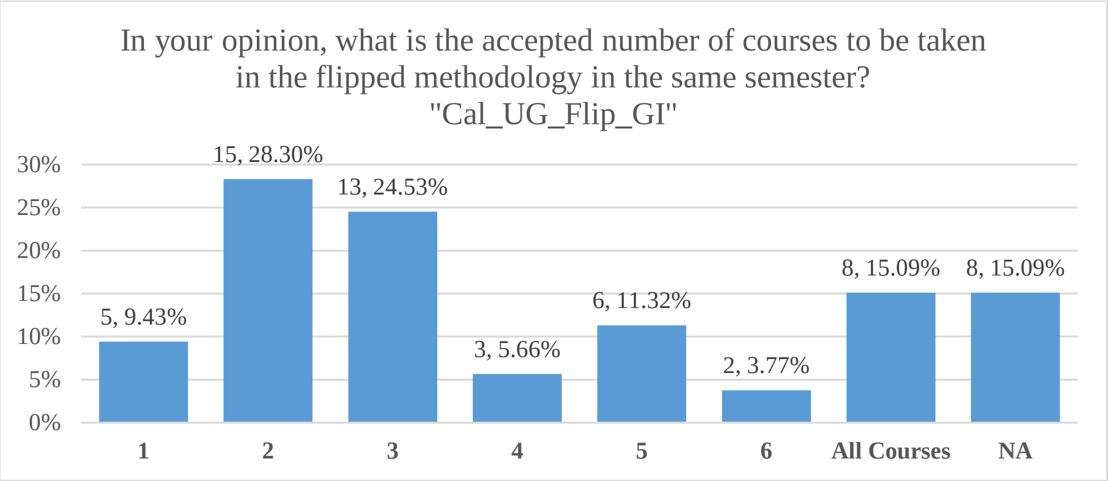

Figure 19: Coded response for the accepted number of courses to be taken in the flipped methodology in the same semester – undergraduate mathematics classes “Cal_UG_Flip_GI”

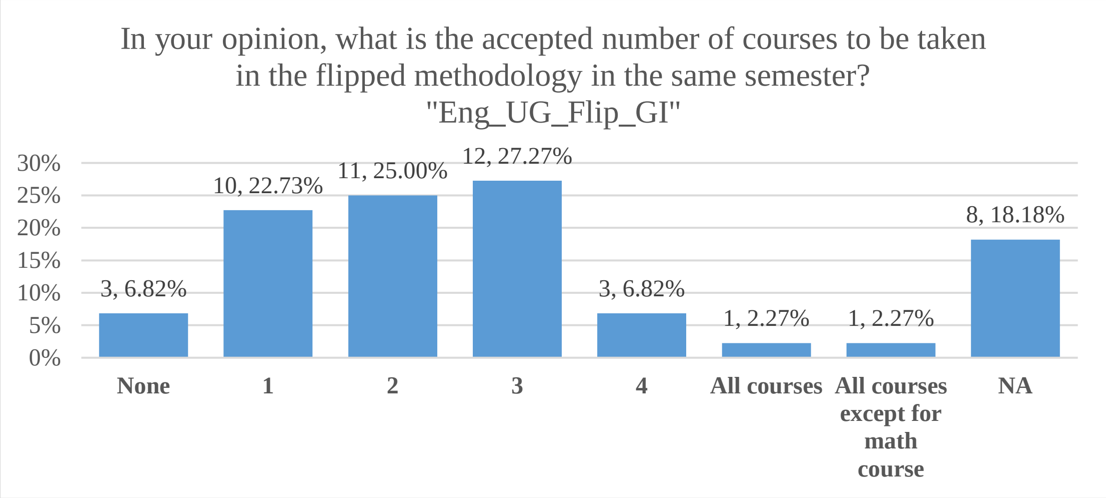

Figure 20: Coded response for the accepted number of courses to be taken in the flipped methodology in the same semester – undergraduate engineering classes "Eng_UG_Flip_GI"

Students were asked to explain their selection for the reported accepted number of flipped courses in the same semester. Students who responded with none or one to four courses (Cal_UG_Flip_GI: 67.92%, Eng_UG_Flip_GI: 88.64%) commented about the study load mostly (Cal_UG_Flip_GI: 20.75%, Eng_UG_Flip_GI: 47.73%) as shown in Table 70. This was followed by students commenting that the flipped method doesn't suit all courses (Cal_UG_Flip_GI: 3.77%, Eng_UG_Flip_GI: 4.55%). In the mathematics undergraduate classes "Cal_UG_Flip_GI", 7.55% of students commenting about the necessity of lecture-based courses and that the flipped method is still new for them. Yet, three students (5.66%) mentioned about the necessity of flipped method mixed with the lecture-based method in order to change the mood and make classes more entertaining. Three students had clearly stated that the flipped method is needed for Calculus and Physics courses only. Some individual comments were about the fear of loss of grade as the number of flipped courses increases, the difficulty to always maintain useful in-class discussions, in addition to one student who selected "4" courses as a response from the class "Cal_UG_Flip_GI" commenting about believing that the flipped method works. Table 151 in Appendix F shows unedited quoted responses for students who selected from none or one to four accepted flipped courses in the same semester.

Table 70: Reasons identified for selecting accepted number of flipped courses in the same semester to be none or within 1 to 4 courses – Undergraduate flipped classes

N/ Identified Reason	Cal_UG_Flip_GI	Eng_UG_Flip_GI
N	53	44
Study Load	11 20.75%	21 47.73%
Not suitable for all courses	2 3.77%	2 4.55%
The must of traditional courses/ New to approach	4 7.55%	- -
For calculus and physics	3 5.66%	- -
The must of flipped method to have a change	3 5.66%	- -
Others	1 1.89%	2 4.55%
NA	8 15.09%	11 25.00%

On the other hand, students who reported about accepting five or more flipped courses in the same semester were mostly from the undergraduate mathematics classes Cal_UG_Flip_GI (31.37%). They had mostly commented (9.43%) about believing in the flipped method and about the advantages they have seen such as better understanding, improving study practices in addition to the availability of online video lectures for reviewing anytime, as shown in Table 71. This was followed by three students (5.66%) commenting that the flipped method does not increase the study load. In other words, we can say that those students are also seeing the advantages of the flipped method and that they can accept multiple flipped courses in the same semester as it is not creating an extra load for them.

For the undergraduate engineering classes, only 4.65% (2 students) of them selected five or more courses, with only one student providing a reason of selecting “All courses” to the usefulness of flipped methodology in improving study habits. Table 152 in Appendix F shows unedited quoted responses for students who accepted the number of flipped courses in the same semester to be equal to or greater than five courses.

Table 71: Reasons identified for selecting accepted number of flipped courses in the same semester to be equal to or greater than 5 courses – Undergraduate flipped classes

N/ Identified Reason	Cal_UG_Flip_GI	Eng_UG_Flip_GI
N	53	44
Better understanding/Improve study habits/Availability of online video lectures/it's good	5 9.43%	1 2.27%
It doesn't increase study load	3 5.66%	- -
NA	5 9.43%	1 2.27%

Coded responses of graduate students are shown in Figure 21 and Figure 22. For the engineering graduate technical class "Eng_G_Flip_A", 27.27% of the class agreed to have one flipped course at the semester involving full or partial flip. This was followed by 18.18% agreement for two or three flipped courses per the semester. On the other hand, for the engineering graduate conceptual classes "Eng_G_Flip_GI", the highest agreement was for two courses per semester (35.14%), followed by 18.92% of the students agreeing to have one flipped course as the accepted number of courses per semester. It was welcoming that 13.51% of the students responded with agreeing to flip all the courses they are taking per semester. Some students responded with a number of courses greater than three; they might be referring to the number of courses to be taken in flip methodology per the program as three is the maximum allowed load per semester. Therefore, these comments are excluded.

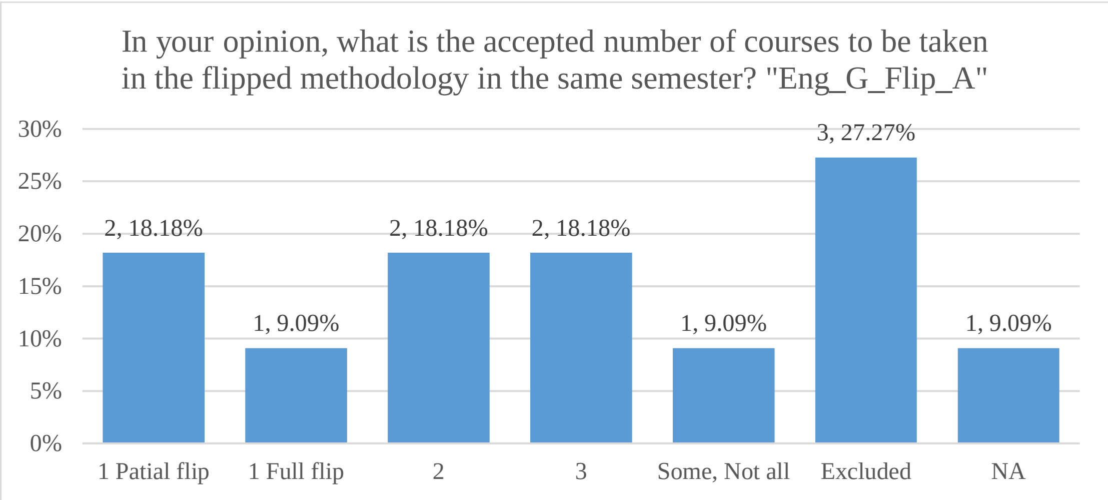

Figure 21: Coded response for the accepted number of courses to be taken in the flipped methodology in the same semester – engineering graduate technical class "Eng_G_Flip_A"

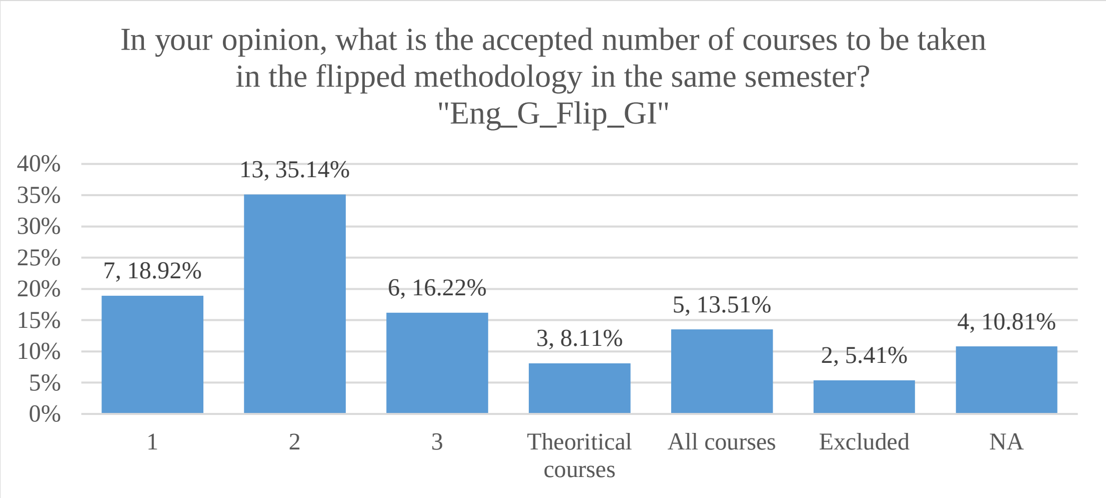

Figure 22: Coded response for the accepted number of courses to be taken in the flipped methodology in the same semester – engineering graduate conceptual classes “Eng_G_Flip_GI”

Similarly, graduate students were asked to reason their selection for an accepted number of flipped courses in the same semester. Comments for the excluded responses were also excluded. As shown in Table 72, students who selected one or two flipped courses to be accepted per semester had mainly concerned about the study load (Eng_G_Flip_A: 36.36%, Eng_G_Flip_GI: 18.92%). One student who selected one course from class Eng_G_Flip_A (9.09%) had commented about being new to the method. Two students who selected two courses from classes Eng_G_Flip_GI (5.41%) commented that the flipped method provides better engagement.

On the other hand, all students who selected to accept three or all courses to be flipped in the same semester had commented on the benefits of flipped methodology in providing better and easier understanding in addition to describing the method as more effective (Eng_G_Flip_GI: 10.81%).

Some students had commented that flipped methodology suits theoretical courses (Eng_G_Flip_GI: 10.81%), where their responses for an accepted number of flipped courses was “Theoretical courses” and one of them stating two courses. Table 153 in Appendix F shows unedited quoted responses for graduate students about their reasons for the selected number of accepted flipped courses in the same semester.

Table 72: Reasons identified for the selected number of accepted flipped courses in the same semester – Graduate flipped classes “Eng_G_Flip_A” & “Eng_G_Flip_GI”

Response	Identified Reason	Eng_G_Flip_A	Eng_G_Flip_GI
N		11	37
1 or 2	**Study Load**	4 36.36%	7 18.92%
1	**New to method**	1 9.09%	- -
2	**Better engagement**	- -	2 5.41%
2 or theoretical courses	**Suits theory courses**	- -	4 10.81%
3 or all courses	**Easier to handle & understand/ more effective**	- -	4 10.81%
2, 3 or all courses	**Other (Depends on student registration (part/full) - Partial flip)**	- -	2 5.41%
1, 2, 3 or all courses	**NA**	2 18.18%	13 35.14%

6.5.4. Study practices items. As the flipped methodology affects students' study practices by being a student-centered approach and by making the pre-class study mandatory, then the aim of study practices questions was to first check for students' preparation routines in a non-flipped class, second, check the use of textbook under flipped classes and in comparison to lecture-based classes, and third, check if the flipped methodology is helping students to improve study habits in non-flipped courses.

Three questions were asked to students in the flipped classes to check for the students' study practice as shown in Table 73, Study1 had targeted the preparation routine for students in a non-flipped class, Study2 had questioned if the textbook was used, while Study3 checked if the flipped methodology had improved their study habits for other non-flipped courses.

Table 73: Items of study practices construct – Flipped classes

Item code	Item			
Study1	**49.** In a non-flipped class I usually prepare	☐ As early as possible after the class time	☐ As early as possible before the class time	☐ Only few days before the midterm or quiz
Study2	**50.** Did you use the textbook	☐ Yes		☐ No
Study3	**51.** Does flipped methodology improves your study habits for other non-flipped courses?	☐ Yes		☐ No

Figure 23 and Figure 24 show the time by which students usually prepare or study the course material in a non-flipped class for undergraduate and graduate students sequentially. Students were asked to report their preparation time by selecting one of the three choices; "As early as possible after the class time", "As early as possible before the class time", or "Only few days before the midterm or quiz".

For both study levels, undergraduate and graduate, the majority of the students reported preparing "Only few days before the midterm or quiz". Percentages were 58.76% out of the 97 undergraduate participating students from the undergraduate flipped classes, and 68.75% out of the 48 graduate participating students from the graduate flipped classes. The breakdown per each class is shown in Figure 23 and Figure 24.

Following that, for undergraduate students, 25.77% of them reported to prepare "As early as possible after the class time", and finally 13.40% of them reported to prepare "As early as possible before the class time". On the other hand, for graduate students, nearly equal number of students reported to prepare "As early as possible before the class time" or "As early as possible after the class time". Percentages were 16.67% and 14.58% sequentially.

Therefore, although students are always advised to prepare and study the material on-going, the majority of them are not. On the other hand, it was welcoming that despite it is not obligatory to do a pre-class preparation in a non-flipped class, some students are doing it.

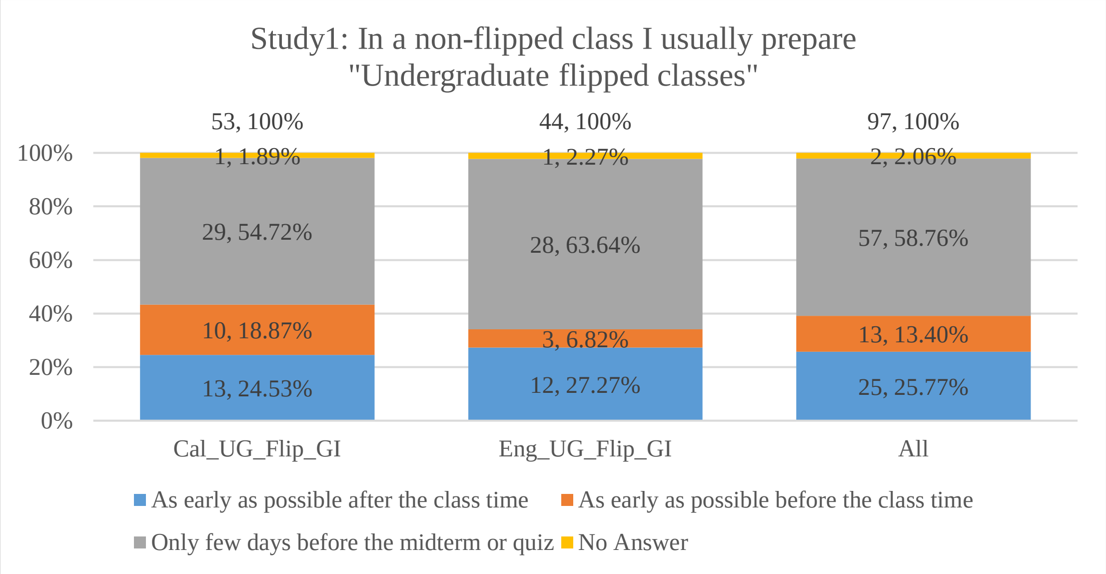

Figure 23: Students’ responses for preparation time (Study1) - Undergraduate flipped classes

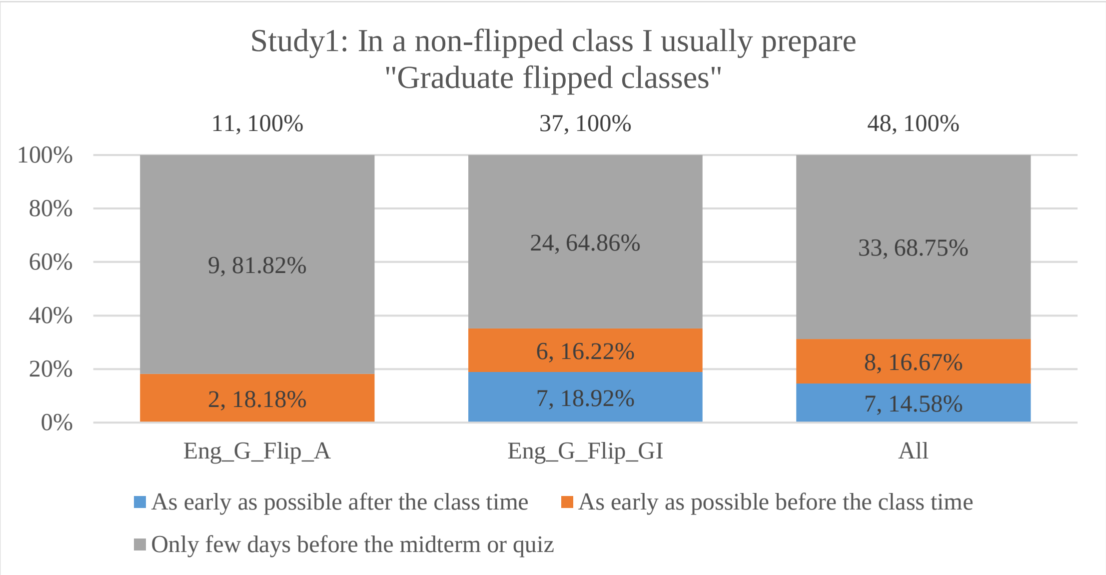

Figure 24: Students’ responses for preparation time (Study1) - Graduate flipped classes

As Figure 25 shows, the majority of the students in the undergraduate flipped classes had used the textbook whether the pre-class material was video-based (Cal_UG_Flip_GI: 54.72%) or reading-based (Eng_UG_Flip_GI: 68.18%). The majority of the graduate students did not use the textbook whether the course nature was technical (Eng_G_Flip_A: 90.91%) or conceptual (Eng_G_Flip_GI: 78.38%). Based on these percentages, the responses were grouped as per the study level to apply statistical tests. According to chi-square test results presented in Table 74, the use of the textbook in the undergraduate classes is statistically higher than in the graduate ones with *p*-value = 0.000. No statistical difference is shown for use of textbook between classes of same study level, undergraduate (p = 0.132), or graduate (p = 0.350).

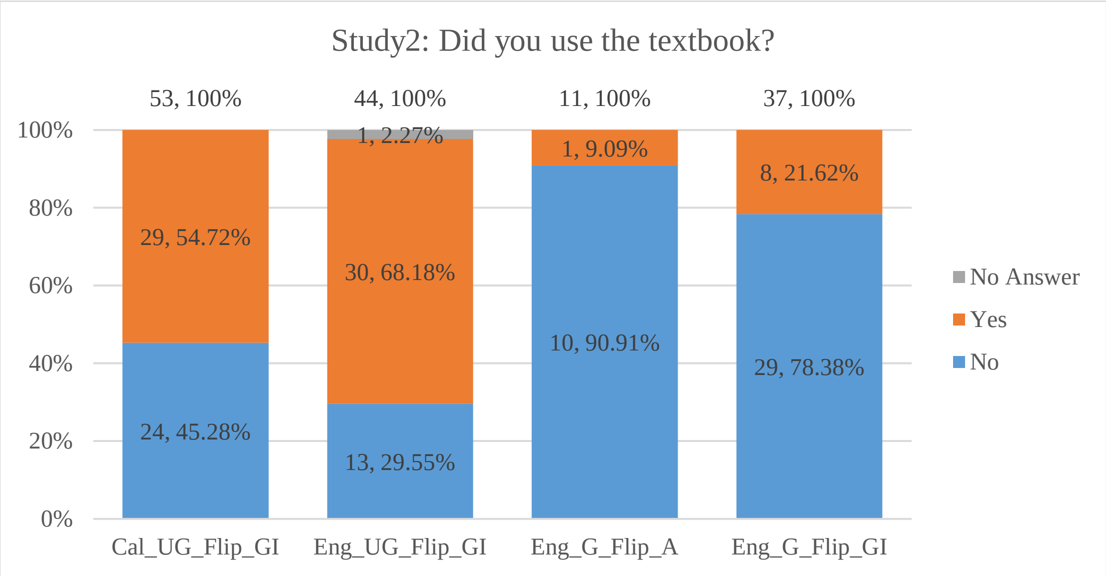

Figure 25: Students’ responses for using the textbook (Study2) - Flipped classes

Table 74: Chi-square test results for use of textbook (Study2) - Flipped classes

Item	$x^2(p)$ **Cal_UG_Flip_GI & Eng_UG_Flip_GI**	$x^2(p)$ **Eng_G_Flip_A & Eng_G_Flip_GI**	$x^2(p)$ **Undergraduate & Graduate**
Study2: Use of Textbook	2.270 (0.132)	0.874 (0.350)	23.420 (0.000)*

* $p < 0.05$

As most of the students are usually preparing only a few days before the exam or quiz, which is confirmed also by our data as shown in Figure 23 and Figure 24, students in the flipped classes were asked if the flipped methodology improved their study habits for other non-flipped courses. As shown in Figure 26, the majority of the students in undergraduate mathematics classes (Cal_UG_Flip_GI), the graduate technical class (Eng_G_Flip_A) and graduate conceptual classes (Eng_G_Flip_GI) had agreed about the usefulness of the flipped methodology in improving study habits in non-flipped courses. Agreement percentages were 69.81%, 81.82% and 72.97% sequentially. On the other hand, the majority of students in the undergraduate engineering classes (Eng_UG_Flip_GI) were disagreeing with percentage of 59.09%.

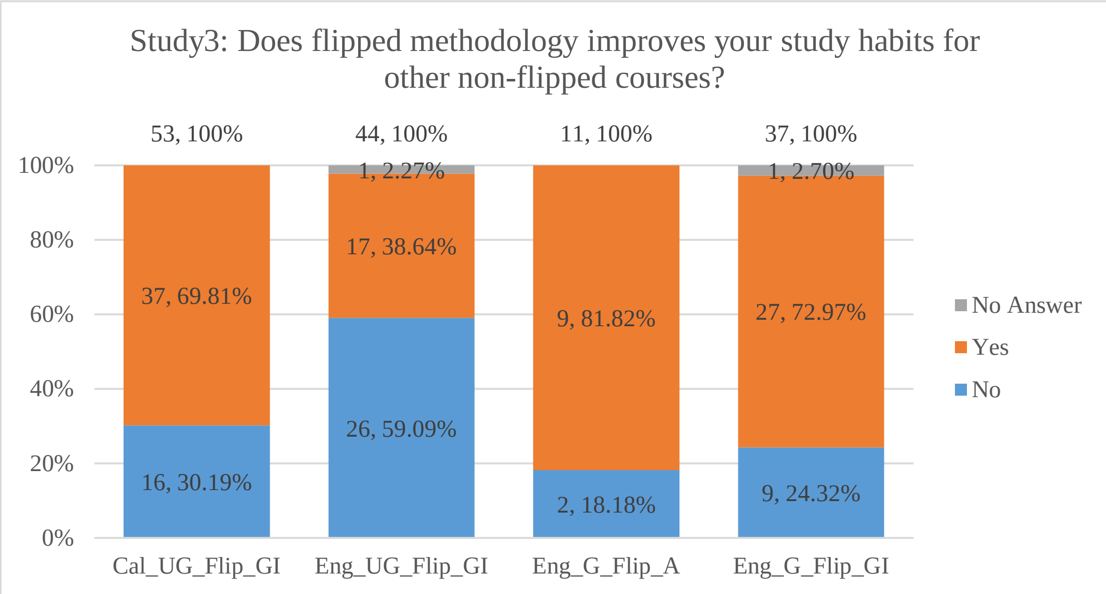

Figure 26: Students' responses for agreement about usefulness of flipped methodology in improving study habits in non-flipped courses (Study3) – Flipped classes

6.5.5. Motivation toward the teaching method items. To check for the motivation toward the flipped teaching method, students were asked to rate their motivation toward the teaching method in response to M1: "I liked the teaching style/method of this course?". We are assuming that the motivation toward the teaching method would be the major player toward the impact of the flipped method. Therefore, to find the most contributing factors to the impact of the flipped method, correlation analysis was applied between each of the asked questions and item M1, to find out which factors are contributing the most to the motivation toward the flipped method and thus to the impact of it.

Students in the lecture-based classes were also asked the same question (M1) to compare the responses between the two teaching methodologies. Furthermore, to check more the motivation toward the flipped method, students in the flipped classes were asked two more questions, M2 and M3, in order to have a better idea on how much they are liking the flipped method. All survey items related to motivation toward the flipped teaching method are shown in Table 75.

Table 75: Items of motivation toward the teaching method construct – Flipped classes

Item code	Item		
M1	**48.** I liked the teaching style/method of this course?		
M2	**52.** Comparing two methods, I believe that:		
	☐ Flipped method is superior to the lecture-based method	☐ About the same	☐ The flipped method is inferior to the lecture-based method.
M3	**54.** Rank your preferred class method (Rank using 1,2,3 where 1 is the most preferred).		
	☐ 100% Lecture ☐ 50% Lecture, 50% in-class activities (Partial Flipped) ☐ 100% in-class activities (Flipped)		
	Please explain your choices (open-ended)		

Descriptive statistics of students' responses to M1 "I liked the teaching style/method of this course" in all the examined flipped classes are shown in Table 76. Students rated their satisfaction on 5 points Likert scale. Students in mathematics undergraduate classes, and engineering graduate classes, both technical and conceptual, reported to highly like the flipped method.

On the other hand, students in the engineering undergraduate classes reported moderate like of the flipped method. The highest satisfaction was reported by students in the mathematics undergraduate classes Cal_UG_Flip_GI with values of (mean: 4.63 out of 5, median: 5.00 out of 5), followed by engineering graduate conceptual classes Eng_G_Flip_GI with values of (mean: 4.27, median: 4.00), and then engineering graduate technical class Eng_G_Flip_A with values of (mean: 4.18, median: 4.00). The like of the flipped method by students in the engineering undergraduate classes (Eng_UG_Flip_GI) was notably lower, with values of (mean: 3.00, median: 3.00), which shows a moderate like.

Table 76: Descriptive statistics of liking the teaching method item in flipped classes

Item	**Cal_UG_Flip_GI**			**Eng_UG_Flip_GI**			**Eng_G_Flip_A**			**Eng_G_Flip_GI**		
	N	*Mean ±Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ± Std.*	*Median*
M1: I liked the teaching style/ method of this course	52	4.63 ±0.63	5.00	43	3.00 ±1.20	3.00	11	4.18 ±0.60	4.00	37	4.27 ±0.61	4.00

A Mann-Whitney U test showed that there was a statistically significant difference in students' responses about liking the flipped method between the undergraduate classes (p = 0.000), with a median score of 5.00 for mathematics undergraduate classes, and 3.00 for engineering undergraduate classes, and 95% confidence intervals for the median difference as (1 - 2). Thus, students in the mathematics undergraduate classes like the flipped method statistically more than their peers in the engineering undergraduate classes. On the other hand, Mann-Whitney U test did not show significant difference in liking the flipped method between the graduate classes, (p = 0.664), with a median score of 4.00 for all the graduate classes. Mann-Whitney U test results for liking the flipped teaching method are shown in Table 77.

Table 77: Mann-Whitney U test for liking the flipped teaching method as per the study levels

Item	**W (*p*) 95% CI Cal_UG_Flip_GI & Eng_UG_Flip_GI**	**W (*p*) 95% CI Eng_G_Flip_A & Eng_G_Flip_GI**
M1: I liked the teaching style/ method of this course	3343.50 (0.000)* (1, 2)	253.50 (0.664) (-1, -0.00)

* $p < 0.05$

The reported agreement regarding liking the flipped method was checked for comparison across the flipped classes as per the course nature and the use of pre-class video. However, the classes for "Technical" group, the undergraduate engineering classes Eng_UG_Flip_GI and the graduate technical class Eng_G_Flip_A, were not validated for merge according to Mann-Whitney U test (p = 0.002) as shown in Table 78. Therefore, the comparison as per the course nature and the use of pre-class video is not valid to be applied.

Table 78: Mann-Whitney U test for liking the teaching method between technical flipped classes

Item	**W (*p*) Eng_UG_Flip_GI & Eng_G_Flip_A**
M1: I liked the teaching style/ method of this course	1041.50 (0.002)*

* $p < 0.05$

The bar chart presented in Figure 27 illustrates the responses to the question of M1: "I liked the teaching style/method of this course", per each examined flipped class, showing percentages and number of responses for each rating scale. Similar to the conclusion drawn from the descriptive statistics presented in Table 76, it can be seen from the bar chart that students in the mathematics undergraduate classes, and engineering graduate classes, both technical and conceptual, had highly liked the flipped teaching method. Satisfaction rates, that is, percentages of responses with strongly agree or agree were 90.56% in the mathematics undergraduate classes (Cal_UG_Flip_GI), 90.91% in the engineering graduate technical class (Eng_G_Flip_A), and 91.9% in the engineering graduate conceptual classes (Eng_G_Flip_GI). The rest few responses from each of these classes reported with neutral, and there was no disagreement response regarding liking the flipped method in these classes.

It was also notable that the majority of satisfaction responses in the mathematics undergraduate classes (Cal_UG_Flip_GI) were from the "Strongly Agree" response, 69.81%. While in the engineering graduate classes, most of the satisfaction responses were from the "Agree" response, 63.64% in the engineering graduate technical class (Eng_G_Flip_A), and 56.76% in the engineering graduate conceptual classes (Eng_G_Flip_GI).

On the other hand, students in the engineering undergraduate classes (Eng_UG_Flip_GI) showed fragmented perceptions toward liking the flipped method, where 34.09% reported with strongly agreeing or agreeing, 36.36% were neutral, and 27.27% were disagreeing or strongly disagreeing.

To further check the motivation of students toward the flipped method, students were asked to report about the flipped method in comparison to the lecture-based one as being superior, about the same or inferior.

As shown in Figure 28, a solid majority of the students in the mathematics undergraduate classes, and engineering graduate classes, both technical and conceptual, had reported that "Flipped method is superior to the lecture-based method". Percentages were: 81.13% in the mathematics undergraduate classes (Cal_UG_Flip_GI), 72.73% in the engineering graduate technical class (Eng_G_Flip_A), and 78.38% in the engineering graduate conceptual classes (Eng_G_Flip_GI). The next rated response was "About the same" for these classes. Few students responded that "Flipped method is inferior to the lecture-based method", 3.77% (2 students) in the mathematics undergraduate classes (Cal_UG_Flip_GI), and 5.41% (2 students) in the engineering graduate conceptual classes (Eng_G_Flip_GI). This is a bit interesting because none of the students in these classes had disagreed about liking the flipped method as shown in Figure 27, yet it seems for those few students that despite their like or neutral feelings for the flipped method, they still feel that it is inferior in comparison to the lecture-based method.

On the other hand, most of the students in the engineering undergraduate classes (Eng_UG_Flip_GI) reported to perceive the flipped method to be "About the same" as lecture-based method (40.91%), followed by 36.36% saying that "Flipped method is superior to the lecture-based method", with just 4.55% difference between the two choices, that is, two students. Finally, 20.45% reported that "Flipped method is inferior to the lecture-based method".

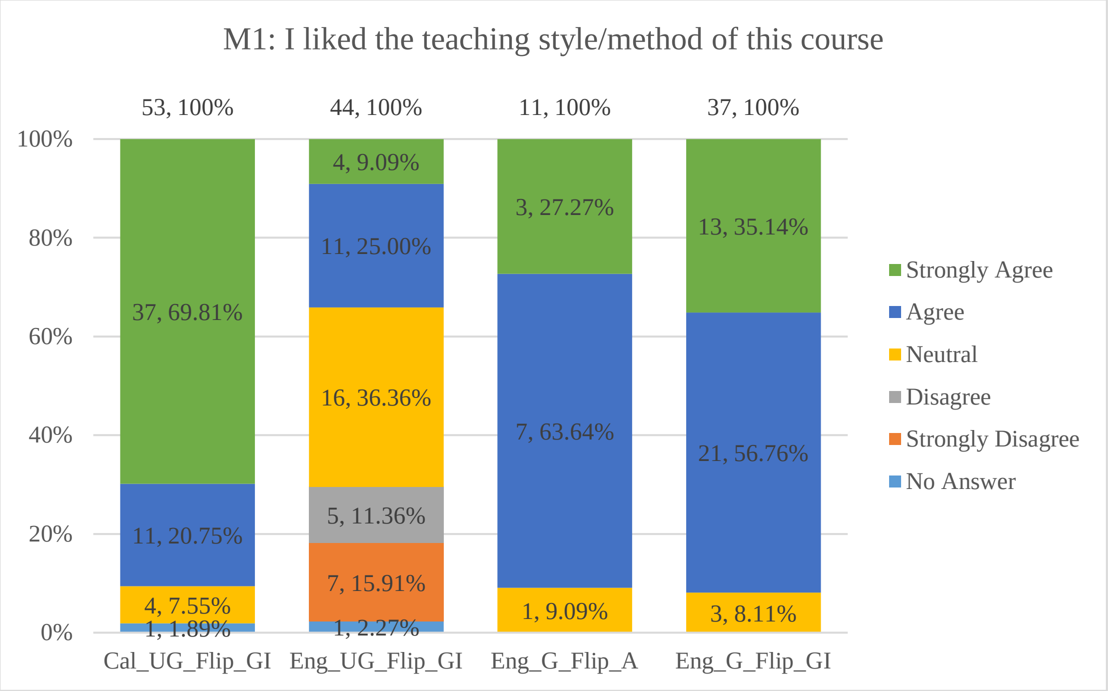

Figure 27: Students' responses regarding liking the teaching method (M1) - All flipped classes

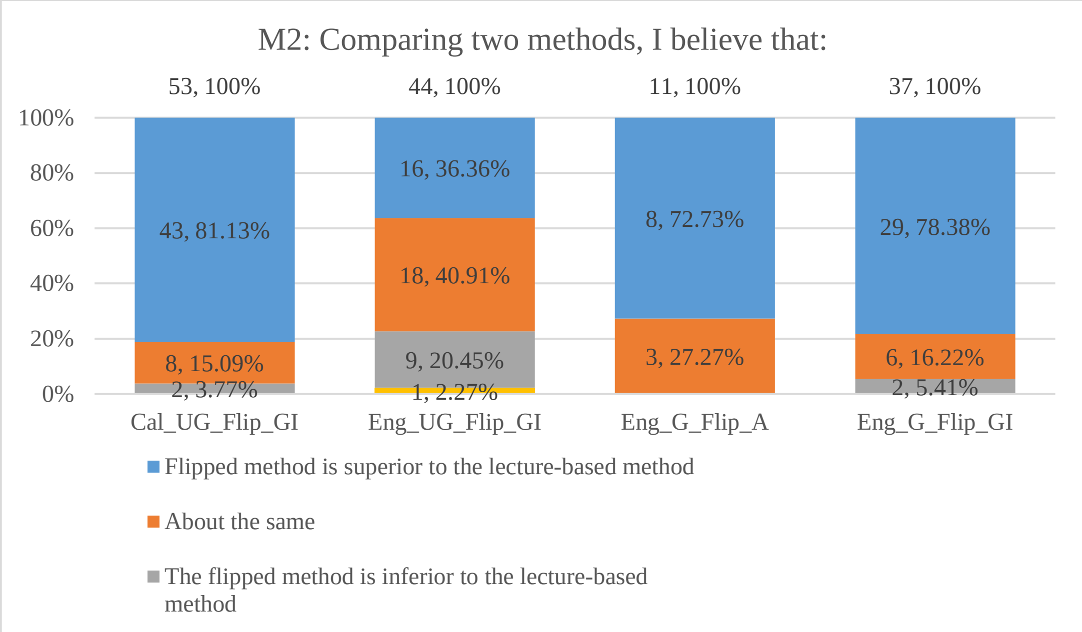

Figure 28: Students' perception of flipped method in compare to lecture-based method (M2) - All flipped classes

Furthermore, students were given three options for class method and asked to rank their preferred method from 1-3. The options were, 100% in-class activities (Flipped), 50% lecture and 50% in-class activities (Partial Flipped), and 100% lecture. Most of the students, however, answered the question as selecting their preferred class method rather than providing a rank. Therefore, because the students incorrectly answered the item, we are considering the rank1 selection.

As shown in Figure 29 - Figure 32, the majority of students in all the examined flipped classes reported to prefer partial flipped class as their rank 1, that is 50% lecture and 50% in-class activities. Percentages were: 81.13% in the mathematics undergraduate classes (Cal_UG_Flip_GI), 63.64% in the engineering undergraduate classes (Eng_UG_Flip_GI), 90.91% in the engineering graduate technical class (Eng_G_Flip_A), and 81.08% in the engineering graduate conceptual classes (Eng_G_Flip_GI).

For mathematics undergraduate classes (Cal_UG_Flip_GI), this was followed by equal preference (7.55%, 4 students) for 100% lecture and 100% flipped class as rank 1 selection. For engineering undergraduate classes (Eng_UG_Flip_GI), the next majority (22.73%) preferred 100% lecture class, and finally, 9.09% preferred 100%

flipped class. While for graduate classes, preference for 100% flipped class was more dominant following the partial flipped class preference.

Considering all respondents as shown in Figure 33, 111 out of 145 selected “partial flipped” as their rank 1, that is 76.55% of participants, followed by 11.03% selecting “100% lecture”, and finally 9.66% selecting “100% flipped”.

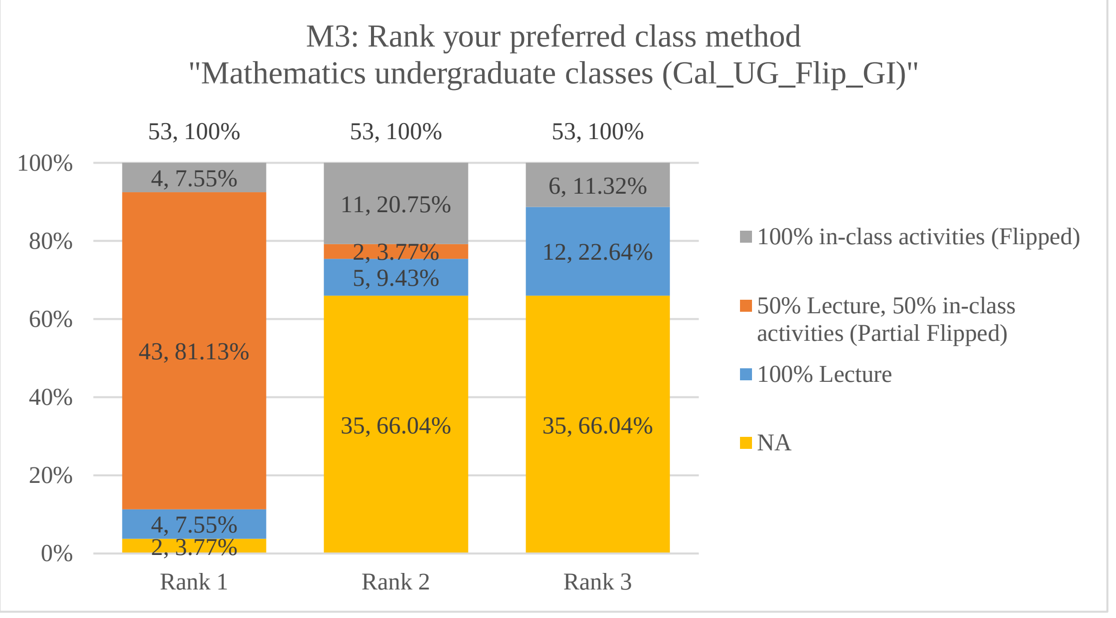

Figure 29: Students' preferred class method (M3) - Mathematics undergraduate classes (Cal_UG_Flip_GI)

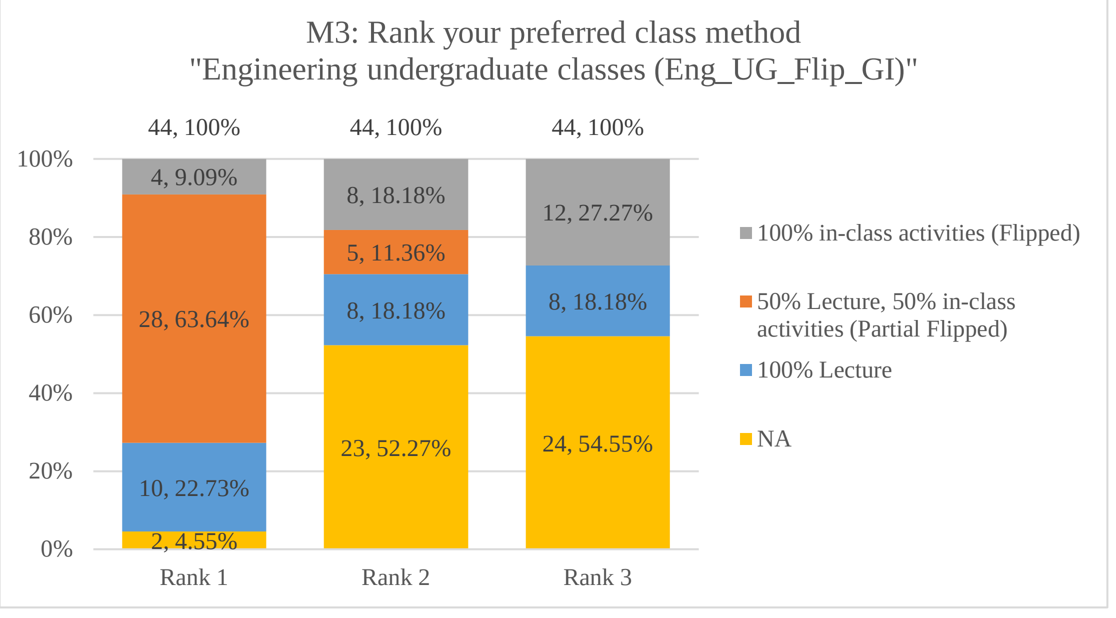

Figure 30: Students' preferred class method (M3) - Engineering undergraduate classes (Eng_UG_Flip_GI)

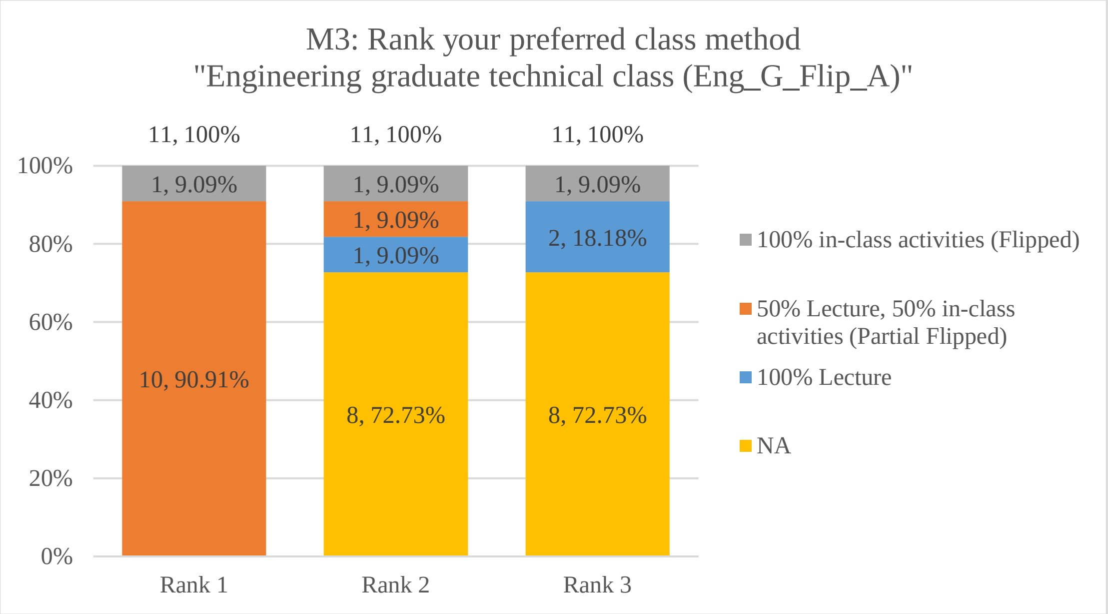

Figure 31: Students' preferred class method (M3) - Engineering graduate technical class (Eng_G_Flip_A)

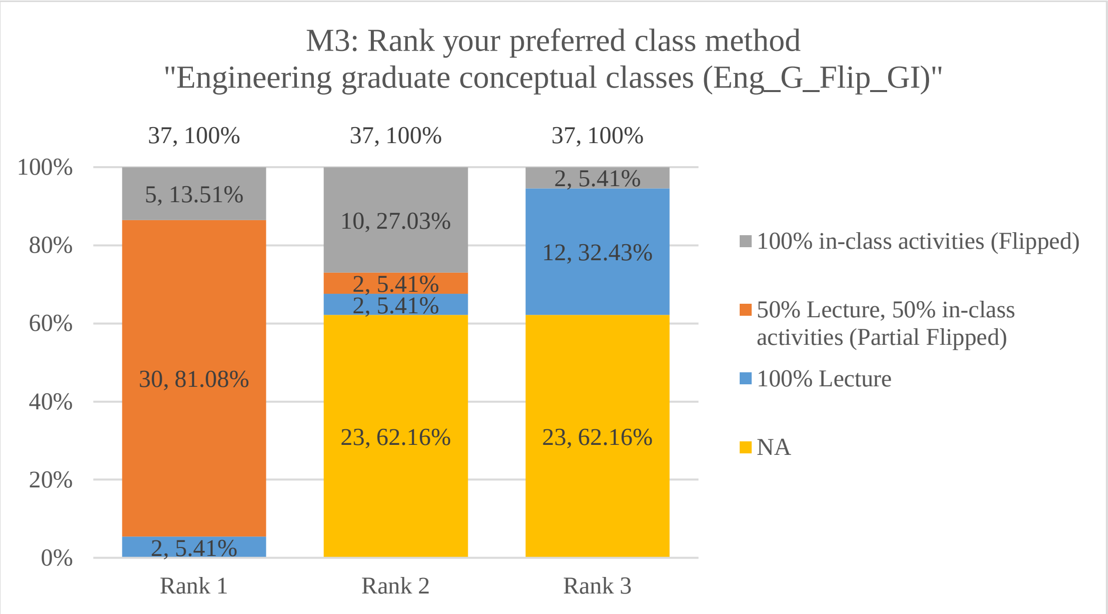

Figure 32: Students' preferred class method (M3) - Engineering graduate conceptual classes (Eng_G_Flip_GI)

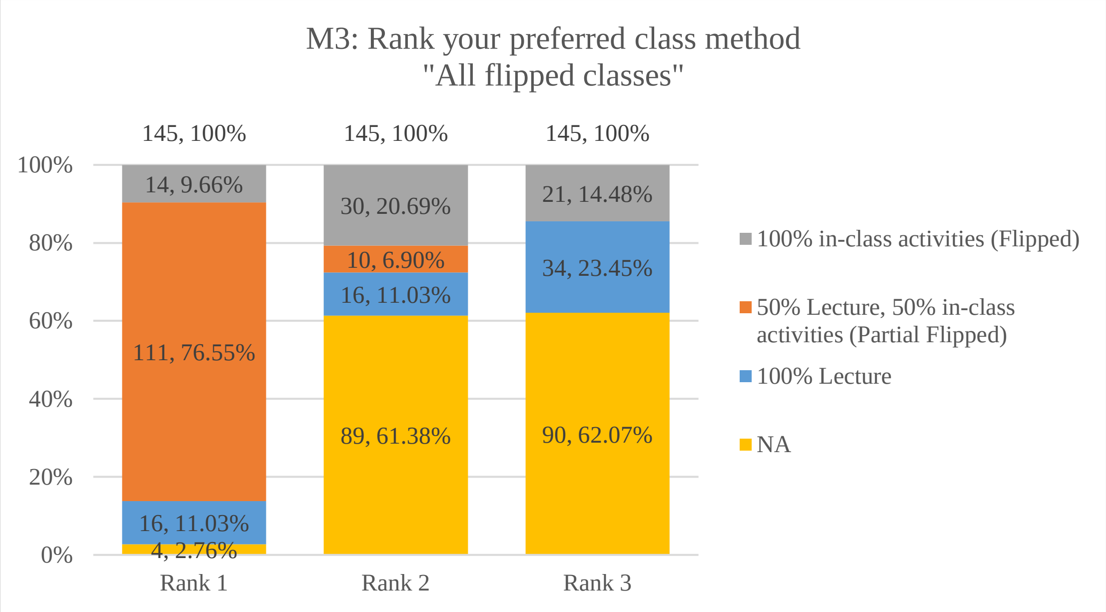

Figure 33: Students' preferred class method (M3) - All flipped classes

Students were also asked to explain their rank selection. We are grouping their reasons as per the selection of Rank 1 of the preferred class. Table 79 shows the themes shown for students selecting "50% lecture, 50% in-class activities (partial flip)" as their preferred class of rank 1 (76.55%). The students' comments were mainly structured on the benefits of the 50% in-class lecture component to understand the material more, review and highlight main ideas, correct misconceptions, fill in the gaps, follow up if the pre-class preparation was missed, and gaining from the instructor's knowledge, or as some had expressed that some topics need instructor explanation. The comments around the demand for 50% in-class lecture were reported by 30.34% of respondents from all the flipped classes.

Then the 50% in-class activities component was seen as a way to make the class more interesting and engaging compared to 100% lecture, and to provide a reasonable level of interaction and collaboration in compare to 100% flip. This was reported by 13.10% of all respondents. The 50% in-class activities component was also seen as a chance to put knowledge in practice, solve more problems, notice one's own mistakes, and practice, share and discuss with other peer students as reported by 9.66%.

10.34% of students had reasoned their selection for partial flip instead of 100% lecture class, commenting generally about the usefulness of flipped method for better understanding, developing skills and being helpful for exams, in addition to positively referring to the pre-class study in encouraging preparation beforehand and reinforcing learning. One of these students commented about the usefulness of videos for review. Some students (6.86%) had just mentioned that combination of both provides better experience, with some others (4.83%) mentioning that 100% flip is time demanding and stressing, and that partial flip would reduce the study load. Few students (4.14%) referred that in 100% flip class, they might not understand everything, or that they are not used to it, or not interested in it. One student commented about not understanding everything in 100% lecture and feeling shy to ask. 19.31% of the students did not provide a reason for their selection. Table 154 in Appendix F shows unedited quoted responses for students about their reasons for selecting "50% lecture, 50% in-class activities/partial flip" as their preferred class of rank 1.

Table 79: Reasons identified for partial flip class preference

Identified Reason	Cal_UG_Flip_GI	Eng_UG_Flip_GI	Eng_G_Flip_A	Eng_G_Flip_GI	Total
N	53	44	11	37	145
50% lecture benefits	17 32.08%	13 29.55%	5 45.45%	9 24.32%	44 30.34%
100% lecture is boring/ Partial flip is more Interesting, more engaging and provides reasonable interaction	5 9.43%	9 20.45%	- -	5 13.51%	19 13.10%
Flipped method help in better learning and understanding, develop skills and help in exam/ Pre-class study is useful for learning	5 9.43%	5 11.36%	1 9.09%	4 10.81%	15 10.34%
50% in-class activities benefits	8 15.09%	2 4.55%	- -	4 10.81%	14 9.66%
Combination of both gives better experience	4 7.55%	- -	1 9.09%	5 13.51%	10 6.86%
100% flip is time demanding and stressing/partial flip reduce study load	- -	6 13.63%	- -	1 2.70%	7 4.83%
100% flip: don't understand everything/ not used to it/ not interested in it	3 5.66%	- -	1 9.09%	2 5.41%	6 4.14%
100% lecture: don't understand everything/ feel shy to ask	- -	1 2.27%	- -	- -	1 0.69%
To have videos for review	1 1.89%	- -	- -	- -	1 0.69%
NA	11 20.75%	8 18.18%	2 18.18%	7 18.92%	28 19.31%

On the other hand, students (11.03%) who selected “100% lecture” as their preferred class showed concern that effectiveness of the flipped session depends on the class and group members and that professors have better knowledge (2.76%, 4 students), some points may be misunderstood with the flipped session (2.07%, 3 students), in addition to disliking the pre-class quiz and feeling that flip method brings more pressure and lower the grades (1.38%, 2 students) as shown in Table 80. Another individual reason for selecting 100% lecture was having accessibility issues to videos at home (1 student). 4.14% of the students did not provide a reason for their selection. Table 155 in Appendix F shows unedited quoted responses for students about their reasons for selecting “100% lecture class” as their preferred class of rank 1.

Table 80: Reasons identified for 100% lecture class preference

Identified Reason	Cal_UG _Flip_GI	Eng_UG _Flip_GI	Eng_G _Flip_A	Eng_G _Flip_GI	Total
N	53	44	11	37	145
Effectiveness of flipped session depends on the class and group members/professor have better knowledge	1 1.89%	2 4.55%	- -	1 2.70%	4 2.76%
Some points may be misunderstood with flipped session	1 1.89%	2 4.55%	- -	- -	3 2.07%
Dislike the pre-class quiz/ flip bring more pressure and lower the grades	- -	2 4.55%	- -	- -	2 1.38%
Can't access pre-class material at home	1 1.89%		- -	- -	1 0.69%
NA	1 1.89%	4 9.09%	- -	1 2.70%	6 4.14%

Finally, students (9.66%) who selected “100% flip” as their preferred class method, mentioned mainly that the flipped method is less boring, and makes the learning process more interesting and engaging as reported by (6.21%). Moreover, few more (2.07%, 3 students) mentioned that the flipped method is simply working and effective for learning. 2.07% of the students did not provide a reason for their selection. Table 81 shows the identified reasons for 100% flip class preference. Table 156 in Appendix F shows unedited quoted responses for students about their reasons for selecting “100% flip class” as their preferred class of rank 1.

Table 81: Reasons identified for 100% flip class preference

Identified Reason	Cal_UG _Flip_GI	Eng_UG _Flip_GI	Eng_G _Flip_A	Eng_G _Flip_GI	Total
N	53	44	11	37	145
Less boring, more interesting and engaging	1 1.89%	4 8.51%	1 9.09%	3 8.11%	9 6.21%
It's working and effective for learning	2 3.77%	1 2.13%	- -	- -	3 2.07%
NA	1 1.89%	- -	- -	2 5.41%	3 2.07%

Goodman-Kruskal's gamma test was run to determine the association between each of the asked items and the motivation toward the flipped teaching method among all involved flipped classes. A Gamma value equal to or greater than 0.6 is considered to be significant. As shown in Table 168 in Appendix G, teaching presence items seem to contribute positively and the most toward the motivation of flipped teaching method among all the involved flipped classes. Total number of significant associations related to teaching presence was twenty-one associations. In particular, items of TP1 (The instructor clearly communicated important course topics), TP4 (The instructor clearly communicated important due dates/time frames for learning activities) and TP10 (My Instructor provided clarifying explanations or other feedback that allowed me to better understand the content of the course), were significantly associated with motivation toward the flipped method in three of our flipped groups for each item. Thus, as the flipped method increase the student-instructor interaction through more in-class activities and discussion, this more interaction seem to be associated with students' motivation toward the flipped method. In this study, communicating important course topics and learning activities due dates in addition to providing constructivist feedback were the top teaching presence matters associated with the motivation toward the flipped method.

The next outstanding contributing constructs were cognitive presence and In-class construct, with more contribution showing in the undergraduate flipped classes rather than the graduate ones. Total number of significant associations related to cognitive presence and In-class constructs was seven and eight associations sequentially, where two associations from each construct coming from the graduate classes. Items of CP2 (I felt motivated to explore content related questions), CP7

(Reflection on course content and discussions helped me understand fundamental concepts in this class) and In-class5 (The pre-class preparation helps me better participate and ask questions at the class in comparison to my participation in other courses) were at the top of cognitive presence and In-class construct associations toward the motivation of the flipped method. Thus, the chance of exploration brought by the student-centered structure of the flipped method, along with the chance of more discussions and reflections brought by the in-class activities component, in addition to the chance of more participation due to the pre-class preparation, were the top cognitive presence matters associated with the motivation toward the flipped method.

For the study load construct, which implies that the flipped methodology reduces the study load and stress, only one association was found significant with value of 0.75, however, all the other associations ranged between 0.42 and 0.56, except for one as 0.22. Thus, there is a positive contribution to the study load construct toward the motivation of the flipped teaching method, but it is to a lesser degree than teaching, cognitive and In-class constructs.

On the other hand, learning and social presences show a little contribution to the motivation toward the flipped method in all the flipped classes, with four significant associations related to the learning presence and no significant ones related to the social presence. The insignificance in the association of learning presence and motivation toward the flipped method might be due to the generally the moderate learning presence in our flipped classes, with mean values ranging from 3.64 to 4.00, which is expected as student-centered learning is not the norm. However, the insignificance between the social presence and the motivation toward the flipped method is interesting, as social presence usually plays a big role toward the motivation for the flipped method or active learning. However, in our classes, social presence was not as high as expected and ranges between mean values of 3.83 to 4.17. Thus, there is a need to address the social environment and enhance it in our flipped classes. Given that most of the students came from a lecture-based system with rare social in-class work and discussions, then this may affect the ability of the students to productively participate in the in-class activities and thus would badly reflect on the creation of a productive social learning environment.

6.6. Survey and Academic Performance Analysis – Mathematics undergraduate classes (Flipped versus lecture-based)

6.6.1. RCOI constructs. Overall, students' perceived learning experience in both types of mathematics undergraduate classes, flipped and lecture-based, was positive according to their responses to RCOI constructs as shown in Table 82. The mean values ranged between 3.75 and 4.63 for the flipped group, while for the lecture-based groups, they ranged between 3.45 and 4.41 The median values for the flipped group ranged between 3.83 and 4.90, while for the lecture-based groups, they ranged between 3.33 and 4.40.

It was interesting that the rank of satisfaction for the constructs was similar for the three groups, considering mean and median values. Teaching presence had the highest level of satisfaction, followed by learning presence, cognitive presence and finally social presence.

Table 82: Descriptive statistics of RCOI in mathematics undergraduate classes

Construct	Cal_UG_Flip_GI			Cal_UG_LB_GII			Cal_UG_LB_GIII		
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*
TP	53	4.63 ± 0.47	4.90	49	4.41 ± 0.50	4.40	37	4.08 ± 0.51	4.00
SP	53	3.75 ± 0.73	3.83	49	3.77 ± 0.65	3.67	37	3.45 ± 0.86	3.33
CP	53	4.00 ± 0.72	4.11	49	3.79 ± 0.54	3.78	36	3.68 ± 0.52	3.67
LP	53	4.00 ± 0.56	4.00	49	4.14 ± 0.49	4.00	36	3.89 ± 0.48	3.86

Table 83 and Table 84, present the normality and homogenous of variances tests for RCOI constructs in mathematics undergraduate classes, the flipped group, Cal_UG_Flip_GI and the lecture-based groups, Cal_UG_LB_GII and Cal_UG_LB_GIII. Normality was violated for TP in groups Cal_UG_Flip_GI and Cal_UG_LB_GII, in addition to SP in groups Cal_UG_LB_GII and Cal_UG_LB_GIII. For rest of presences, normality was met. Homogenous of variances was validated for our data in the comparison tests except for data of CP for both comparisons (Cal_UG_Flip_GI and Cal_UG_LB_GII) and (Cal_UG_Flip_GI and Cal_UG_LB_GIII). Thus, for these two comparisons, the results of non-parametric

Mann Whitney U test will be considered for analysis in case of any difference between the parametric and the non-parametric tests.

Table 83: Normality test results of RCOI for mathematics undergraduate classes

Construct	Cal_UG_Flip_GI	Cal_UG_LB_GII	Cal_UG_LB_GIII
T*P*	Not Normal ($p < 0.005$)*	Not Normal ($p < 0.005$)*	Normal ($p = 0.351$)
S*P*	Normal ($p = 0.207$)	Not Normal ($p = 0.013$)*	Not Normal ($p < 0.005$)*
C*P*	Normal ($p = 0.09$)	Normal ($p = 0.524$)	Normal ($p = 0.199$)
L*P*	Normal ($p = 0.282$)	Normal ($p = 0.118$)	Normal ($p = 0.189$)

* $p < 0.05$

Table 84: RCOI Levene's test results between flipped and lecture-based mathematics undergraduate classes

Construct	*p*-value Cal_UG_Flip_GI & Cal_UG_LB_GII	*p*-value Cal_UG_Flip_GI & Cal_UG_LB_GIII
TP	0.616	0.585
SP	0.436	0.407
CP	0.044*	0.043*
LP	0.264	0.227

* $p < 0.05$

As Table 85 describes, according to the two independent samples t-test, teaching presence was statistically significantly higher in the flipped group Cal_UG_Flip_GI with a mean score of (TP: 4.63 ± 0.47) compared to the lecture-based group Cal_UG_LB_GII with a mean score of (TP: 4.41 ± 0.50), with *p*-value of 0.019, and 95% confidence intervals for the mean difference as (0.04 - 0.42). Similarly, the non-parametric Mann-Whitney U test showed that teaching presence was statistically significantly higher in the flipped group Cal_UG_Flip_GI with a median score (TP: 4.90) in comparison to the lecture-based group Cal_UG_LB_GII with a median score (TP: 4.40), with *p*-value of 0.012, and 95% confidence intervals for the median difference as (0 - 0.40). Furthermore, cognitive presence was statistically significantly higher in the flipped group Cal_UG_Flip_GI with median score (TP: 4.11) in compare to the lecture-based group Cal_UG_LB_GII with median score (TP: 3.78), according to Mann-Whitney U test, which is the appropriate statistical test for this comparison as explained before, with *p*-value of 0.038, and 95% confidence intervals for the median difference as (0 - 0.56). On the other hand, social and learning presence showed no statistical difference between the flipped group, Cal_UG_Flip_GI, and the lecture-based group, Cal_UG_LB_GII, according to both the parametric and the non-parametric tests.

Comparing the flipped group, Cal_UG_Flip_GI, to the other lecture-based group, Cal_UG_LB_GIII, presented in Table 85, the results were similar to the comparison to the lecture-based group, Cal_UG_LB_GII. According to the parametric two independent samples t-test and the non-parametric Mann-Whitney U test, teaching presence was statistically significantly higher in the flipped group, Cal_UG_Flip_GI, with mean and median scores of (TP: 4.63 ± 0.47, 4.90), compared to the lecture-based group Cal_UG_LB_GIII, with mean and median scores of (TP: 4.08 ± 0.51, 4.00). The *p* values were 0.000 for both tests, and the 95% confidence interval was (0.35 - 0.77) for mean difference, and (0.40 - 0.90) for median difference. Also, cognitive presence was statistically significantly higher in the flipped group Cal_UG_Flip_GI with a median score (CP: 4.11) compared to the lecture-based group Cal_UG_LB_GIII with a median score (CP: 3.67), according to Mann-Whitney U test, which is the appropriate statistical test for this comparison as explained before, with *p*-value of 0.011, and 95% confidence intervals for the median difference as (0.11 - 0.67). Similarly, social and learning presence showed no statistical difference between the flipped group Cal_UG_Flip_GI, and the other lecture-based group Cal_UG_LB_GIII, according to both the parametric and the non-parametric tests.

Table 85: RCOI 2 independent samples t-test and Mann-Whitney U test between flipped and lecture-based mathematics undergraduate classes

Construct	***t (p)*** **Cal_UG_Flip_GI & Cal_UG_LB_GII**	***W (p)*** **Cal_UG_Flip_GI & Cal_UG_LB_GII**	***t (p)*** **Cal_UG_Flip_GI & Cal_UG_LB_GIII**	***W (p)*** **Cal_UG_Flip_GI & Cal_UG_LB_GIII**
TP	2.39 (0.019)* (0.04, 0.42)	3098.00 (0.012)* (0.00, 0.40)	5.35 (0.000)* (0.35, 0.77)	2974.50 (0.000)* (0.4, 0.9)
SP	-0.17 (0.863) (-0.30, 0.25)	2764.00 (0.819) (-0.17, 0.33)	1.72 (0.089) (-0.05, 0.64)	2596.00 (0.131) (-0.00, 0.67)
CP	1.69 (0.094) (-0.04, 0.46)	3039.50 (0.038)* (0.00, 0.56)	2.42 (0.017)* (0.06, 0.58)	2690.00 (0.011)* (0.11, 0.67)
LP	-1.32 (0.191) (-0.34, 0.07)	2555.50 (0.244) (-0.43, 0.14)	1.03 (0.308) (-0.11, 0.34)	2503.00 (0.324) (-0.14, 0.43)

* $p < 0.05$

Thus, according to the above discussions, mathematics undergraduate flipped classes reported statistically higher teaching and cognitive presences in compare to the lecture-based ones. While social and learning presences showed no statistical differences.

Following the general comparison of each of the RCOI constructs between flipped and lecture-based classes, individual items among each construct were also compared between the flipped group and each of the lecture-based groups, to check for items contributing to the construct presence difference. Only items that are statistically significant for both comparisons, flipped group and each of the lecture-based groups, are considered the significant items for this study.

As presented in Table 86, the statistical significant differences between the flipped group and each of the lecture-based groups for teaching presence are found in items of TP3 (The instructor provided clear instructions on how to participate in course learning activities), TP6 (The instructor helped to keep students engaged and participating in productive dialogue), TP8 (Instructor actions reinforced the development of a sense of community among students) and TP9 (The instructor helped to focus discussion on relevant issues in a way that helped me to learn), with p values ≤ 0.023. Higher presences were reported for the flipped group. Those differences in TP items implies that the instructor presence in the flipped class as a moderator directing students during the class and encouraging them to participate was stratifying for the students and had been positively acknowledged.

As presented in Table 87, for social presence, no statistical difference is found common for both comparisons of the flipped group and each of the lecture-based groups. This matched our earlier conclusion that there is no statistical difference for social presence between the flipped and lecture-based mathematics undergraduate classes. However, this insignificant difference along with relatively low satisfaction is a concern, as the flipped class is supposed to enhance social presence the most in comparison to a lecture-based class, given that in our mathematics lecture-based classes, there is no group activity nor formal in-class activity. Thus, this result implies that an attention is needed towards the group dynamics and students’ cooperation during the in-class activities to promote learning into a community of inquiry.

Table 86: Mann-Whitney U test of TP items between flipped & lecture-based mathematics undergraduate classes

TP Item	Cal_UG_Flip_GI		Cal_UG_LB_GII		Cal_UG_LB_GIII		W (p) GI & GII	W (p) GI & GIII
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
TP1	4.79 ± 0.41	5.00	4.61 ± 0.53	5.00	4.32 ± 0.58	4.00	2942.50 (0.069)	2828.50 (0.000)*
TP2	4.72 ± 0.49	5.00	4.55 ± 0.58	5.00	4.19 ± 0.66	4.00	2920.50 (0.121)	2837.50 (0.000)*
TP3	4.68 ± 0.58	5.00	4.37 ± 0.73	5.00	4.08 ± 0.98	4.00	3035.50 (0.017)*	2768.50 (0.001)*
TP4	4.68 ± 0.55	5.00	4.55 ± 0.61	5.00	3.95 ± 0.88	4.00	2869.00 (0.259)	2893.00 (0.000)*
TP5	4.64 ± 0.59	5.00	4.55 ± 0.68	5.00	4.19 ± 0.74	4.00	2813.00 (0.501)	2757.00 (0.001)*
TP6	4.62 ± 0.71	5.00	4.27 ± 0.67	4.00	4.00 ± 0.82	4.00	3145.50 (0.002)*	2844.00 (0.000)*
TP7	4.49 ± 0.70	5.00	4.33 ± 0.77	4.00	4.19 ± 0.85	4.00	2879.00 (0.264)	2603.50 (0.082)
TP8	4.55 ± 0.64	5.00	4.16 ± 0.75	4.00	3.92 ± 0.72	4.00	3099.00 (0.006)*	2868.50 (0.000)*
TP9	4.60 ± 0.63	5.00	4.29 ± 0.79	4.00	3.97 ± 0.69	4.00	3029.50 (0.023)*	2893.50 (0.000)*
TP10	4.60 ± 0.77	5.00	4.41 ± 0.73	5.00	3.95 ± 0.74	4.00	2971.00 (0.058)	2890.50 (0.000)*

* $p < 0.05$

Table 87: Mann-Whitney U test of SP items between flipped & lecture-based mathematics undergraduate classes

SP Item	Cal_UG_Flip_GI		Cal_UG_LB_GII		Cal_UG_LB_GIII		W (*p*) GI & GII	W (*p*) GI & GIII
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
SP1	3.51 ± 1.28	4.00	3.76 ± 1.11	4.00	3.27 ± 1.15	3.00	2607.00 (0.396)	2555.00 (0.225)
SP2	3.51 ± 1.07	4.00	3.84 ± 0.80	4.00	3.38 ± 1.04	3.00	2536.00 (0.171)	2482.00 (0.545)
SP3	4.11 ± 1.01	4.00	4.04 ± 0.82	4.00	3.70 ± 1.02	4.00	2868.00 (0.324)	2673.50 (0.021)*
SP4	4.06 ± 0.99	4.00	3.88 ± 0.83	4.00	3.51 ± 0.96	4.00	2925.00 (0.163)	2745.00 (0.004)*
SP5	3.62 ± 1.04	4.00	3.41 ± 0.96	3.00	3.32 ± 1.03	3.00	2906.50 (0.214)	2561.50 (0.193)
SP6	3.68 ± 1.02	4.00	3.71 ± 0.87	4.00	3.51 ± 0.99	3.00	2759.50 (0.835)	2531.50 (0.302)

* $p < 0.05$

As presented in Table 88, the statistical differences between the flipped group and each of the lecture-based groups for cognitive presence are found in items of CP1

(In-class group activities increased my interest in the course) and CP6 (Learning activities helped me construct explanations/solutions), with *p* values ≤ 0.004. Higher presences were reported for the flipped group. Those differences in CP1 and CP6 implies that utilizing the time for in-class activities had increased students' interest and challenged them to apply higher-order thinking skills toward constructing solutions.

Table 88: Mann-Whitney U test for of CP items between flipped & lecture-based mathematics undergraduate classes

CP Item	Cal_UG_Flip_GI		Cal_UG_LB_GII		Cal_UG_LB_GIII		W (*p*) GI & GII	W (*p*) GI & GIII
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
CP1	3.93 ± 1.02	4.00	3.37 ± 0.99	3.00	3.36 ± 0.96	3.00	3155.50 (0.003)*	2711.00 (0.004)*
CP2	3.77 ± 1.05	4.00	3.67 ± 0.88	4.00	3.42 ± 0.77	3.00	2833.50 (0.466)	2611.50 (0.047)*
CP3	3.98 ± 1.03	4.00	3.88 ± 0.99	4.00	3.81 ± 0.98	4.00	2822.00 (0.516)	2493.50 (0.340)
CP4	4.00 ± 0.94	4.00	3.96 ± 0.82	4.00	3.72 ± 0.88	4.00	2790.50 (0.667)	2555.00 (0.135)
CP5	4.25 ± 0.83	4.00	4.00 ± 0.79	4.00	3.64 ± 0.76	4.00	2969.00 (0.086)	2778.50 (0.000)*
CP6	4.26 ± 0.92	4.00	3.76 ± 0.78	4.00	3.72 ± 0.88	4.00	3213.50 (0.001)*	2736.50 (0.002)*
CP7	4.21 ± 0.93	4.00	3.98 ± 0.78	4.00	3.92 ± 0.87	4.00	2964.50 (0.093)	2574.00 (0.094)
CP8	3.79 ± 0.99	4.00	3.90 ± 0.77	4.00	3.89 ± 0.62	4.00	2680.00 (0.728)	2356.50 (0.802)
CP9	3.83 ± 1.16	4.00	3.59 ± 0.99	4.00	3.67 ± 0.93	4.00	2939.00 (0.143)	2515.50 (0.255)

* $p < 0.05$

As presented in Table 89, for learning presence, no statistical difference is found common for both comparisons of the flipped group and each of the lecture-based groups. This matched our earlier conclusion that there is no statistical difference for learning presence between the flipped and lecture-based mathematics undergraduate classes. This insignificance difference for learning presence along with moderate to high reported presences in the examined mathematics undergraduate classes may imply the good self-regulation of the participating students.

Table 89: Mann-Whitney U test of LP items between flipped & lecture-based mathematics undergraduate classes

LP Item	Cal_UG_Flip_GI		Cal_UG_LB_GII		Cal_UG_LB_GIII		W (*p*) GI & GII	W (*p*) GI & GIII
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
LP1	3.91 ± 0.84	4.00	4.06 ± 0.80	4.00	3.78 ± 0.87	4.00	2590.50 (0.310)	2447.50 (0.567)
LP2	3.77 ± 1.03	4.00	4.10 ± 0.82	4.00	3.94 ± 0.67	4.00	2505.50 (0.114)	2323.50 (0.589)
LP3	4.11 ± 0.89	4.00	3.98 ± 0.99	4.00	3.67 ± 1.07	4.00	2815.50 (0.543)	2609.00 (0.049)
LP4	4.02 ± 1.17	4.00	4.33 ± 0.75	4.00	4.17 ± 0.81	4.00	2607.00 (0.378)	2383.50 (0.993)
LP5	4.00 ± 0.83	4.00	4.12 ± 0.73	4.00	3.92 ± 0.84	4.00	2633.00 (0.487)	2430.50 (0.686)
LP6	3.94 ± 0.86	4.00	4.06 ± 0.83	4.00	3.78 ± 0.93	4.00	2626.50 (0.466)	2475.50 (0.428)
LP7	4.26 ± 0.81	4.00	4.33 ± 0.72	4.00	3.97 ± 0.65	4.00	2696.50 (0.812)	2612.50 (0.041)*

* $p < 0.05$

6.6.2. In-class understanding and participation construct. Figure 34 shows students responses in the mathematics undergraduate classes, flipped and lecture-based, regarding in-class confidence to ask questions, In-class6 “At the class time, I feel confident asking questions about the lecture topic”.

71.7% in the flipped group Cal_UG_Flip_GI strongly agreed or agreed about being confident to ask questions in the class. The percentages in the lecture-based groups were 77.6% for group Cal_UG_LB_GII and 64.8% for group Cal_UG_LB_GIII. Thus, the percentage in the lecture-based group Cal_UG_LB_GII was the highest considering the top 2 boxes score, however considering the top box score, that is the Strongly Agree, then the flipped group Cal_UG_Flip_GI reported the highest (52.8%), followed by the lecture-based group Cal_UG_LB_GII (42.9%) followed by the lecture-based group Cal_UG_LB_GIII (37.8%).

According to Mann-Whitney U test results presented in Table 90, there is no statistical difference between the flipped and each of the lecture-based groups of mathematics undergraduate classes regarding students’ confidence to ask questions in the class, as the *p*-value for each of the comparisons is greater than 0.05.

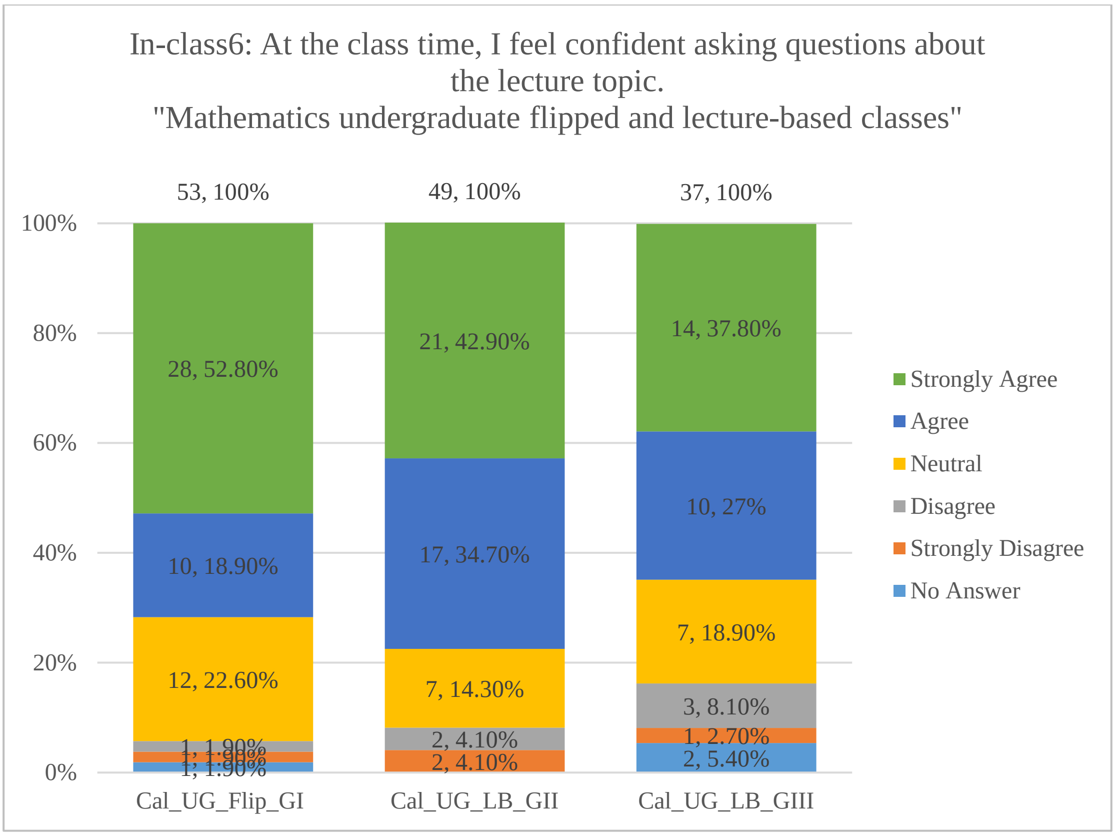

Figure 34: Students' responses to in-class confidence to ask questions (In-class6) – Flipped and lecture-based mathematics undergraduate classes

Table 90: Mann-Whitney U test for in-class confidence to ask questions between flipped & lecture-based mathematics undergraduate classes

Item	**Cal_UG_Flip_GI**			**Cal_UG_LB_GII**			**Cal_UG_LB_GIII**			***W (p)* GI & GII**	***W (p)* GI & GIII**
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ± Std.*	*Median*		
In-class6: In-class confidence to ask questions	52	4.21 ±0.99	5	49	4.08 ±1.06	4	35	3.94 ±1.11	4	2745.00 (0.498) (0, 0)	2415.00 (0.239) (0, 1)

Few students had explained their selection regarding in-class confidence in each group, in response to In-class6: "At the class time, I feel confident asking questions about the lecture topic. Please explain briefly your selection.". 16 students out of 53 (30.19%) responded in the flipped group Cal_UG_Flip_GI, 20 out of 49 (40.82%) responded in the lecture-based group Cal_UG_LB_GII, and 4 students out of 37 (10.81%) responded in the lecture-based group Cal_UG_LB_GIII. Responses of lecture-based groups Cal_UG_LB_GII and Cal_UG_LB_GIII are merged together as they were few and showed similar themes.

Reasons identified for high confidence levels to ask questions in the classes for the flipped and lecture-based groups are summarized in Table 91. This involves responses with Strongly Agree or Agree. As shown before, the main theme for the high confidence of asking questions for students in the flipped group was the pre-class study as reported by 18.86% of respondents. The other mentioned reasons as reported by only two students referred to the instructor's willingness to answer questions and the class environment. On the other hand, reasons identified for high confidence to ask in-class questions in the lecture-based groups were regarding professor welcoming questions in the first place (11.63%), followed by reasons related to students' personality that makes them comfortable to ask questions (8.14%), and finally comments by two students about the class environment. Table 157 in Appendix F shows unedited quoted responses from students regarding high confidence to ask in-class questions in flipped and lecture-based classes.

Table 91: Reasons identified for high confidence level of asking in-class questions – Flipped and lecture-based mathematics undergraduate classes

Identified Reason	Cal_UG_Flip_GI	Cal_UG_LB_GII & Cal_UG_LB_GIII
N	53	86
Pre-class study	10 18.86%	- -
Class environment	1 1.89%	2 2.33%
Professor welcomes questions	1 1.89%	10 11.63%
I am comfortable to ask	- -	7 8.14%
NA	26 49%	44 51.16%

On the other hand, students reporting low confidence to ask questions responding with Neutral, Disagree or Strongly Disagree, did not comment much about the reasons as shown in Table 92. Only 4 students (3.45%) responded from the flipped group Cal_UG_Flip_GI, 5 students (10.20%) from the lecture-based group Cal_UG_LB_GII, and one student (2.70%) from the lecture-based group

Cal_UG_LB_GIII. Responses of lecture-based groups Cal_UG_LB_GII and Cal_UG_LB_GIII are merged together as they are few and they showed similar themes.

From the flipped classes, three students mentioned that they “just don’t ask questions in the class”, and interestingly one student said that he “understand clearly from the videos that” he “did not need to ask that much”. On the other hand, from the lecture-based classes, 4 students mentioned that “just don’t ask questions in the class”, and other two students mentioned about not feeling confident to ask in-class questions. Table 158 in Appendix F shows unedited quoted responses from students regarding low confidence to ask in-class questions in the mathematics undergraduate flipped and lecture-based classes. However, due to low number of responses, there is no theme to consider regarding reasons of low confidence to ask questions in the flipped or lecture-based classes. The only theme for both classroom types is regarding students commenting that they just do not ask in-class questions.

Table 92: Reasons identified for low confidence level of asking in-class questions - Flipped and lecture-based mathematics undergraduate classes

Identified Reason	Cal_UG_Flip_GI	Cal_UG_LB_GII & Cal_UG_LB_GIII
N	53	86
I don't ask in-class questions	3 5.66%	4 4.65%
I did not need to ask that much due to Pre-class study	1 1.89%	- -
I don’t feel confident to ask questions	- -	2 2.33%
NA	10 18.86%	16 18.60%

Figure 35 shows students responses in the mathematics undergraduate classes, flipped and lecture-based, regarding in-class understanding, In-class7 “Generally, at the end of the class, you feel you have understood everything”. 84.9% in the flipped group Cal_UG_Flip_GI has strongly agreed or agreed to the statement about in-class understanding. The percentages in the lecture-based groups were 75.5% for group Cal_UG_LB_GII and 59.4% for group Cal_UG_LB_GIII. Thus, according to the top 2 boxes score, the flipped group has the highest stratification rate regarding the in-class understanding. Furthermore, considering the top box score, that is the strongly agree, the flipped group Cal_UG_Flip_GI was the highest (39.6%) as well, followed by the lecture-based group Cal_UG_LB_GII (30.6%) followed by the lecture-based group Cal_UG_LB_GIII (18.9%).

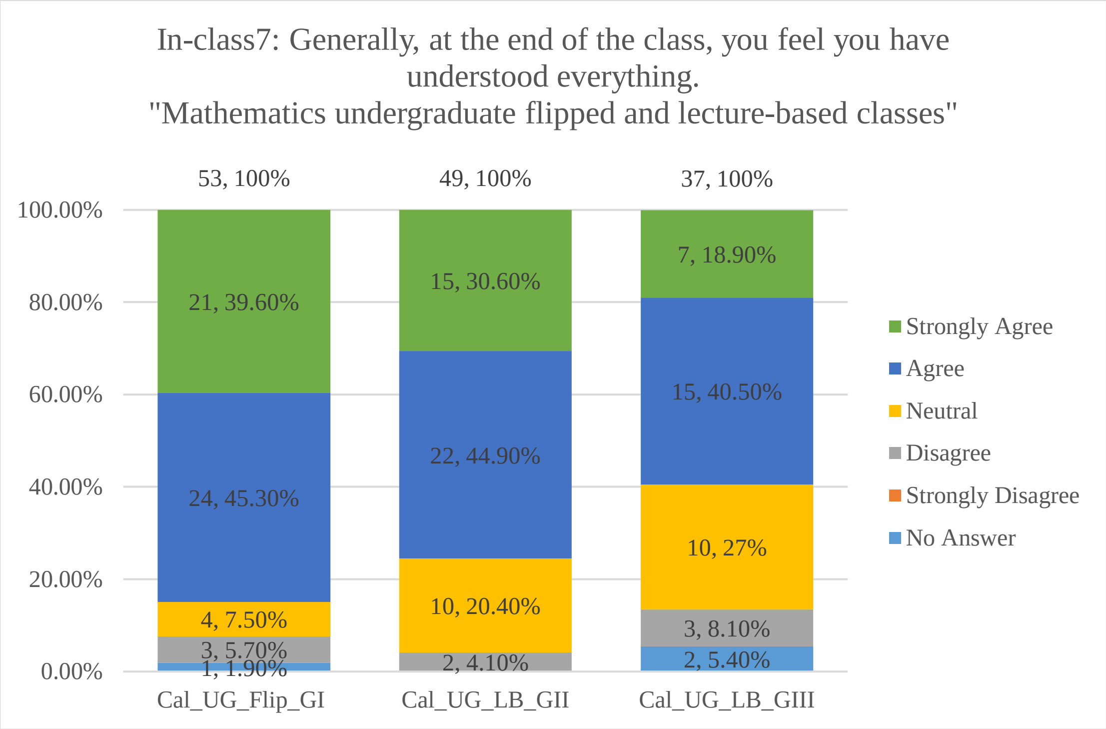

Figure 35: Students' responses to in-class understanding (In-class7) – Flipped and lecture-based mathematics undergraduate classes

According to Mann-Whitney U test results presented in Table 93. The *p*-value for the comparison of the flipped group Cal_UG_Flip_GI and lecture-based group Cal_UG_LB_GII was 0.187 which is higher than 0.05, the cut-off value for a 95% confidence interval. Thus, we can say that there is no statistical difference between the flipped group Cal_UG_Flip_GI and the lecture-based group Cal_UG_LB_GII regarding students' in-class understanding. However, there is a significant difference (p = 0.010) between the flipped group Cal_UG_Flip_GI, and the other lecture-based group Cal_UG_LB_GIII, regarding students' in-class understanding. Although the median score is the same for both groups, but their mean ranks are not, and higher satisfaction rates of in-class understanding are reported in the flipped group.

Therefore, we can say that students' reporting for in-class understanding in the flipped group was statistically similar or higher in comparison to the lecture-based groups.

Table 93: Mann-Whitney U test for in-class understanding between flipped & lecture-based mathematics undergraduate classes

Item	**Cal_UG_Flip_GI**			**Cal_UG_LB_GII**			**Cal_UG_LB_GIII**			***W (p)*** **95%CI GI & GII**	***W (p)*** **95%CI GI & GIII**
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*		
In-class7: In-class understanding	52	4.21 ±0.83	4	49	4.02 ±0.83	4	35	3.74 ±0.89	4	2832.50 (0.187) (0, 1)	2568.00 (0.010) (0, 1)

6.6.3. Study practices items. Figure 36 shows the time by which students usually prepare or study the course material in a non-flipped class for mathematics undergraduate participating classes. The majority of the participating students from the mathematics classes, flipped and lecture-based, reported to prepare "Only few days before the midterm or quiz". The percentage was 55.63% out of the 142 participating students. The next majority of the rest of the students, 26.06% of them, reported to usually prepare "As early as possible after the class time". Finally, the smallest portion, 16.20% of the students, reported preparing "As early as possible before the class time". The breakdown per each mathematics undergraduate class is shown in the figure.

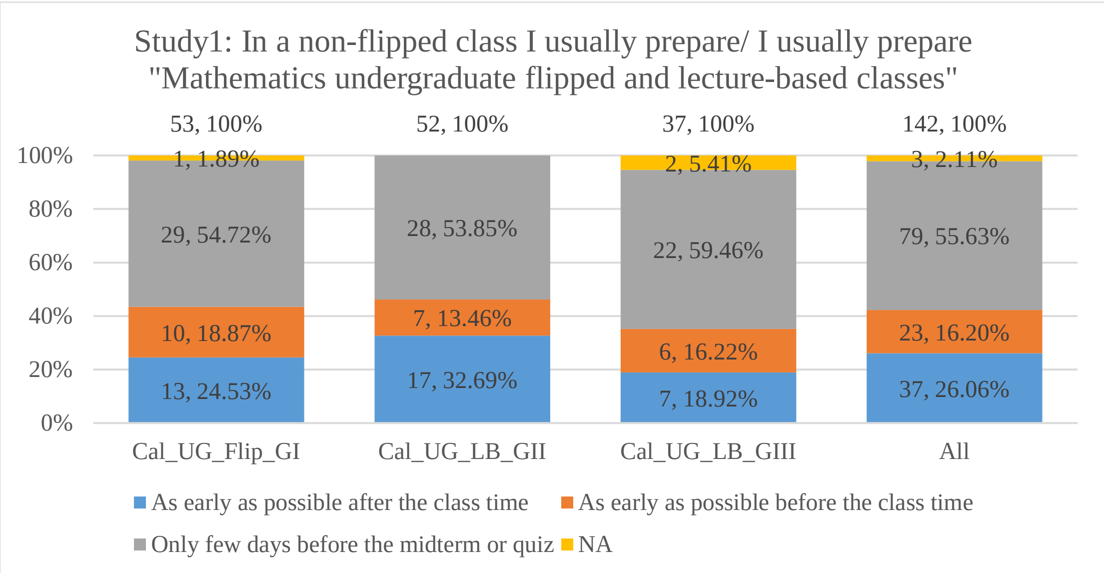

Figure 36: Students' responses for preparation time (Study1) – Mathematics undergraduate flipped and lecture-based classes

Students in both groups, the flipped and lecture-based, were asked if they used the textbook, Study2: "Did you use the textbook". Figure 37 shows their responses. In the flipped classes Cal_UG_Flip_GI, students' responses were almost divided into half reporting the use the textbook (54.72%), while the others do not (45.28%). On the other hand, in each of the lecture-based groups, the majority of students reported using the textbook, 65.31% from group Cal_UG_LB_GII, and 59.46% from group Cal_UG_LB_GIII.

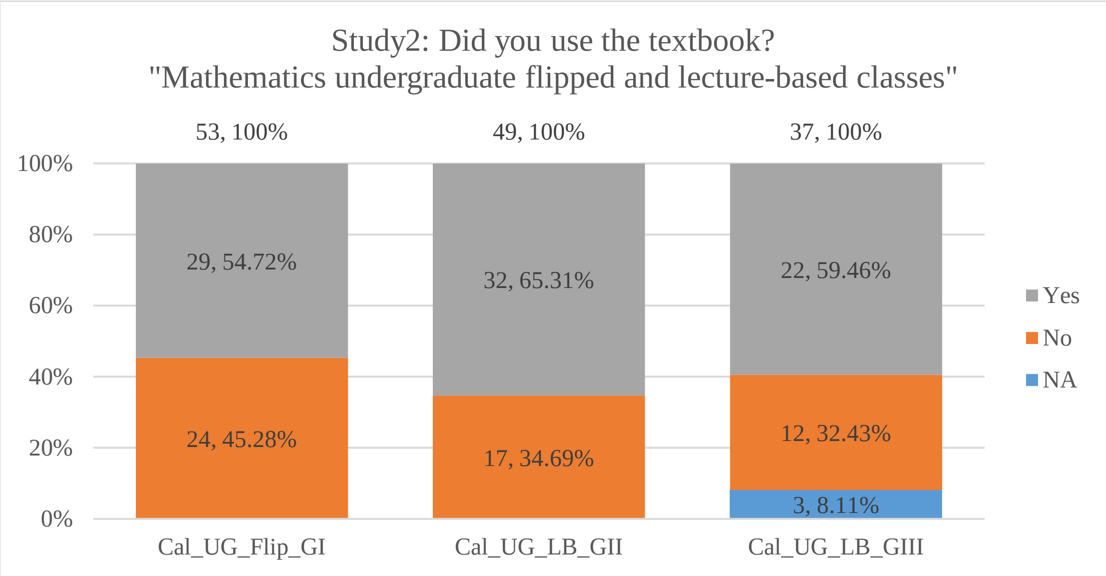

Figure 37: Students' responses for use of textbook (Study2) – Mathematics undergraduate flipped and lecture-based classes

Chi-square test was applied to check if there is a statistical difference between the flipped and each of the lecture-based groups regarding the use of the textbook. As shown in Table 94, the *p*-value for each of the comparison is greater than 0.05, therefore there is insufficient evidence to reject the null hypothesis. So, we can conclude that for mathematics undergraduate classes, there is no statistical difference between the flipped and each of the lecture-based groups regarding the use of the textbook.

Table 94: Chi-square test results for use of textbook between flipped & lecture-based mathematics undergraduate classes

Item		**Cal_UG_Flip_GI**	**Cal_UG_LB_GII**	**Cal_UG_LB_GIII**	**$x^2(p)$ GI & GII**	**$x^2(p)$ GI & GIII**
Study2: Use of textbook	Yes	29	32	22	1.188 (0.276)	0.852 (0.356)
	No	24	17	12		
	NA	-	-	3		

6.6.4. Motivation toward the teaching method items. Figure 38 shows students' responses to their self-report of liking the teaching method of the surveyed course for mathematics' undergraduate classes, both flipped and lecture-based. The question asked was M1: “I liked the teaching style/method of this course?”. 90.56% in the flipped group Cal_UG_Flip_GI strongly agreed or agreed about liking the flipped teaching method. In contrast, the percentages about liking the lecture-based method were 81.63% for group Cal_UG_LB_GII and 59.46% for group Cal_UG_LB_GIII. Thus, the satisfaction percentage in the flipped group Cal_UG_Flip_GI was the highest considering the top 2 boxes score or even the top box score.

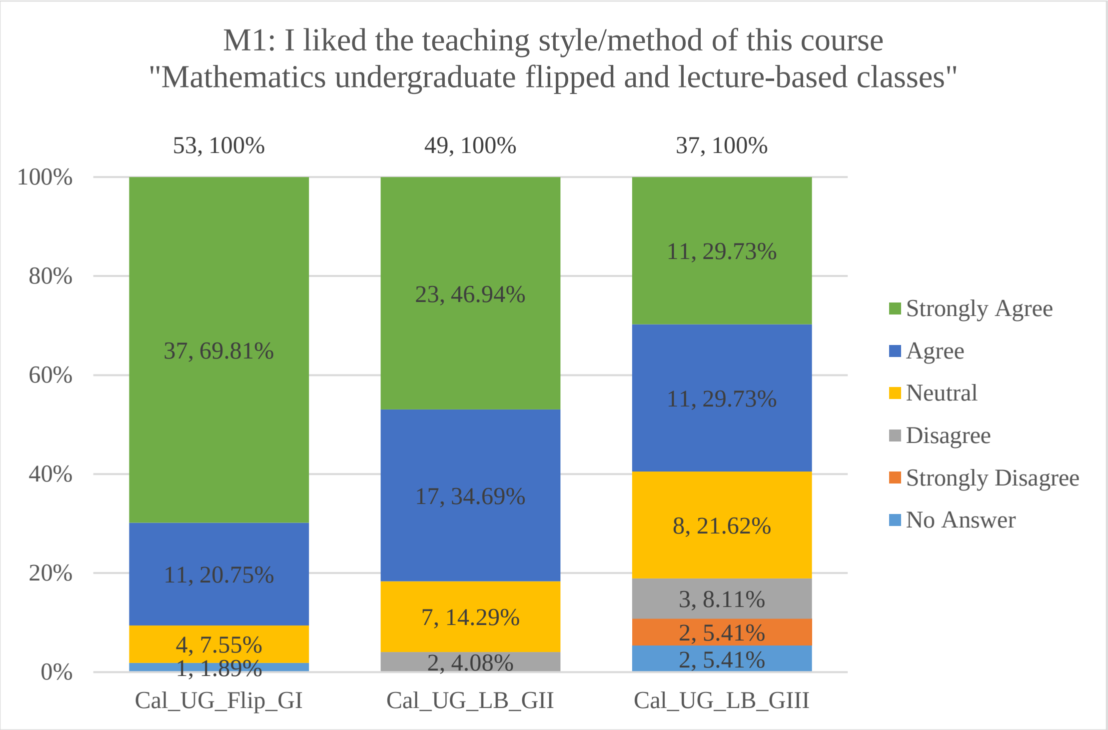

Figure 38: Students’ responses to regarding liking the teaching method (M1) - Mathematics undergraduate flipped and lecture-based classes

A Mann-Whitney U test with 95% confidence interval showed that there was a statistically significant difference regarding liking the teaching method between the flipped group Cal_UG_Flip_GI and each of the lecture-based groups, Cal_UG_LB_GII: (p = 0.026), Cal_UG_LB_GIII: (p = 0.000), with median score of 5.00 for the flipped group, and 4.00 for both lecture-based groups. The 95% confidence intervals for median differences was (0 - 1) for both comparisons. Mann-Whitney U test results for liking the teaching method in the mathematics undergraduate classes are shown in Table 95. Thus, students in the mathematics undergraduate flipped classes like the teaching method statistically more than their peers in the lecture-based classes.

Table 95: Mann-Whitney U test for Like of teaching method between flipped & lecture-based mathematics undergraduate classes

Item	Cal_UG_Flip_GI			Cal_UG_LB_GII			Cal_UG_LB_GIII			*W (p)* 95%CI GI & GII	*W (p)* 95%CI GI & GIII
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*		
M1: I liked the teaching style/method of this course	52	4.64 ±0.63	5.00	49	4.25 ±0.86	4.00	35	3.74 ±1.17	4.00	2980 (0.026) (0, 1)	2709 (0.000) (0, 1)

6.6.5. Academic performance. As shown before in section 6.2.2, pre-course CGPA, gender, age and level of study carry no statistical difference between the flipped group Cal_UG_Flip_GI and each of the lecture-based groups Cal_UG_LB_GII and Cal_UG_LB_GIII, considering demographics of all students (Table 23) enrolled in the participating classes, which is the comparison scope for academic performance.

The students' grade frequency distribution is shown in Figure 39 and Table 96. Failure rate, that is percentage of D and F grades, was 19.36% in the flipped group Cal_UG_Flip_GI, 29.51% in the lecture-based group Cal_UG_LB_GII, and 30.36% in the lecture-based group Cal_UG_LB_G III. Thus, the failure rate was lower in the flipped group with about 10%. Furthermore, percentage of students scoring between A and B- was 48.38% in the flipped group Cal_UG_Flip_GI, in comparison to 29.52% in the lecture-based group Cal_UG_LB_GII, and 30.36% in the lecture-based group Cal_UG_LB_GIII. Thus, the percentage of students scoring between A and B- was higher in the flipped group with about 18%, in comparisons to the lecture-based groups.

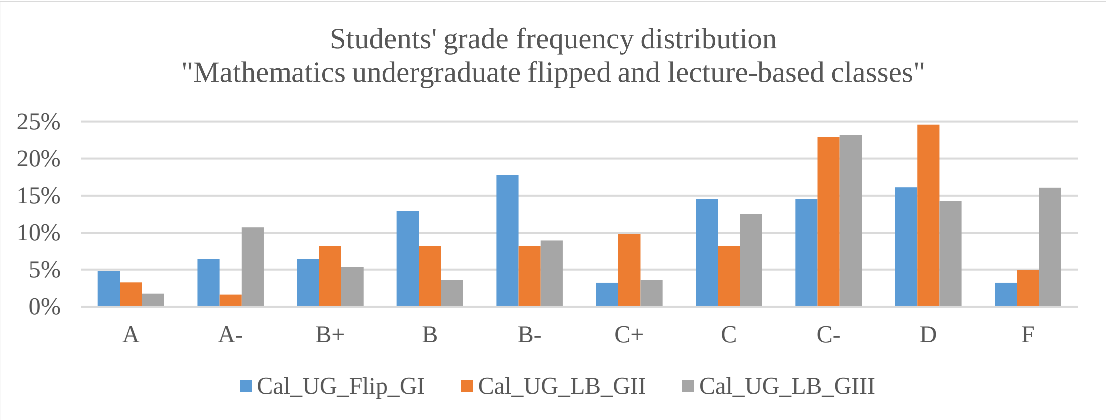

Figure 39: Students' grade frequency distribution - Mathematics undergraduate flipped and lecture-based classes

Table 96: Students' grade frequency distribution - Mathematics undergraduate flipped and lecture-based classes

Class	A	A-	B+	B	B-	C+	C	C-	D	F	All
Cal_UG_Flip_GI	3	4	4	8	11	2	9	9	10	2	62
	4.84%	6.45%	6.45%	12.9%	17.74%	3.23%	14.52%	14.52%	16.13%	3.23%	100%
Cal_UG_LB_GII	2	1	5	5	5	6	5	14	15	3	61
	3.28%	1.64%	8.2%	8.2%	8.2%	9.84%	8.2%	22.95%	24.59%	4.92%	100%
Cal_UG_LB_GIII	1	6	3	2	5	2	7	13	8	9	56
	1.79%	10.71%	5.36%	3.57%	8.93%	3.57%	12.5%	23.21%	14.29%	16.07%	100%

Figure 40 shows the descriptive statistics of students' course grades for mathematics undergraduate flipped and lecture-based classes. Considering the equivalent GPA point for each letter grade, Mann-Whitney U test with 95% confidence interval was conducted to check for statistical significance between the flipped group and each of the lecture-based groups.

As per the results presented in Table 97, the Mann-Whitney U test results showed that the course grades of students were statistically significantly higher in the flipped group Cal_UG_Flip_GI, with a median score of (2.3), in comparison to the lecture-based group Cal_UG_LB_GII, with a median score of (1.7). The *p*-value was 0.057, and the estimated difference was 0.3, with 95% confidence interval for the median difference as (0 - 0.7). The course grades of students in the flipped group Cal_UG_Flip_GI, were also statistically higher than the course grades of students in the other lecture-based group Cal_UG_LB_GIII, with a median score of (1.7). The *p*-value was 0.043, and the estimated difference was 0.3, with 95% confidence interval for the median difference as (0 - 1.0).

Thus, students in the mathematics undergraduate flipped classes are scoring higher than their peers in the lecture-based classes with 95% confident about median difference range (0.0 - 0.7). Given that the students' demographic data carry no significant difference, and that the exam and course assessments were the same for all our studied classes, then this result is significant.

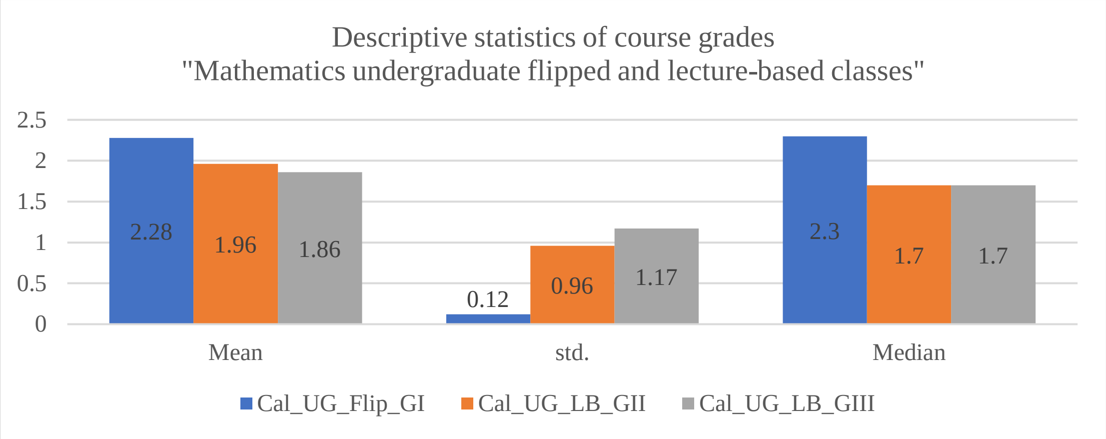

Figure 40: Descriptive statistics of course grades - Mathematics undergraduate flipped and lecture-based classes

Table 97: Mann-Whitney U test for course grades data between flipped & lecture-based mathematics undergraduate classes

Factor	**Cal_UG_Flip_GI**			**Cal_UG_LB_GII**			**Cal_UG_LB_GIII**			***W (p)* 95%CI GI & GII**	***W (p)* 95%CI GI & GIII**
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*		
Course grade	62	2.28± 0.12	2.30	61	1.96 ±0.96	1.7	56	1.86 ±1.17	1.7	4217.00 (0.057) (0, 0.7)	4062.00 (0.043) (0, 1.0)

6.7. Survey and Academic Performance Analysis – Engineering undergraduate classes (Flipped versus lecture-based)

6.7.1. RCOI constructs. As shown earlier in section 6.1.2, flipped classes Eng_UG_Flip_A and Eng_UG_Flip_B were validated for merge through checking RCOI constructs. Only CP showed slightly significant different with (p-value = 0.05).

Lecture-based classes were not validated for merge and are to be considered each alone. Since CP showed a slightly significant difference, and the RCOI constructs presences were higher in flipped class Eng_UG_Flip_A than in class Eng_UG_Flip_B, we decided to compare both Eng_UG_Flip_GI and class Eng_UG_Flip_A to each of the lecture-based classes (Eng_UG_LB_C and Eng_UG_LB_D), in order to avoid any wrong conclusions by considering only Eng_UG_Flip_GI where the average of RCOI constructs is lower than the individual class Eng_UG_Flip_A, especially for CP.

Table 98 and Table 99 show the normality and homogenous of variances tests for data involved in the comparison of flipped and lecture-based engineering undergraduate classes. Normality was validated for all RCOI constructers for the flipped group Eng_UG_Flip_GI and class Eng_UG_Flip_A, but not for lecture-based classes. Homogenous of variances was validated for all our data in the comparison tests except for data of TP for comparisons of Eng_UG_Flip_GI and Eng_UG_LB_C. Thus, for this comparison, the results of non-parametric Mann Whitney U test will be considered for analysis in case of difference between the parametric and non-parametric tests.

Table 98: Normality test results of RCOI for engineering undergraduate classes

Construct	Eng_UG_A_Flip	Eng_UG_Flip_GI	Eng_UG_LB_C	Eng_UG_LB_D
TP	Normal (p = 0.175)	Normal (p = 0.081)	Not Normal (p<0.005)*	Not Normal (p<0.005)*
SP	Normal (p = 0.088)	Normal (p = 0.101)	Not Normal (p = 0.022)	Normal (p = 0.307)
CP	Normal (p = 0.217)	Normal (p = 0.421)	Not Normal (p<0.005)*	Normal (p = 0.052)
LP	Normal (p = 0.103)	Normal (p = 0.052)	Normal (p = 0.262)	Not Normal (p = 0.033)*

* $p < 0.05$

Table 99: RCOI Levene's test results between flipped and lecture-based engineering undergraduate classes

Construct	***p*-value Eng_UG_Flip_A & Eng_UG_LB_C**	***p*-value Eng_UG_Flip_GI & Eng_UG_LB_C**	***p*-value Eng_UG_Flip_A & Eng_UG_LB_D**	***p*-value Eng_UG_Flip_GI & Eng_UG_LB_D**
TP	0.097	0.008*	0.475	0.651
SP	0.112	0.302	0.403	0.845
CP	0.710	0.498	0.769	0.885
LP	0.097	0.097	0.995	0.958

* $p < 0.05$

In comparison to the lecture-based class Eng_UG_LB_C, presented in Table 100, according to the parametric two independent samples t-test, the teaching and cognitive presences were statistically significantly higher in the lecture-based class Eng_UG_LB_C with mean values of (TP: 4.70 ± 0.40, CP: 4.40 ± 0.66) compared to the flipped class Eng_UG_Flip_A with mean scores of (TP: 3.87 ± 0.67, CP: 3.82 ± 0.74). The *p* values were (TP: 0.000, CP: 0.005), and the 95% confidence intervals for the mean differences were TP (0.51 - 1.15), CP (0.18 - 0.98). Similarly, according to the non-parametric Mann-Whitney U test, the teaching and cognitive presences were statistically significantly higher in the lecture-based class Eng_UG_LB_C with median values of (TP: 4.90, CP: 4.33) compared to the flipped class Eng_UG_Flip_A with median scores of (TP: 3.80, CP: 3.78). The *p* values were (TP: 0.000, CP: 0.002), and the 95% confidence intervals for the median differences were TP (0.5 - 1.2), CP (0.22 - 1).

Comparing the lecture-based class Eng_UG_LB_C to the flipped group Eng_UG_Flip_GI, then similar results were found as shown in Table 101. According to the parametric two independent samples t-test, the teaching and cognitive presences were statistically significantly higher in the lecture-based class Eng_UG_LB_C with mean values of (TP: 4.70 ± 0.40, CP: 4.40 ± 0.66) in compare to the flipped group Eng_UG_Flip_GI with mean scores of (TP: 3.76 ± 0.76, CP: 3.65 ± 0.78). The *p* values were (TP: 0.000, CP: 0.000), and the 95% confidence intervals for the mean differences were TP (0.66 - 1.23), CP (0.36 - 1.13). Similarly, according to the non-parametric Mann-Whitney U test, the teaching and cognitive presences were statistically significantly higher in the lecture-based class Eng_UG_LB_C with median values of (TP: 4.90, CP: 4.33) in comparison to the flipped group Eng_UG_Flip_GI with median scores of (TP: 3.80, CP: 3.78). The *p* values were (TP: 0.000, CP: 0.000), and the 95% confidence intervals for the median differences were TP (0.6 - 1.2), CP (0.44 - 1.11).

On the other hand, social and learning presence showed no statistical difference between the lecture-based class, Eng_UG_LB_C, and each of the flipped class Eng_UG_Flip_A and group Eng_UG_Flip_GI, according to both parametric and non-parametric tests results, as *p* values were greater than 0.05 as shown in Table 100 and Table 101.

Table 100: RCOI 2 independent samples t-test and Mann-Whitney U test between engineering undergraduate flipped class (Cal_UG_Flip_A) & lecture-based class (Cal_UG _LB_C)

Construct	**Eng_UG_Flip_A**			**Eng_UG_LB_C**			***t (p)*** **A & C**	***W (p)*** **A & C**
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*		
TP	29	3.87 ± 0.67	3.80	23	4.70 ± 0.40	4.90	-5.23 (0.000)* (-1.15, -0.51)	525.00 (0.000)* (-1.2, -0.5)
SP	29	4.12 ± 0.59	4.00	23	4.11 ± 0.90	4.33	0.09 (0.932) (-0.40, 0.44)	742.50 (0.636) (-0.5, 0.33)
CP	29	3.82 ± 0.74	3.78	23	4.40 ± 0.66	4.33	-2.93 (0.005)* (-0.98, -0.18)	600.00 (0.002)* (-1, -0.22)
LP	29	3.96 ± 0.48	4.14	23	4.04 ± 0.67	4.00	-0.48 (0.635) (-0.40, 0.25)	758.50 (0.860) (-0.43, 0.29)

* $p < 0.05$

Table 101: RCOI 2 independent samples t-test and Mann-Whitney U test between engineering undergraduate flipped group (Cal_UG_Flip_GI) & lecture-based class (Cal_UG _LB_C)

Construct	Eng_UG_Flip_GI			Eng_UG_LB_C			***t (p)*** **GI & C**	***W (p)*** **GI & C**
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*		
TP	44	3.76 ± 0.76	3.80	23	4.70 ± 0.40	4.90	-6.66 (0.000)* (-1.23, -0.66)	1125.50 (0.000)* (-1.2, -0.6)
SP	44	3.996 ± 0.72	4.00	23	4.11 ± 0.90	4.33	-0.56 (0.579) (-0.52, 0.29)	1424.50 (0.346) (-0.67, 0.17)
CP	44	3.65 ± 0.78	3.78	23	4.40 ± 0.66	4.33	-3.89 (0.000)* (-1.13, -0.36)	1206.50 (0.000)* (-1.11, -0.44)
LP	44	3.92 ± 0.50	4.00	23	4.04 ± 0.67	4.00	-0.75 (0.453) (-0.40, 0.18)	1462.00 (0.657) (-0.43, 0.14)

* $p < 0.05$

Looking into the comparison to the other lecture-based class Eng_UG_LB_D, according to Mann-Whitney U test, teaching presence was statistically significantly higher in the lecture-based class Eng_UG_LB_D with median score (4.40) in comparison to the flipped class Eng_UG_Flip_A with median score (3.80) and group Eng_UG_Flip_GI with median score (3.80). The *p* values were 0.051, 0.018 sequentially, and the 95% confidence intervals for median differences were (0 - 0.7), and (0.10 - 0.80) sequentially, as shown in Table 102 and Table 103. However, two independent samples t-test did not show significant difference for TP. Noting that TP was not normal in lecture-based class Eng_UG_LB_D, then we are considering the results of Mann-Whitney U test for the TP comparison.

According to two independent samples t-test, social presence was statistically significantly higher in the flipped class Eng_UG_Flip_A with mean score of (4.12 ± 0.59) in comparison to the lecture-based class Eng_UG_LB_D with mean score of (3.76 ± 0.69), with *p*-value of 0.040, and 95% confidence intervals for mean difference as (0.02 - 0.72) as presented in Table 102. The non-parametric Mann-Whitney U test showed that social presence was slightly significantly higher in the flipped class Eng_UG_Flip_A with median score of (4.00) in comparison to the lecture-based class Eng_UG_LB_D with median score of (3.67), with *p*-value of 0.080, and 95% confidence intervals for median difference as (0.0 - 0.67). However, as presented in Table 103, social presence did not show significant difference when considering the flipped group Eng_UG_Flip_GI in comparison to lecture-based class Eng_UG_LB_D according to both parametric and non-parametric tests results.

Cognitive and learning presences showed no statistical difference between the lecture-based class, Eng_UG_LB_D, and each of the flipped class Eng_UG_Flip_A and group Eng_UG_Flip_GI, according to both parametric and non-parametric tests results, as *p* values were greater than 0.05 for all the comparison tests.

Table 102: RCOI 2 independent samples t-test and Mann-Whitney U test between engineering undergraduate flipped class (Cal_UG_Flip_A) & lecture-based class (Cal_UG _LB_D)

Construct	Eng_UG_Flip_A			Eng_UG_LB_D			***t (p)* A & D**	***W (p)* A & D**
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*		
TP	29	3.87 ± 0.674	3.80	24	4.10 ± 0.85	4.40	-1.12 (0.267) (-0.66, 0.19)	673.50 (0.051)* (-0.7, 0.0)
SP	29	4.12 ± 0.59	4.00	24	3.76 ± 0.69	3.67	2.10 (0.040)* (0.02, 0.72)	881.00 (0.080) (0.0, 0.67)
CP	29	3.82 ± 0.74	3.78	24	3.46 ± 0.81	3.56	1.69 (0.097) (-0.07, 0.79)	865.00 (0.144) (-0.11, 0.67)
LP	29	3.96 ± 0.48	4.14	24	3.79 ± 0.49	3.86	1.30 (0.201) (-0.10, 0.45)	873.00 (0.107) (0.0, 0.43)

* $p < 0.05$

Table 103: RCOI 2 independent samples t-test and Mann-Whitney U test between engineering undergraduate flipped group (Cal_UG_Flip_Group I) & lecture-based class (Cal_UG _LB_D)

Construct	Eng_UG_Flip_GI			Eng_UG_LB_D			***t (p)* GI & D**	***W (p)* GI & D**
	N	*Mean ± Std.*	*Median*	*N*	*Mean ± Std.*	*Median*		
TP	44	3.76 ±0.76	3.80	24	4.10 ±0.85	4.400	-1.72 (0.090) (-0.750, 0.055)	1333.50 (0.018)* (-0.8, -0.10)
SP	44	3.996 ±0.72	4.00	24	3.76 ±0.69	3.67	1.33 (0.187) (-0.119, 0.597)	1621.00 (0.187) (-0.17, 0.67)
CP	44	3.65 ±0.78	3.78	24	3.46 ±0.81	3.56	0.97 (0.334) (-0.206, 0.598)	1581.00 (0.422) (-0.22, 0.56)
LP	44	3.92 ±0.50	4.00	24	3.79 ±0.49	3.86	1.14 (0.258) (-0.107, 0.393)	1635.50 (0.131) (0.0, 0.43)

* $p < 0.05$

According to the above discussion about comparing each of the flipped class Eng_UG_Flip_A and group Eng_UG_Flip_GI to each of the lecture-based classes Eng_UG_LB_C and Eng_UG_LB_D, it was found that only for SP, the flipped class

Eng_UG_Flip_A showed significantly higher presence in comparison to lecture-based class Eng_UG_LB_D, but the flipped group Eng_UG_Flip_GI did not show any significant different. For all other comparisons, flipped class Eng_UG_Flip_A and group Eng_UG_Flip_GI showed the same results. This difference in SP can be due to relatively low response rate for class Eng_UG_Flip_B (40.54%: 15 out of 37) as shown earlier in Table 13. Thus, our merge of flipped classes into one flipped group Eng_UG_Flip_GI is safe to be considered for further analysis.

As shown above, the flipped group Eng_UG_Flip_GI showed statistically significant difference in teaching presence in comparison to both lecture-based classes Eng_UG_LB_C and Eng_UG_LB_D, with higher presence in the lecture-based classes. Furthermore, cognitive presence was significantly higher in the lecture-based class Eng_UG_LB_C in compare to the flipped group Eng_UG_Flip_GI.

The highest satisfied presence for the flipped group Eng_UG_Flip_GI was social presence, followed by learning presence, teaching presence and finally cognitive presence as shown in Table 103. The mean values ranged between 3.65 and 3.996 for the flipped group, and the median values ranged between 3.78 and 4.00. Both of the lecture-based classes Eng_UG_LB_C and Eng_UG_LB_D had reported the teaching presence as the highest satisfaction construct. The rest of presences order was different for each lecture-based class as shown in Table 101 and Table 103. The mean values ranged between 3.46 and 4.70 for the lecture-based classes, and the median values ranged between 3.56 and 4.90.

Looking into individual item differences, as presented in Table 104, the statistical significant difference between the flipped group and each of the lecture-based classes for teaching presence is found in items of TP1 (The instructor clearly communicated important course topics), TP2 (The instructor clearly communicated important course goals), TP4 (The instructor clearly communicated important due dates/time frames for learning activities), TP5 (The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking) and TP10 (My Instructor provided clarifying explanations or other feedback that allowed me to better understand the content of the course).

Higher presences were reported for lecture-based classes. Those differences in TP items implies that instructor presence in the lecture-based classes was acknowledged more. Thus, this implies a concern in the design of the flipped engineering undergraduate classes, as the TP was reported higher in both lecture-based classes involved in the comparison.

Table 104: Mann-Whitney U test of TP items between flipped & lecture-based engineering undergraduate classes

TP Item	Eng_UG_Flip_GI		Eng_UG_LB_C		Eng_UG_LB_D		W (*p*) GI & C	W (*p*) GI & D
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
TP1	3.80 ± 0.88	4.00	4.70 ± 0.56	5.00	4.38 ± 0.92	5.00	1186.00 (0.000)*	1298.50 (0.002)*
TP2	4.02 ± 0.79	4.00	4.74 ± 0.45	5.00	4.29 ± 1.00	4.50	1227.50 (0.000)*	1382.50 (0.055)
TP3	3.82 ± 0.97	4.00	4.61 ± 0.58	5.00	3.96 ± 1.20	4.00	1247.50 (0.000)*	1444.00 (0.312)
TP4	3.23 ± 1.22	3.00	4.61 ± 0.50	5.00	4.13 ± 0.99	4.00	1156.00 (0.000)*	1156.00 (0.000)*
TP5	3.36 ± 1.16	4.00	4.78 ± 0.52	5.00	4.38 ± 1.10	5.00	1129.50 (0.000)*	1241.50 (0.000)*
TP6	3.89 ± 1.04	4.00	4.70 ± 0.56	5.00	4.25 ± 1.03	5.00	1251.00 (0.000)*	1392.50 (0.087)
TP7	4.25 ± 0.78	4.00	4.70 ± 0.47	5.00	3.92 ± 0.97	4.00	1325.50 (0.012)*	1616.50 (0.168)
TP8	3.68 ± 1.10	4.00	4.74 ± 0.45	5.00	3.58 ± 1.18	4.00	1192.00 (0.000)*	1542.00 (0.753)
TP9	3.82 ± 1.00	4.00	4.70 ± 0.47	5.00	4.00 ± 0.98	4.00	1225.00 (0.000)*	1458.00 (0.415)
TP10	3.71 ± 0.95	4.00	4.74 ± 0.45	5.00	4.17 ± 0.87	4.00	1177.50 (0.000)*	1367.50 (0.040)*

* $p < 0.05$

As presented in Table 105, for social presence, no statistical difference is found common for both comparisons of the flipped group and each of the lecture-based classes. This matches our earlier conclusion that there is no statistical difference for social presence between the flipped and lecture-based learning engineering undergraduate classes.

The reported social presence was moderate to high in all involved classes, both flipped and lecture-based, thus, this insignificance difference may raise a concern, as social presence is expected to be the most enhanced factor in the flipped classes and thus be significantly higher than in the lecture-based classes. However, as the reported SP was moderate to high in the lecture-based classes as well, then this implies that continuous in-class problem activities applied in these classes, in addition to group projects, create a good social presence.

Table 105: Mann-Whitney U test of SP items between flipped & lecture-based engineering undergraduate classes

SP Item	Eng_UG_Flip_GI		Eng_UG_LB_C		Eng_UG_LB_D		W (*p*) GI & C	W (*p*) GI & D
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
SP1	4.07 ± 0.97	4.00	3.78 ± 1.13	4.00	3.38 ± 1.25	3.50	1565.50 (0.338)	1688.50 (0.023)*
SP2	4.14 ± 0.88	4.00	4.09 ± 1.00	4.00	3.83 ± 0.70	4.00	1499.50 (0.966)	1650.00 (0.070)
SP3	3.91 ± 0.96	4.00	4.26 ± 1.21	5.00	4.00 ± 1.02	4.00	1356.00 (0.051)	1479.00 (0.602)
SP4	4.14 ± 0.77	4.00	4.30 ± 1.02	5.00	3.96 ± 0.91	4.00	1398.00 (0.163)	1577.00 (0.418)
SP5	3.89 ± 0.84	4.00	4.13 ± 1.29	5.00	3.63 ± 1.01	4.00	1363.50 (0.065)	1589.00 (0.331)
SP6	3.84 ± 0.91	4.00	4.09 ± 0.95	4.00	3.75 ± 0.90	4.00	1411.50 (0.237)	1542.00 (0.742)

* $p < 0.05$

As presented in Table 106, the statistical difference between the flipped group and each of the lecture-based classes for cognitive presence is found in item of CP3 (I used a variety of information sources to deepen my understanding in this course). However, this is not the difference we are considering, as for this item, lecture-based class Eng_UG_LB_C reported higher than the flipped group, while the flipped group reported higher than the lecture-based class Eng_UG_LB_D.

Our concerned items are those that are reported in the flipped classes as significantly higher or lower in comparison to both lecture-based classes. This matched our earlier conclusion that cognitive presence is reported significantly lower in the flipped group Eng_UG_Flip_GI in comparison to the lecture-based class Eng_UG_LB_C, but there is no difference in comparison to lecture-based class Eng_UG_LB_D. Thus, this reported lower significance difference implies some concern in the design of the flipped class, which can be associated with the lower reported teaching presence as well.

Table 106: Mann-Whitney U test of CP items between flipped & lecture-based engineering undergraduate classes

CP Item	**Eng_UG_Flip_GI**		**Eng_UG_LB_C**		**Eng_UG_LB_D**		**W (*p*) GI & C**	**W (*p*) GI & D**
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
CP1	3.55 ± 1.17	4.00	4.44 ± 0.95	5.00	3.38 ± 1.28	4.00	1268.50 (0.002)*	1553.50 (0.644)
CP2	3.59 ± 1.11	4.00	4.22 ± 0.95	4.00	3.21 ± 1.25	3.50	1321.00 (0.015)*	1608.00 (0.231)
CP3	3.66 ± 1.03	4.00	4.17 ± 0.98	4.00	3.00 ± 1.29	3.00	1341.50 (0.033)*	1666.50 (0.049)*
CP4	3.64 ± 1.04	4.00	4.13 ± 1.06	4.00	3.25 ± 1.07	3.00	1341.00 (0.031)*	1630.00 (0.131)
CP5	3.75 ± 0.89	4.00	4.39 ± 0.94	5.00	3.50 ± 0.93	4.00	1274.50 (0.002)*	1587.00 (0.348)
CP6	3.55 ± 1.11	4.00	4.39 ± 1.03	5.00	3.75 ± 1.07	4.00	1254.00 (0.001)*	1455.00 (0.400)
CP7	3.77 ± 0.77	4.00	4.70 ± 0.47	5.00	3.83 ± 0.96	4.00	1167.50 (0.000)*	1483.00 (0.628)
CP8	3.68 ± 0.91	4.00	4.57 ± 0.59	5.00	3.63 ± 0.82	4.00	1213.00 (0.000)*	1528.50 (0.887)
CP9	3.71 ± 0.93	4.00	4.61 ± 0.50	5.00	3.58 ± 1.14	4.00	1208.00 (0.000)*	1528.00 (0.896)

* $p < 0.05$

As presented in Table 107, for learning presence, no statistical difference is found common for both comparisons of flipped group and each of the lecture-based classes, which matched our earlier conclusion that there is no statistical difference for learning presence between the flipped and lecture-based engineering undergraduate classes.

Like the results of mathematics undergraduate classes, this insignificance difference for learning presence along with moderate to high reported presences in the examined engineering undergraduate classes may imply the good self-regulation of the participating students.

Table 107: Mann-Whitney U test of LP items between flipped & lecture-based engineering undergraduate classes

LP Item	Eng_UG_Flip_GI		Eng_UG_LB_C		Eng_UG_LB_D		W (*p*) GI & C	W (*p*) GI & D
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
LP1	3.80 ± 0.85	4.00	4.00 ± 0.85	4.00	3.67 ± 0.87	4.00	1432.50 (0.370)	1569.00 (0.486)
LP2	3.89 ± 0.69	4.00	4.04 ± 1.02	4.00	3.54 ± 1.06	4.00	1407.50 (0.195)	1611.00 (0.185)
LP3	3.98 ± 0.76	4.00	3.91 ± 1.08	4.00	3.75 ± 0.90	4.00	1491.50 (0.954)	1593.00 (0.255)
LP4	4.23 ± 0.94	4.00	4.09 ± 1.13	4.00	4.13 ± 0.74	4.00	1510.50 (0.841)	1587.00 (0.335)
LP5	3.57 ± 0.93	4.00	4.22 ± 0.74	4.00	3.63 ± 1.01	4.00	1305.00 (0.006)*	1501.00 (0.817)
LP6	3.80 ± 0.98	4.00	3.78 ± 1.09	4.00	3.83 ± 0.82	4.00	1491.00 (0.949)	1521.00 (0.972)
LP7	4.25 ± 0.65	4.00	4.22 ± 0.74	4.00	3.96 ± 0.96	4.00	1497.00 (0.994)	1600.00 (0.252)

* $p < 0.05$

6.7.2. In-class understanding and participation construct. Figure 41 shows students' responses in the engineering undergraduate classes regarding in-class confidence to ask questions, In-class6 "At the class time, I feel confident asking questions about the lecture topic", for the flipped group Eng_UG_Flip_GI, and the lecture-based classes Eng_UG_LB_C and Eng_UG_LB_D. Considering the top 2 boxes score, the highest satisfaction was reported in lecture-based class (Eng_UG_LB_C) with 86.96% of the students as strongly agreeing or agreeing about being confident to ask questions in the class. This was followed by 79.16% from the lecture-based class Eng_UG_LB_D and finally the flipped group Eng_UG_Flip_GI (59.09%). Similar satisfaction order applies considering the top box score, that is the strongly agree responses.

According to Mann-Whitney U test results presented in Table 108, students in the lecture-based class (Eng_UG_LB_C) reported statistically significantly higher confidence to ask in-class questions with median score (5.00), in comparison to students in the flipped group (Eng_UG_Flip_GI) with median score (4.00). The *p*-value was 0.000, with 95% confidence intervals for median difference as (1). On the other hand, there was no statistical difference between the flipped group (Eng_UG_Flip_GI) and the other lecture-based class (Eng_UG_LB_C) students' confidence to ask in-class questions ($p = 0.116$).

Therefore, we can say that for Engineering undergraduate classes, students' confidence to ask in-class questions in the flipped classes were statistically similar or less in comparison to the lecture-based classes.

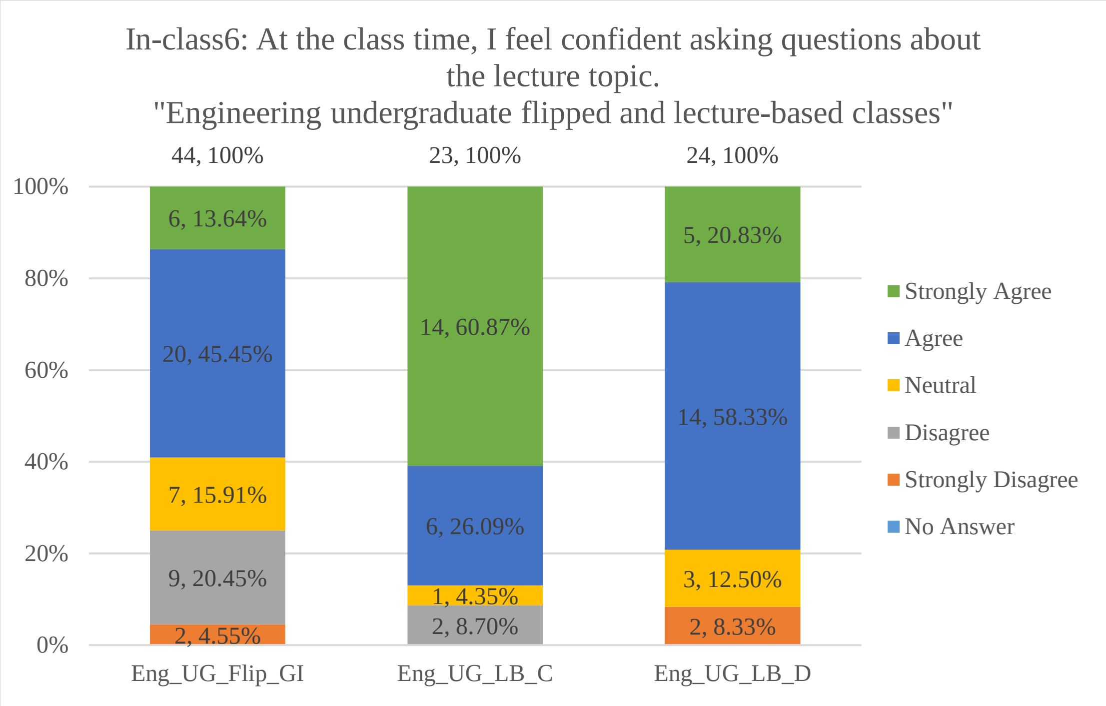

Figure 41: Students' responses to in-class confidence to ask questions (In-class6) – Engineering undergraduate flipped and lecture-based classes

Table 108: Mann-Whitney U test for in-class confidence to ask questions between flipped and lecture-based engineering undergraduate classes

Item	**Eng_UG_Flip_GI**			**Eng_UG_LB_C**			**Eng_UG_LB_D**			**W (*p*) GI & C**	**W (*p*) GI & D**
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*		
In-class6: In-class confidence to ask questions	44	3.43 ±1.11	4	23	4.39 ±0.94	5	24	3.83 ±1.05	4	1232.50 (0.000)* (-1, -1)	1403.50 (0.116) (-1, 0)

* $p < 0.05$

Few students had explained their selection regarding in-class confidence in each group, in response to In-class6: "At the class time, I feel confident asking questions about the lecture topic. Please explain briefly your selection.". 13 students out of 44

(29.55%) responded in the flipped group Eng_UG_Flip_GI, 4 out of 23 (17.39%) responded in the lecture-based class Eng_UG_LB_C, and 11 students out of 24 (45.83%) responded in the lecture-based class Eng_UG_LB_D. Responses of lecture-based classes Eng_UG_LB_C and Eng_UG_LB_D are merged together as they were few and showed similar themes.

Reasons identified for high confidence levels to ask questions in the classes for the flipped and lecture-based groups are summarized in Table 109. This involves responses with Strongly Agree or Agree. For the flipped group Eng_UG_Flip_GI, there is no predominant reason identified. 6.82% of the students reasoned their confidence to ask as simply being comfortable to ask in-class questions with some referring to their personality. 4.55% referred to the pre-class study and being prepared. Another 4.55% referred to professor welcoming questions. One student commented on the class environment (2.27%). On the other hand, for the lecture-based classes, the main theme for high confidence of asking in-class questions was regarding professor welcoming questions (19.15%), followed by comments related to students simply feeling comfortable to ask questions (10.64%), and finally a comment by one student regarding the class environment. Table 159 in Appendix F shows unedited quoted comments from students regarding high confidence to ask in-class questions in flipped and lecture-based classes.

Table 109: Reasons identified for high confidence level of asking in-class questions – Flipped and lecture-based engineering undergraduate classes

Identified Reason	Eng_UG_Flip_GI	Eng_UG_LB_C & Eng_UG_LB_D
N	44	47
Pre-class study	2 4.55%	- -
Class environment	1 2.27%	1 2.13%
Professor welcomes questions	2 4.55%	9 19.15%
I am comfortable to ask	3 6.82%	5 10.64%
NA	18 40.91%	25 53.19%

On the other hand, students reporting low confidence to ask questions did not comment much about the reasons as shown in Table 110. Only 5 students (11.36%)

responded from the flipped classes, and 1 student from the lecture-based class Eng_UG_LB_D.

From the flipped classes, four students mentioned reasons related to community concerns, such as getting judged by others or feeling shy. One student mentioned about not knowing what to ask despite lacking the understanding of some concepts. On the other hand, from the lecture-based class Eng_UG_LB_D, the only student who commented mentioned the concerns from peers' judge on asking a silly easy question. Table 160 in Appendix F shows unedited quoted responses from students regarding low confidence to ask in-class questions in flipped and lecture-based classes. However, due to low number of responses, there is no theme to consider regarding reasons of low confidence to ask questions in the flipped or lecture-based classes.

Table 110: Reasons identified for low confidence level of asking in-class questions - Flipped and lecture-based engineering undergraduate classes

Identified Reason	Eng_UG_Flip_GI	Eng_UG_LB_C & Eng_UG_LB_D
N	44	47
Community concerns	4 9.09%	1 2.13%
I don't know what to ask	1 2.27%	- -
NA	13 29.55%	7 14.89%

Figure 42 shows students' responses in the engineering undergraduate classes regarding in-class understanding, In-class7 "Generally, at the end of the class, you feel you have understood everything". Considering the top 2 boxes score, the highest satisfaction was reported in lecture-based class Eng_UG_LB_C with 86.95% of the students as strongly agreeing or agreeing about generally understanding everything by the end of the class. This was followed by 62.50% from the lecture-based class Eng_UG_LB_D and finally 36.36% from the flipped group Eng_UG_Flip_GI. Similar satisfaction order applies considering the top box score, that is the strongly agree responses.

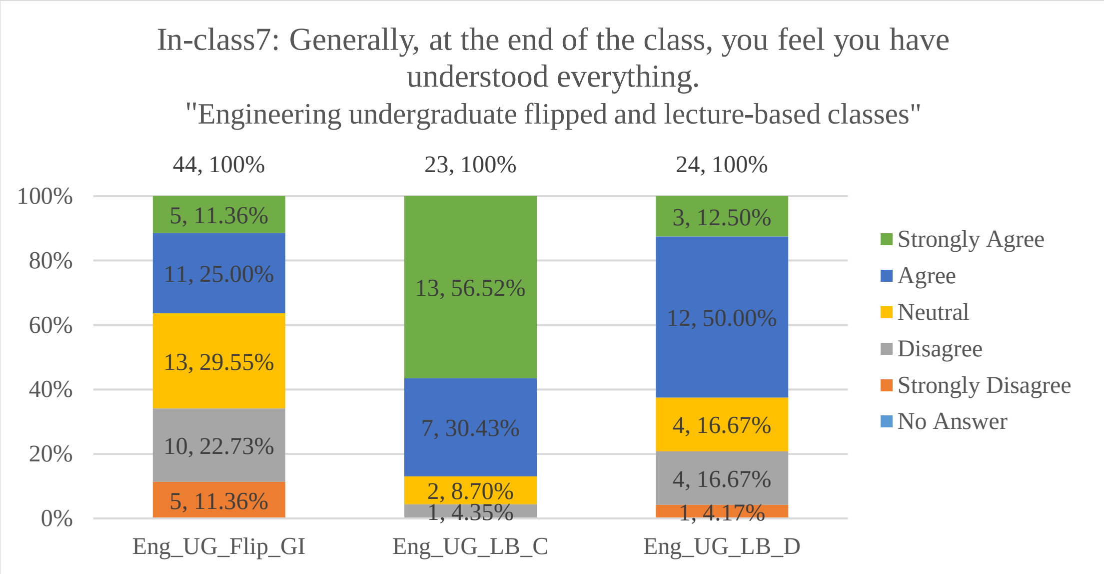

Figure 42: Students' responses to in-class understanding (In-class7) – Engineering undergraduate flipped and lecture-based classes

According to Mann-Whitney U test results presented in Table 111. Students in the lecture-based class (Eng_UG_LB_C) reported statistically significantly higher satisfaction regarding in-class understanding with median score of (5.00), in comparison to the students in the flipped group (Eng_UG_Flip_GI) with median score of (3.00). The *p*-value was 0.000, with 95% confidence intervals for median difference as (1 - 2). Comparing the in-class understanding in the flipped group (Eng_UG_Flip_GI) to the other lecture-based class (Eng_UG_LB_C) using Mann-Whitney U test, there is slightly statistical difference with *p*-value of 0.093, and higher satisfaction rates in the lecture-based class (Eng_UG_LB_D) as well with median score of (4.00), and 95% confidence intervals for median difference as (0 - 1).

Therefore, we can say that for Engineering undergraduate classes, students' in-class understanding in the flipped classes were statistically less in comparison to the lecture-based classes.

Table 111: Mann-Whitney U test for in-class understanding between flipped and lecture-based engineering undergraduate classes

Item	**Eng_UG_Flip_GI**			**Eng_UG_LB_C**			**Eng_UG_LB_D**			**W (*p*)**	**W (*p*)**
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	**GI & C**	**GI & D**
In-class7: In-class understanding	44	3.02 ±1.19	3	23	4.39 ±0.84	5	24	3.5 ±1.06	4	1175 (0.000)* (-2, -1)	1391 (0.093) (-1, -0)

* $p < 0.05$

6.7.3. Study practices items. Figure 43 shows the time by which students usually prepare or study the course material in a non-flipped class for engineering undergraduate participating classes, flipped and lecture-based.

Like students in the mathematics courses, the majority of the students in the undergraduate engineering courses reported to prepare “Only few days before the midterm or quiz”. Percentage was 68.13% out of the 91 participating students from the engineering classes, flipped and lecture-based. Following that, 20.88% reported to prepare “As early as possible after the class time”, and finally 9.89% reported to prepare “As early as possible before the class time”. The breakdown per each engineering undergraduate class is shown in the figure.

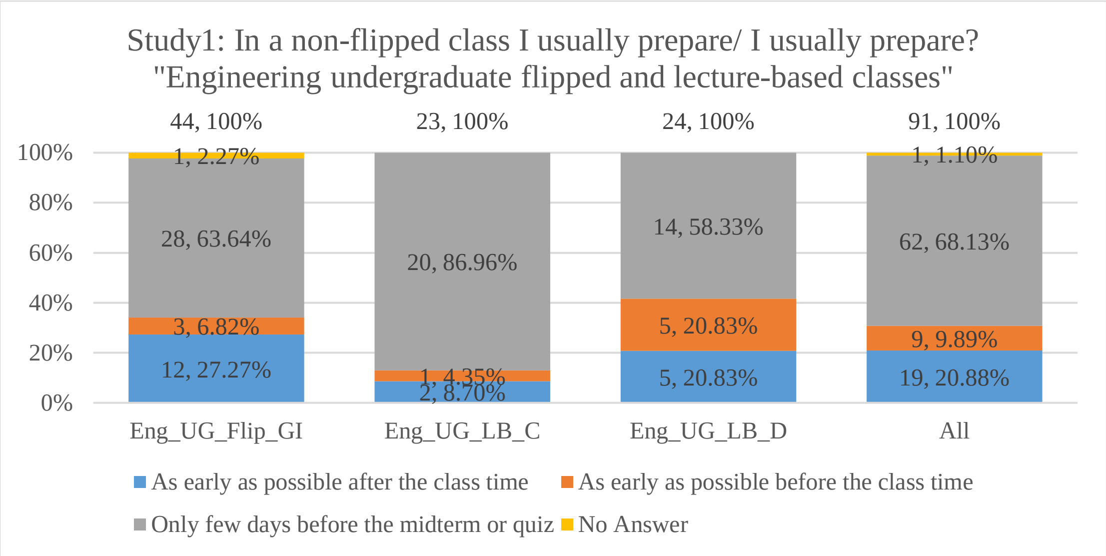

Figure 43: Students’ responses for preparation time (Study1) – Engineering undergraduate flipped and lecture-based classes

The majority of students in the engineering undergraduate flipped classes Eng_UG_Flip_GI (68.18%) had used the textbook as shown in Figure 44. This is expected as the pre-class material was text-based, and students were asked to read from the textbook along with lecture notes. On the other hand, few students in the engineering undergraduate lecture-based classes had used the textbook, one student (4.35%) from class Eng_UG_LB_C, and six students (25.00%) from class Eng_UG_LB_D.

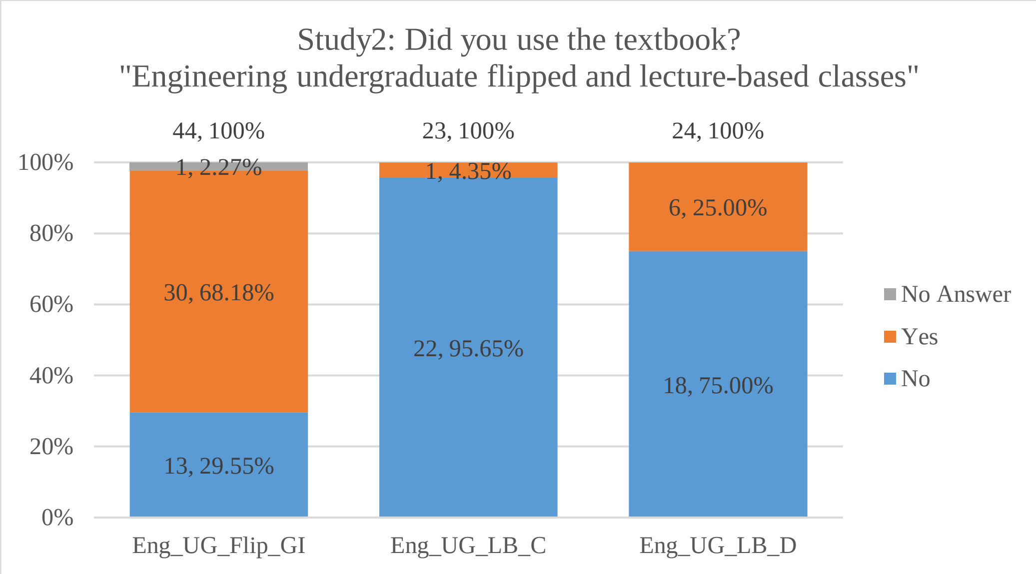

Figure 44: Students' responses for use of textbook (Study2) – Engineering undergraduate flipped and lecture-based classes

According to chi-square test results presented in Table 112, for engineering undergraduate classes, the use of textbook is statistically higher in the flipped classes in comparison to each of the lecture-based ones with *p*-value of 0.000.

Table 112: Chi-square test results for use of textbook between flipped and lecture-based engineering undergraduate classes

Item		Eng_UG_Flip_GI	Eng_UG_LB_C	Eng_UG_LB_D	$x^2(p)$ GI & C	$x^2(p)$ GI & D
Study2: Use of textbook	Yes	30	1	6	25.747 (0.000)*	12.417 (0.000)*
	No	13	22	18		
	NA	1	-	-		

* $p < 0.05$

6.7.4. Motivation toward the teaching method items. Figure 45 shows students' responses to their self-report of liking the teaching method of the surveyed course for engineering undergraduate classes, both flipped and lecture-based.

34.09% of students in the flipped classes (Eng_UG_Flip_GI) has strongly agreed or agreed about liking the flipped teaching method. In contrast, the percentages for liking the lecture-based method were 82.61% for class (Eng_UG_LB_C) and 70.84% for class (Eng_UG_LB_D). Thus, the satisfaction percentage in engineering undergraduate lecture-based classes was clearly higher than in the lecture-based classes considering the top 2 boxes score or even the top box score.

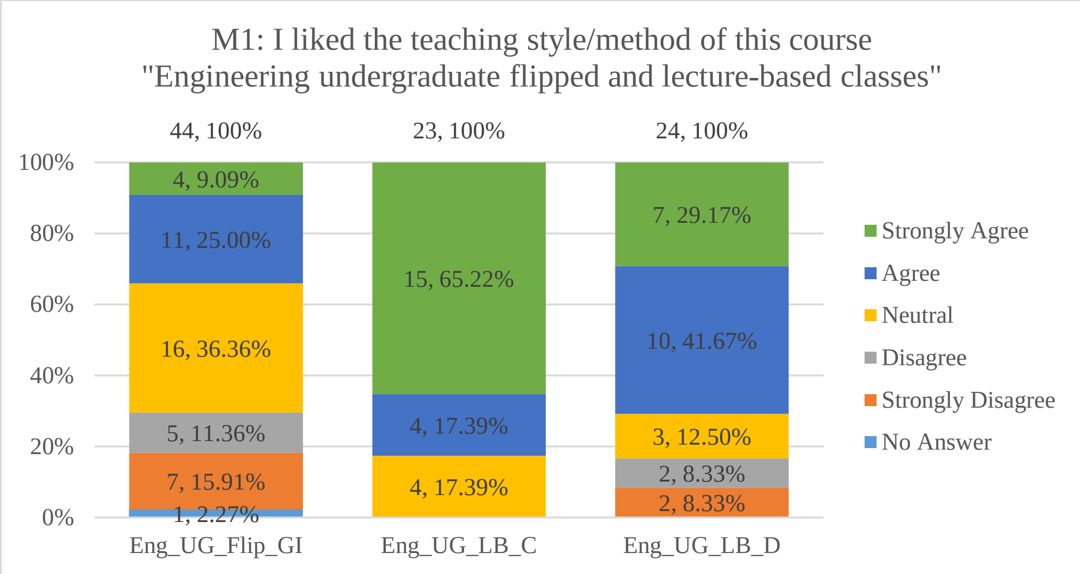

Figure 45: Students' responses to regarding liking the teaching method (M1) - Engineering undergraduate flipped and lecture-based classes

A Mann-Whitney U test with 95% confidence interval showed that students in the lecture-based class (Eng_UG_LB_C) are liking the teaching method statistically more than their peers in the flipped group (Eng_UG_Flip_GI) with *p*-value of 0.000. The median scores for the classes were 5.00 and 3.00 sequentially, with 95% confidence interval for the median difference as (1 - 2). Similarly, students in the other lecture-based class (Eng_UG_LB_D) like the teaching method statistically more than their peers in the flipped group (Eng_UG_Flip_GI) with *p*-value of 0.010. The median scores for the classes were 4.00 and 3.00 sequentially, with 95% confidence interval for the median difference as (0 - 1). Mann-Whitney U test results for liking the teaching method in the engineering undergraduate classes are shown in Table 113. Thus, students in the engineering undergraduate lecture-based classes like the teaching method statistically more than their peers in the flipped classes.

Table 113: Mann-Whitney U test for like of teaching method between flipped and lecture-based engineering undergraduate classes

Item	**Eng_UG_Flip_GI**			**Eng_UG_LB_C**			**Eng_UG_LB_D**			**W (*p*) 95%CI GI & C**	**W (*p*) 95%CI GI & D**
	N	*Mean ± Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*		
M1: I liked the teaching style/method of this course	43	3.00 ±1.19	3.00	23	4.48 ±0.79	5.00	24	3.75 ±1.23	4.00	1106 (0.000)* (-2, -1)	1270 (0.010)* (-1, 0)

* $p < 0.05$

6.7.5. Academic performance. The two flipped engineering undergraduate classes (Eng_UG_Flip_A) and (Eng_UG_Flip_B) of course "Analysis of Production Systems" offered in Spring 2017 and Fall 2017 were compared to the same course offered previously in Fall 2015 by the same instructor in lecture-based method (Eng_UG_LB_E). The course assessments were not the same among the three classes, but they carry similar difficulty and cover the same material.

As shown in Table 114, pre-course CGPA and gender carry no statistical difference between each of the flipped classes and the lecture-based class as *p*-value is greater than 0.05 in all comparisons. This demographics data involves all students enrolled in the participating classes whether they responded to the survey or not, which is the comparison scope for academic performance.

Table 114: Equivalence testing of flipped and lecture-based engineering undergraduate classes involved for academic performance comparison

Factor		Eng_UG_Flip_A	Eng_UG_Flip_B	Eng_UG_LB_E	*W(p) or t(p) or* $x^2(p)$ A & E	*W(p) or t(p) or* $x^2(p)$ B & E
Total		33	37	19	-	-
Pre-course CGPA	Median	2.66	2.51	2.42	935.50 (0.250)	1058.00 (0.959)
	Mean ± std.	2.73 ± 0.38	2.75 ± 0.53	2.71 ± 0.53	0.14 (0.891)	0.28 (0.784)
Gender	Female	20	25	10	0.314 (0.575)	1.195 (0.274)
	Male	13	12	9		

The students' grade frequency distribution for engineering undergraduate flipped and lecture-based classes is shown in Figure 46 and Table 115. Failure rate, that is percentage of D and F grades, was 21.21% in the flipped class (Eng_UG_Flip_A), 5.41% in the flipped class (Eng_UG_Flip_B), and zero in the lecture-based class (Eng_UG_LB_E). Thus, the failure rate was higher in both flipped classes. Furthermore, percentage of students scoring between A- and B- was 39.39% in the flipped class (Eng_UG_Flip_A), 35.14% in the flipped class (Eng_UG_Flip_B), in comparison to 57.89% in the lecture-based class (Eng_UG_LB_E). Thus, for engineering undergraduate classes, the percentage of students scoring between A and B- was lower in both flipped classes in comparison to the lecture-based class with around 19% and 23% differences.

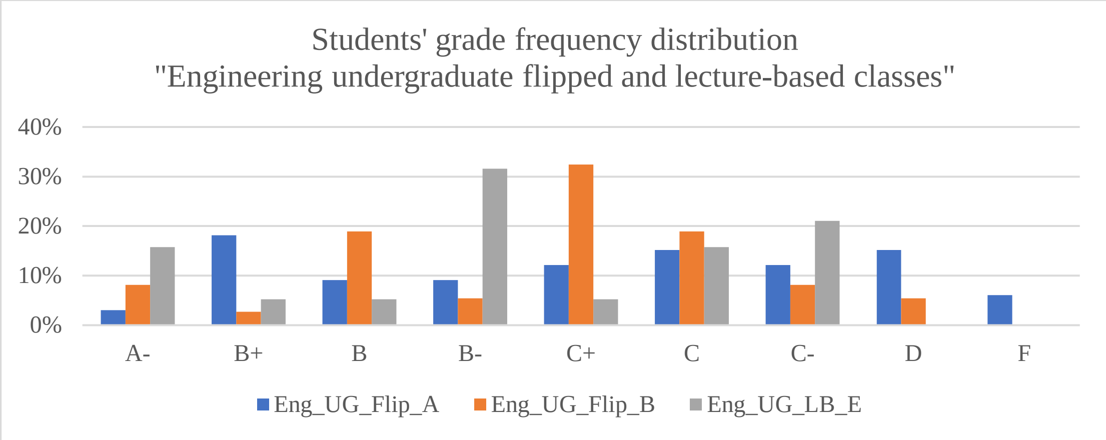

Figure 46: Students' grade frequency distribution - Engineering undergraduate flipped and lecture-based classes

Table 115: Student's grade frequency distribution - Engineering undergraduate flipped and lecture-based classes

Class	A-	B+	B	B-	C+	C	C-	D	F
Eng_UG _Flip_A	1	6	3	3	4	5	4	5	2
	3.03%	18.18%	9.09%	9.09%	12.12%	15.15%	12.12%	15.15%	6.06%
Eng_UG _Flip_B	3	1	7	2	12	7	3	2	0
	8.11%	2.70%	18.92%	5.41%	32.43%	18.92%	8.11%	5.41%	0%
Eng_UG _LB_E	3	1	1	6	1	3	4	0	0
	15.79%	5.26%	5.26%	31.58%	5.26%	15.79%	21.05%	0%	0%

Considering the equivalent GPA point for each letter grade, Mann-Whitney U test were conducted to check for statistical significance between the each of the flipped classes and the lecture-based class.

Figure 47 shows the descriptive statistics of students' course grades for engineering undergraduate flipped and lecture-based classes. As per the results presented in Table 116, the Mann-Whitney U test with 95% confidence interval showed that there is no statistically significant difference in the students course grades between the flipped class Eng_UG_Flip_A and the lecture-based class Eng_UG_LB_E (p = 0.246), or between the other flipped class Eng_UG_Flip_B and the lecture-based class Eng_UG_LB_E (p = 0.661), with median score of (2.3) for the both flipped classes, and 2.7 for the lecture-based class.

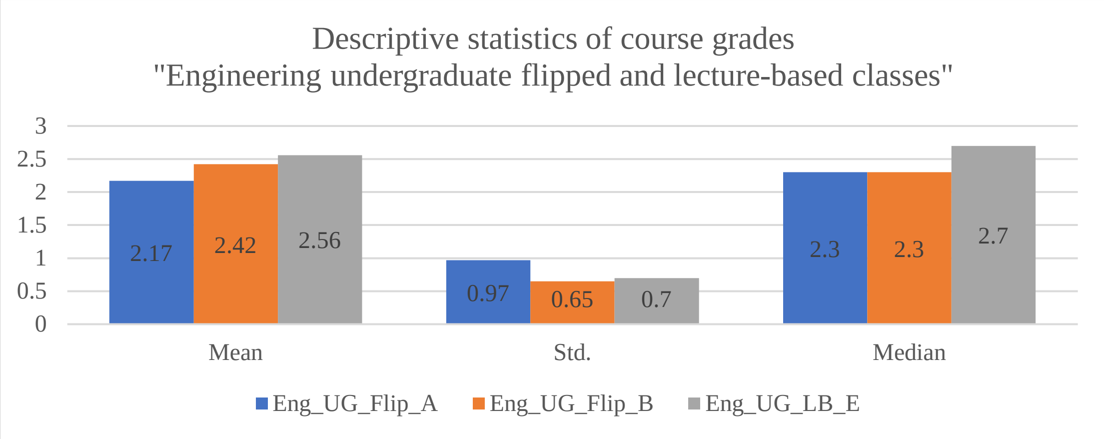

Figure 47: Descriptive statistics of course grades - Engineering undergraduate flipped and lecture-based classes

Table 116: Mann-Whitney U test for course grades data between flipped and lecture-based engineering undergraduate classes

Factor	**Eng_UG_Flip_A**			**Eng_UG_Flip_B**			**Eng_UG_LB_E**			***W (p)* 95%CI A & E**	***W (p)* 95%CI B & E**
	N	*Mean ± Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*		
Course grade	33	2.17 ±0.97	2.3	37	2.42 ±0.65	2.3	19	2.56 ±0.70	2.7	813.50 (0.246) (-0.7, 0.3)	1029.00 (0.661) (-0.6, 0.3)

6.8. Survey and Academic Performance Analysis – Engineering graduate classes (Flipped versus lecture-based)

6.8.1. RCOI constructs. As shown in section 6.1.3, flipped conceptual classes (Eng_G_Flip_B and Eng_G_Flip_C) were validated for merge through checking RCOI constructs, while the flipped technical class (Eng_G_Flip_A) showed different students' perceptions from each of the conceptual classes and is therefore considered by itself.

On the other hand, all lecture-based graduate engineering classes (Eng_G_LB_D, Eng_G_LB_E) showed no significant difference through RCOI constructs. However, since all these lecture-based classes are technical ones, we are then comparing the students' perceptions reported in them to the flipped technical course (Eng_G_Flip_A) only.

Thus, as mentioned before, to avoid comparison of unequal sample sizes, we compared the reported students' perceptions in the flipped technical course to each of the two technical lecture-based classes individually instead of merging the lecture-based classes.

Overall, students' perceived learning experience in both types of engineering graduate technical classes, flipped and lecture-based, was positive according to their responses to RCOI constructs, as presented in Table 117. The mean values ranged between 3.60 and 4.06 for the flipped class, while for the lecture-based classes, they ranged between 3.79 and 4.37. The median values for the flipped class ranged between 3.43 and 4.00, while for the lecture-based classes, they ranged between 3.50 and 4.35.

The highest satisfied presence for the flipped class was teaching presence, followed by cognitive presence, social presence and finally learning presence. Both of the lecture-based classes had reported the teaching presence as the highest satisfaction construct. The rest of presences order was different for each lecture-based class.

Table 117: Descriptive statistics of RCOI in engineering graduate technical classes

Construct	**Eng_G_Flip_A**			**Eng_G_LB_D**			**Eng_G_LB_E**		
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*
TP	11	4.06 ±0.41	4.00	10	4.22 ±0.51	4.25	16	4.37 ±0.43	4.35
SP	11	3.83 ±0.60	4.00	10	3.88 ±0.71	3.50	16	4.10 ±1.01	4.42
CP	11	3.91 ±0.42	3.89	10	4.03 ±0.67	3.94	16	3.89 ±0.74	3.83
LP	11	3.60 ±0.65	3.43	10	3.79 ±0.73	3.79	16	3.95 ±0.63	3.93

Table 118 and Table 119 shows the normality and homogenous of variances tests for data involved in the comparison of flipped and lecture-based engineering graduate classes. Normality was validated for all TP, CP, and LP constructs for both flipped class Eng_G_Flip_A and lecture-based classes, Eng_G_LB_D and Eng_G_LB_E. However, data of SP constructs was normal in the lecture-based class Eng_G_LB_D, but not in the others. Homogenous of variances was validated for all our data in the comparison tests.

Table 118: Normality test results of RCOI for engineering graduate technical classes

Construct	Eng_G_Flip_A	Eng_G_LB_D	Eng_G_LB_E
TP	Normal (p = 0.08)	Normal (p = 0.787)	Normal (p = 0.650)
SP	Not Normal (p = 0.014)*	Normal (p = 0.063)	Not Normal (p = 0.008)*
CP	Normal (p = 0.382)	Normal (p = 0.669)	Normal (p = 0086)
LP	Normal (p = 0.137)	Normal (p = 0.544)	Normal (p = 0.455)

* $p < 0.05$

Table 119: RCOI Levene's test results between flipped and lecture-based engineering graduate technical classes

Construct	***p*-value** Eng_G_Flip_A & Eng_G_LB_D	***p*-value** Eng_G_Flip_A & Eng_G_LB_E
TP	0.506	0.900
SP	0.644	0.395
CP	0.137	0.197
LP	0.654	0.876

Table 120 shows the results of comparing the flipped technical class Eng_G_Flip_A to each of the lecture-based technical classes, Eng_G_LB_D and Eng_G_LB_E, sequentially. According to both the parametric two independent samples t-test and the non-parametric Mann-Whitney U test, there was no statistically significant difference to report for constructs of SP, CP and LP. Regarding TP, according to two independent samples t-test, it was slightly statistically higher in the lecture-based technical class Eng_G_LB_E with mean score (4.37 ± 0.43), in comparison to the flipped technical class Eng_G_Flip_A with mean score of (4.06 ± 0.41). The *p*-value is 0.069 with 95% confidence interval for mean difference as (0.03 - 0.65). According to Mann-Whitney U test, TP was statistically higher in the lecture-based technical class Eng_G_LB_E with median score (4.35), in comparison to the flipped technical class Eng_G_Flip_A with median score of (4.00). The *p*-value is 0.035 with 95% confidence interval for median difference as (0 - 0.7). Noting that the TP was normal in the compared classes, and the homogeneous of variables was verified, then the parametric test is more accurate and will be considered, and so the difference is slightly significant as the *p*-value is 0.069. However, there was no statistical difference for TP between the other lecture-based class Eng_G_LB_E and the flipped class Eng_G_Flip_A according to both parametric two independent samples t-test and the non-parametric Mann-Whitney U test.

Therefore, we conclude that for engineering graduate technical classes involved in our study, there was no statistical difference reported between the flipped and lecture-based classes for RCOI constructs of SP, CP and LP. However, TP was reported in the flipped class either slightly lower or similar to the lecture-based class.

Table 120: RCOI 2 independent samples t-test and Mann-Whitney U test between flipped and lecture-based engineering graduate technical classes

Construct	***t (p)*** **Eng_G_Flip_A & Eng_G_LB_D**	***W (p)*** **Eng_G_Flip_A & Eng_G_LB_D**	***t (p)*** **Eng_G_Flip_A & Eng_G_LB_E**	***W (p)*** **Eng_G_Flip_A & Eng_G_LB_E**
TP	-0.82 (0.421) (-0.59, 0.26)	110.50 (0.479) (-0.7, 0.30)	-1.90 (0.069) (-0.65, 0.03)	111.00 (0.035)* (-0.7, 0)
SP	-0.18 (0.863) (-0.65, 0.55)	125.00 (0.803) (-0.83, 0.67)	-0.79 (0.435) (-0.97, 0.43)	124.50 (0.148) (-0.83, 0.16)
CP	-0.51 (0.613) (-0.63, 0.38)	114.00 (0.645) (-0.67, 0.33)	0.08 (0.935) (-0.49, 0.53)	153.00 (0.980) (-0.44, 0.44)
LP	-0.50 (0.626) (-0.78, 0.48)	113.50 (0.621) (-0.86, 0.57)	-1.25 (0.224) (-0.82, 0.20)	129.00 (0.225) (-0.86, 0.29)

* $p < 0.05$

Looking into individual item differences, as presented in Table 121, there is a statistically significant difference between the flipped class and each of the lecture-based classes for teaching presence in items of TP1 (The instructor clearly communicated important course topics) and TP2 (The instructor clearly communicated important course goals). Higher presences were reported for lecture-based groups. The comparison of total TP score did not show this difference for classes of (Eng_G_Flip_A) and (Eng_G_LB_D) as shown before in Table 120.

These differences can be associated with the course subject rather than the teaching method, as the flipped course involved is an elective course for ESM graduate students, covering financial content, which is not common for engineers, and therefore course topics or goals might not be very clear to some of them. While both lecture-based classes are major courses, that ESM students would be more aware ahead of time about the course topics and goals.

Table 121: Mann-Whitney U test of TP items between flipped & lecture-based engineering graduate technical classes

TP Item	Eng_G_Flip_A		Eng_G_LB_D		Eng_G_LB_E		W (p) A & D	W (p) A & E
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
TP1	4.00 ± 0.78	4.00	4.70 ± 0.48	5.00	4.75 ± 0.45	5.00	93.00 (0.034)*	106.00 (0.008)*
TP2	4.18 ± 0.60	4.00	4.80 ± 0.42	5.00	4.69 ± 0.48	5.00	91.00 (0.038)*	115.00 (0.031)*
TP3	3.64 ± 0.92	4.00	4.00 ± 1.06	4.00	4.50 ± 0.63	5.00	108.50 (0.398)	107.00 (0.014)*
TP4	4.00 ± 1.18	4.00	4.30 ± 0.82	4.50	4.75 ± 0.58	5.00	114.50 (0.673)	114.50 (0.025)
TP5	4.00 ± 0.63	4.00	4.40 ± 0.70	4.50	4.38 ± 0.62	4.00	103.00 (0.173)	127.00 (0.142)
TP6	4.00 ± 0.45	4.00	4.20 ± 0.79	4.00	3.81 ± 1.05	4.00	111.00 (0.439)	159.50 (0.780)
TP7	4.18 ± 0.75	4.00	4.30 ± 0.82	4.50	4.13 ± 0.81	4.00	115.50 (0.704)	157.00 (0.895)
TP8	4.27 ± 0.65	4.00	3.80 ± 0.92	4.00	4.00 ± 0.89	4.00	137.00 (0.231)	167.50 (0.486)
TP9	4.09 ± 0.54	4.00	3.80 ± 0.79	4.00	4.13 ± 0.89	4.00	130.50 (0.426)	146.00 (0.679)
TP10	4.18 ± 0.75	4.00	3.90 ± 1.19	4.00	4.56 ± 0.63	5.00	125.50 (0.765)	128.50 (0.170)

* $p < 0.05$

As presented in Table 122, for social presence, no statistical difference is found common for both comparisons of the flipped class and each of the lecture-based classes. This matched our earlier conclusion that there is no statistical difference for social presence between the flipped and lecture-based engineering graduate technical classes. The reported social presence was moderate to high in all the involved classes, both flipped and lecture-based, thus, this insignificance difference may raise concern, as social presence is expected to be the most enhanced factor in the flipped classes and thus be significantly higher than in the lecture-based classes. However as the reported SP was moderate to high in the lecture-based classes as well, then this implies that continuous in-class problem activities applied in these classes, in addition to group projects, create a good social presence.

Table 122: Mann-Whitney U test of SP items between flipped & lecture-based engineering graduate technical classes

SP Item	Eng_G_Flip_A		Eng_G_LB_D		Eng_G_LB_E		W (*p*) A & D	W (*p*) A & D
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
SP1	3.82 ± 0.60	4.00	3.30 ± 1.16	3.00	4.06 ± 1.24	4.50	137.50 (0.233)	129.00 (0.200)
SP2	3.73 ± 0.79	4.00	3.70 ± 0.95	4.00	4.31 ± 1.08	5.00	122.50 (0.939)	113.00 (0.031)*
SP3	3.91 ± 0.83	4.00	4.40 ± 0.69	4.50	4.19 ± 1.11	4.50	102.50 (0.162)	131.50 (0.242)
SP4	4.18 ± 0.98	4.00	4.20 ± 0.79	4.00	4.25 ± 1.00	4.00	123.00 (0.910)	150.50 (0.871)
SP5	3.73 ± 0.91	4.00	3.70 ± 1.16	3.00	3.81 ± 0.98	4.00	123.00 (0.912)	146.00 (0.687)
SP6	3.64 ± 0.51	4.00	4.00 ± 0.94	4.00	4.00 ± 1.09	4.00	109.00 (0.383)	125.00 (0.130)

* $p < 0.05$

As presented in Table 123, there is a statistical difference between the flipped class and each of the lecture-based classes for cognitive presence regarding item CP9 (I can apply the knowledge created in this course to my work or other non-class related activities). The comparison of total CP score did not show this difference as shown in Table 120. Higher presences were reported for lecture-based groups. However, this difference can also be associated with the course subject rather than the teaching method, as the flipped course involved is an elective course for ESM students, covering financial content, which is not common for engineers to apply in work areas. While both lecture-based classes are major courses, that tend to be used more in work areas.

As presented in Table 124, for learning presence, no statistical difference is found common for both comparisons of flipped class and each of the lecture-based classes. This matched our earlier conclusion that there is no statistical difference for learning presence between flipped and lecture-based learning for our engineering graduate technical classes. However, this insignificant difference along with the relatively low reported presence of learning presence in the flipped class could raise a concern, as the flipped class is supposed to increase student self-regulation. However, considering that the examined flipped course (Eng_G_Flip_A) is different from the students' backgrounds as explained before, then this would affect their self-regulation of learning in that course.

Table 123: Mann-Whitney U test of CP items between flipped & lecture-based engineering graduate technical classes

CP Item	**Eng_G_Flip_A**		**Eng_G_LB_D**		**Eng_G_LB_E**		**W (*p*) A & D**	**W (*p*) A & D**
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
CP1	4.00 ± 0.89	4.00	3.90 ± 0.88	4.00	3.88 ± 1.15	4.000	126.50 (0.708)	156.00 (0.936)
CP2	4.00 ± 0.89	4.00	4.10 ± 0.74	4.00	3.56 ± 1.15	4.000	119.50 (0.938)	173.00 (0.329)
CP3	3.91 ± 0.94	4.00	3.40 ± 1.17	3.50	3.50 ± 1.27	4.000	135.00 (0.321)	168.50 (0.465)
CP4	3.91 ± 0.83	4.00	4.00 ± 0.94	4.00	3.75 ± 1.24	4.000	118.00 (0.852)	152.00 (0.937)
CP5	4.18 ± 0.60	4.00	4.20 ± 0.79	4.00	3.94 ± 1.18	4.000	119.00 (0.907)	157.00 (0.894)
CP6	3.73 ± 0.91	4.00	4.00 ± 0.94	4.00	4.00 ± 1.09	4.000	110.50 (0.451)	135.50 (0.348)
CP7	4.18 ± 0.41	4.00	4.10 ± 0.74	4.00	3.75 ± 1.00	4.000	123.50 (0.865)	175.00 (0.262)
CP8	3.73 ± 0.47	4.00	4.20 ± 0.63	4.00	4.25 ± 0.58	4.000	99.50 (0.076)	115.50 (0.024)*
CP9	3.55 ± 0.52	4.00	4.40 ± 0.97	5.00	4.38 ± 0.62	4.000	86.00 (0.010)*	98.50 (0.003)*

* $p < 0.05$

Table 124: Mann-Whitney U test of LP items between flipped & lecture-based engineering graduate technical classes

LP Item	**Eng_G_Flip_A**		**Eng_G_LB_D**		**Eng_G_LB_E**		**W (p) A & D**	**W (p) A & D**
	Mean ± Std.	*Median*	*Mean ± Std.*	*Median*	*Mean ± Std.*	*Median*		
LP1	3.09 ± 0.94	3.00	3.50 ± 1.27	3.50	3.94 ± 0.99	4.00	111.00 (0.487)	114.00 (0.042)
LP2	3.46 ± 1.13	4.00	3.70 ± 1.06	3.50	3.94 ± 0.93	4.00	114.50 (0.662)	132.00 (0.256)
LP3	3.27 ± 1.10	4.00	3.40 ± 1.27	3.50	3.50 ± 1.27	4.00	117.00 (0.798)	143.00 (0.590)
LP4	4.00 ± 0.89	4.00	4.00 ± 0.67	4.00	4.13 ± 0.62	4.00	124.00 (0.844)	151.00 (0.888)
LP5	4.00 ± 1.00	4.00	4.20 ± 1.03	4.50	4.00 ± 1.03	4.00	113.50 (0.600)	153.00 (0.979)
LP6	3.64 ± 1.12	4.00	3.60 ± 1.17	4.00	3.75 ± 1.13	4.00	121.50 (1.000)	148.50 (0.798)
LP7	4.00 ± 0.78	4.00	4.10 ± 0.74	4.00	4.38 ± 0.62	4.00	117.00 (0.790)	130.00 (0.205)

6.8.2. In-class understanding and participation construct. Figure 48 shows students' responses in the Engineering graduate technical classes regarding in-class confidence to ask questions, In-class6 "At the class time, I feel confident asking questions about the lecture topic", for the flipped class Eng_G_Flip_A, and the lecture-based classes Eng_G_LB_D and Eng_UG_LB_E.

Considering the top 2 boxes score, the highest satisfaction was reported in lecture-based class Eng_G_LB_D with 90.00% of the students as strongly agreeing or agreeing about being confident to ask questions in the class. This was followed by 81.82% agreement from the flipped class Eng_G_Flip_A and finally the lecture-based class Eng_G_LB_E (68.75%). However, considering the top box score, that is the strongly agree responses, the satisfaction in the lecture-based class Eng_G_LB_E (37.50%) was greater than in the flipped class Eng_G_Flip_A (9.09%). The satisfaction in the lecture-based class Eng_G_LB_D (50.00%) was still the highest considering the top box score.

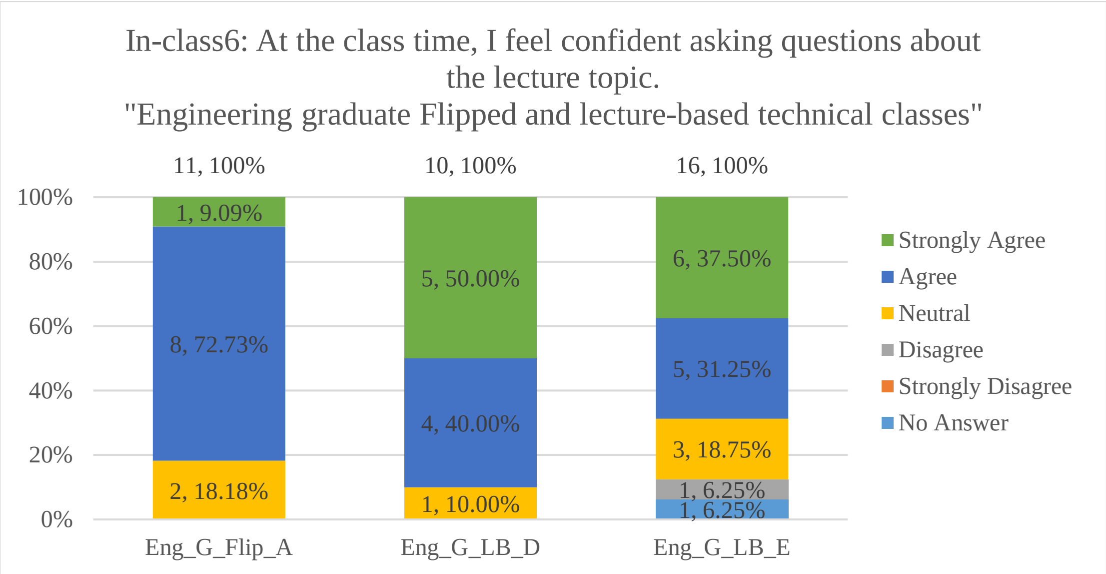

Figure 48: Students' responses to in-class confidence to ask questions (In-class6)– Engineering graduate Flipped and lecture-based technical classes

According to Mann-Whitney U test results presented in Table 125. Students in the lecture-based class (Eng_G_LB_D) reported slightly significantly higher confidence to ask in-class questions with median score of (4.50) in comparison to the students in the flipped class (Eng_G_Flip_A) with median score of (4.00). The *p*-value was 0.081, with 95% confidence interval for median difference as (0 – 1). On the other hand, there was no statistical difference between the flipped class (Eng_G_Flip_A) and the other lecture-based class (Eng_G_LB_E) students' confidence to ask in-class questions (p = 0.464). Therefore, we can say that for Engineering graduate classes, students' confidence to ask in-class questions in the flipped classes were statistically similar or less in comparison to the lecture-based classes.

Table 125: Mann-Whitney U test for in-class confidence to ask questions between flipped and lecture-based engineering graduate technical classes

Item	**Eng_G_Flip_A**			**Eng_G_LB_D**			**Eng_G_LB_E**			**W (*p*) 95%CI A & D**	**W (*p*) 95%CI A & E**
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*		
In-class6: In-class confidence to ask questions	11	3.91 ±0.54	4	10	4.40 ±0.69	4.5	15	4.07 ±0.96	4	98.50 (0.081) (-1, 0)	135.00 (0.464) (-1, 0)

Few students had explained their selection regarding in-class confidence in each class, in response to In-class6: "At the class time, I feel confident asking questions about the lecture topic. Please explain briefly your selection.". One student out of 11 (9.09%) responded in the flipped class Eng_G_Flip_A, 5 students out of 10 (50.00%) responded in the lecture-based class Eng_G_LB_D, and 3 students out of 16 (18.75%) responded in the lecture-based class Eng_G_LB_E. Responses of lecture-based classes D and E are merged together as they were few and showed similar themes.

The only student who reasoned the selection of high confidence to ask in-class question in the flipped class had mentioned the engaging class environment as presented in Table 126. For the lecture-based classes, the main theme for the high confidence of asking in-class questions was regarding the professor welcoming questions (26.92%), with one student mentioning about the encouraging class environment (3.85%). Table 161 in Appendix F shows unedited quoted responses from students regarding high confidence to ask in-class questions in flipped and lecture-based classes.

On the other hand, regarding low confidence to ask in-class questions presented in Table 127, only one student from the lecture-based class Eng_G_LB_E responded, with community concerns "Sometime I shy to ask in front of students in order not to be in picture or being fun in front of any one". Overall, as shown in Figure 48, few students were reporting their confidence to ask in-class questions as low, that is neutral or disagreement responses in our study.

Table 126: Reasons identified for high confidence level of asking in-class questions – Flipped and lecture-based engineering graduate technical classes

Identified Reason	Eng_G_Flip_A	Eng_G_LB_D & Eng_G_LB_E
N	11	26
Class environment	1 9.09%	1 3.85%
Professor welcomes questions	- -	7 26.92%
NA	8 72.73%	13 50.00%

Table 127: Reasons identified for low confidence level of asking in-class questions - Flipped and lecture-based engineering graduate technical classes

Identified Reason	Eng_G_Flip_A	Eng_G_LB_D & Eng_G_LB_E
N	11	26
Community concerns	- -	1 3.85%
NA	2 18.18%	4 15.38%

Figure 49 shows students' responses in the engineering graduate technical classes regarding in-class understanding, In-class7 "Generally, at the end of the class, you feel you have understood everything".

Considering the top 2 boxes score, the highest satisfaction was reported in lecture-based class Eng_G_LB_E with 68.75% of the students as strongly agreeing or agreeing about generally understanding everything by the end of the class. This was followed by 60.00% agreement from the lecture-based class Eng_G_LB_D and finally 54.55% from the flipped class Eng_G_Flip_A. Considering the top box score, that is the strongly agree, responses were few. Only two students from the lecture-based class Eng_G_LB_E had strongly agreed about generally understanding everything by the end of the class, one student from the lecture-based class Eng_G_LB_D, with no student from the flipped class Eng_G_Flip_A.

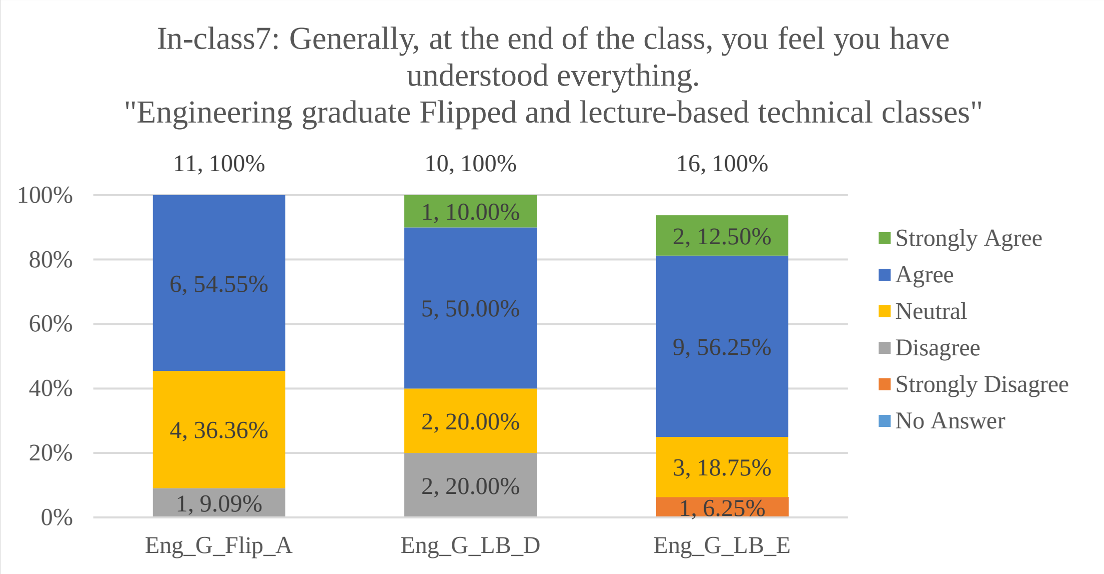

Figure 49: Students' responses to in-class understanding (In-class7) – Engineering graduate Flipped and lecture-based technical classes

According to Mann-Whitney U test results presented in Table 128. There is no significant difference between the flipped class (Eng_G_Flip_A) and each of the lecture-based classes (Eng_G_LB_D) and Eng_G_LB_E regarding students' in-class understanding, as *p*-value was greater than 0.05 for both comparisons. Therefore, we can say that for Engineering graduate classes, students' in-class understanding in the flipped classes were statistically similar to the lecture-based classes.

Table 128: Mann-Whitney U test for in-class understanding between flipped and lecture-based engineering graduate technical classes

Item	**Eng_G_Flip_A**			**Eng_G_LB_D**			**Eng_G_LB_E**			**W (*p*) A & D**	**W (*p*) A & D**
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*		
In-class7: In-class understanding	11	3.46 ±0.69	4	10	3.50 ±0.97	4	16	3.73 ±0.96	4	118.00 (0.847) (-1, 1)	128.00 (0.243) (-1, -0)

6.8.3. Study practices items. Figure 50 shows the time by which students usually prepare or study the course material in a non-flipped class for engineering graduate participating technical classes, flipped and lecture-based.

Like students in the undergraduate classes, the majority of the students in the graduate engineering courses reported to prepare "Only few days before the midterm or quiz". Percentage was 72.97% out of the 37 participating students from the engineering graduate classes, flipped and lecture-based. Following that, unlike undergraduate students, it was interesting that most of the rest of the graduate students reported to usually prepare “As early as possible before the class time”, that is, 18.92% of the students. Finally, few students (5.41%) reported to prepare “As early as possible after the class time”. The breakdown per each engineering undergraduate class is shown in the figure.

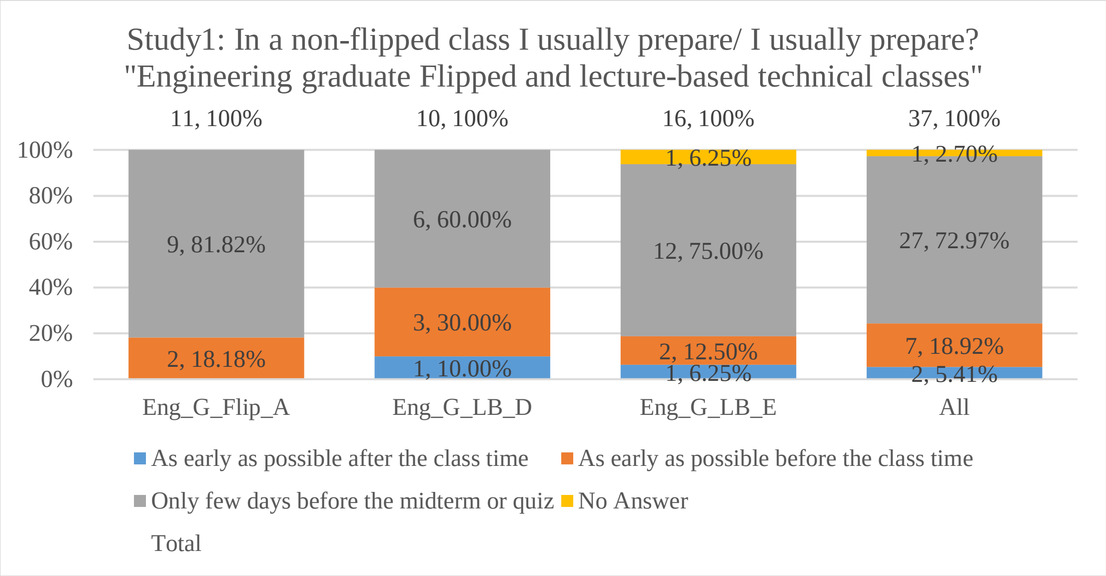

Figure 50: Students’ responses for preparation time (Study1) – Engineering graduate Flipped and lecture-based technical classes

The majority of students in the engineering graduate technical classes, flipped and lecture-based reported not using the textbook as shown in Figure 51. The percentages for “No” responses were 90.91% for the flipped class Eng_G_Flip_A, 60.00% for the lecture-based class Eng_G_LB_D, and 81.25% for the lecture-based class Eng_G_LB_E.

Statistically, there was no significant difference for the use of textbook between flipped and lecture-based engineering graduate technical classes, as *p*-value is greater than 0.05 according to Chi-Square and Fisher’s Exact tests as shown in Table 128. Fisher’s Exact test was used for comparison of textbook use between the flipped class Eng_G_Flip_A and lecture-based class Eng_G_LB_E as Chi-Square results for this comparison can be inaccurate due to small expected cell counts.

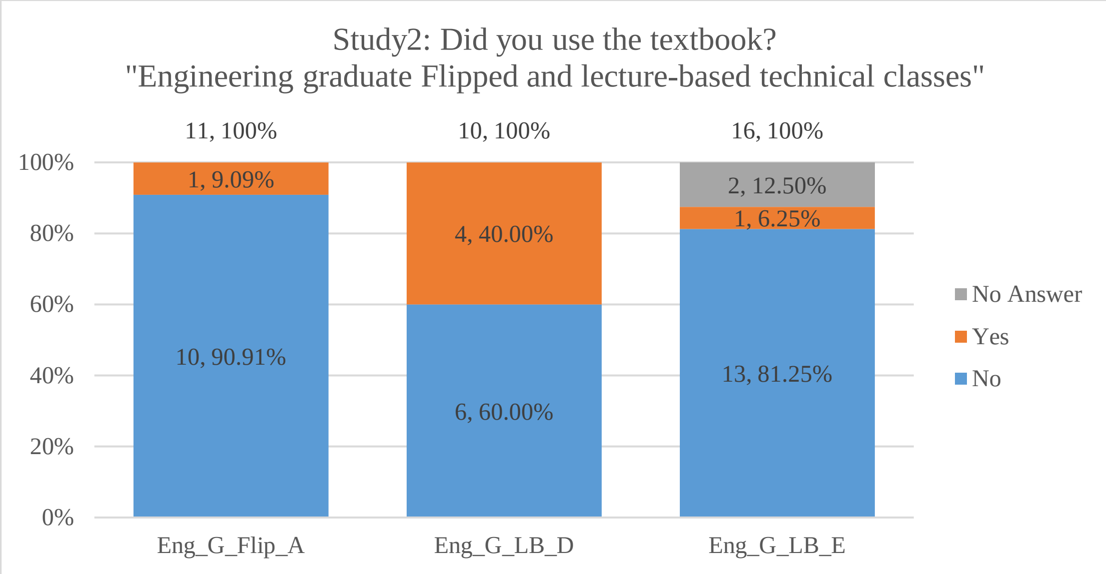

Figure 51: Students' responses for use of textbook (Study2) – Engineering graduate Flipped and lecture-based technical classes

Table 129: Chi-square and Fisher's Exact test results for use of textbook between flipped and lecture-based engineering graduate technical classes

Item		**Eng_G_Flip_A**	**Eng_G_LB_D**	**Eng_G_LB_E**	***x^2(p)*** **A & D**	***p-value*** **A & E**
Sudy2: Use of textbook	Yes	1	4	1	2.759 (0.097)	1.00
	No	10	6	13		
	NA	-	-	2		

6.8.4. Motivation toward the teaching method items. Figure 52 shows students' responses to their self-report of liking the teaching method of the surveyed course for engineering graduate technical classes, both flipped and lecture-based. 90.91% of students in the flipped class (Eng_G_Flip_A) has strongly agreed or agreed about liking the flipped teaching method. In contrast, the percentages for liking the lecture-based method were 70.00% for class (Eng_G_LB_D) and 75.00% for class (Eng_G_LB_E). Thus, the satisfaction percentage in engineering graduate flipped technical class was higher than in the flipped classes considering the top 2 boxes score.

However, a Mann-Whitney U test with 95% confidence interval showed that there is no statistically significant difference regarding liking the teaching method between the flipped class Eng_G_Flip_A and each of the lecture-based classes, Eng_G_LB_D: (p = 0.344), Eng_G_LB_E: (p = 0.887), with median score of (4.00) for all classes, flipped and lecture-based. Thus, students in the engineering graduate technical flipped class like the teaching method statistically like their peers in the lecture-based classes. Mann-Whitney U test results regarding liking the teaching method in the engineering graduate technical classes are shown in Table 130.

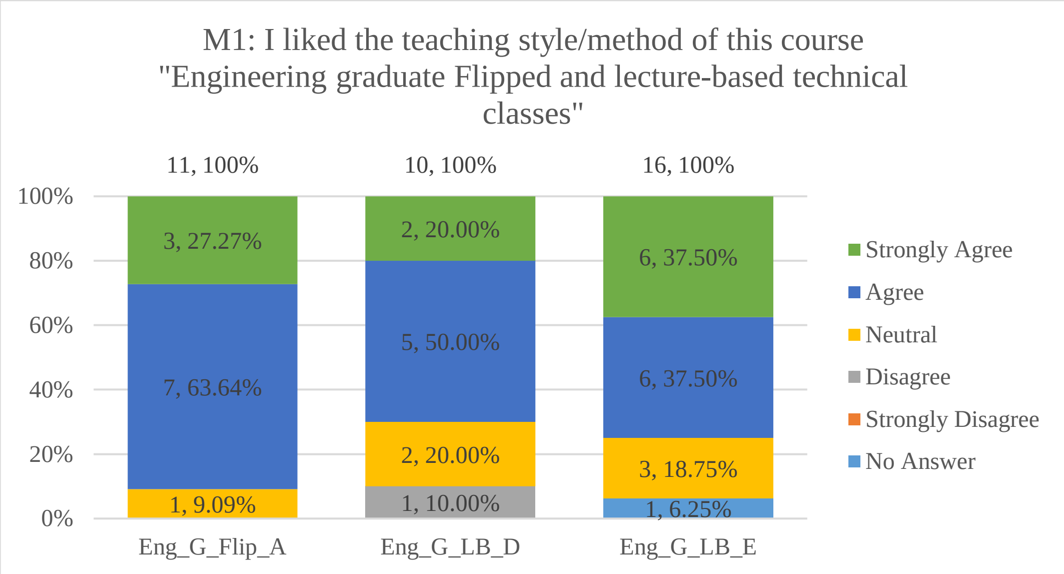

Figure 52: Students' responses to regarding liking the teaching method (M1) - Engineering graduate Flipped and lecture-based technical classes

Table 130: Mann-Whitney U test for like of teaching method between flipped and lecture-based engineering graduate technical classes

Item	**Eng_G_Flip_A**			**Eng_G_LB_D**			**Eng_G_LB_E**			**W (*p*) 95%CI A & D**	**W (*p*) 95%CI A & E**
	N	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*	*N*	*Mean ±Std.*	*Median*		
M1: I liked the teaching style/method of this course	11	4.18 ±0.60	4.00	10	3.80 ±0.92	4.00	15	4.20 ±0.78	4.00	133.50 (0.344) (0, 1)	145.50 (0.887) (-1, 1)

6.8.5. Academic performance. The three flipped engineering graduate classes were examined for academic performance by comparing them to a class of the same course offered previously by the same instructor in the lecture-based method. The flipped and lecture-based classes involved in the comparison for the course "Financial Management for Engineers" were, Eng_G_Flip_A offered in Spring 2017, and Eng_G_LB_F offered in Spring 2016. For the course "Human Resources Management", the flipped class was offered in Fall 2017, coded as (Eng_G_Flip_B), and the lecture-based class was offered in Fall 2015, coded as (Eng_G_LB_G). For the course “Management for Engineers”, the flipped class was offered in Fall 2017, coded as (Eng_G_Flip_C), and the lecture-based class was offered in Fall 2015, coded as (Eng_G_LB_H). The course assessments of each course were not the same for the flipped and lecture-based classes, but they carry similar difficulty and cover the same material.

As shown in Table 131, pre-course CGPA and gender carry no statistical difference between each of the flipped and the lecture-based classes of the same course as *p*-value is greater than 0.05 in all comparisons. This demographics data involves all students enrolled in the participating classes whether they responded to the survey or not, which is the comparison scope for academic performance.

Table 131: Equivalence testing of flipped and lecture-based engineering graduate classes involved for academic performance comparison

Factor		**Eng_G_Flip_A**	**Eng_G_LB_F**	***W(p) or t(p) or x^2(p)*** **A & F**
Total		13	11	-
Pre-course CGPA	Median	3.44	3.38	178.00 (0.384)
	Mean ± std.	3.49 ± 0.30	3.40 ± 0.28	0.74 (0.466)
Gender	Female	8	2	4.608 (0.032)
	Male	5	9	
		Eng_G_Flip_B	**Eng_G_LB_G**	***W(p) or t(p) or x^2(p)*** **B & G**
Total		15	20	-
Pre-course CGPA	Median	3.38	3.48	249.50 (0.505)
	Mean ± std.	3.39 ± 0.24	3.47 ± 0.29	-0.94 (0.354)
Gender	Female	7	7	0.486 (0.486)
	Male	8	13	
		Eng_G_Flip_C	**Eng_G_LB_H**	***W(p) or t(p) or x^2(p)*** **C & H**
Total		26	29	-
Pre-course CGPA	Median	3.5	3.46	258.50 (0.894)
	Mean ± std.	3.41 ± 0.46	3.45 ± 0.28	-0.27 (0.790)
	NA*	9	17	-
Gender	Female	15	11	2.148 (0.143)
	Male	11	18	

* Some students are in their first semester and has no pre-course CGPA

The students' grade frequency distribution for engineering undergraduate flipped and lecture-based classes is shown in Figure 53, Figure 54, Figure 55 and Table 132. There was no one failing any of the courses. The percentage of students scoring A or A- was higher in all the flipped classes in comparison to their contrast lecture-based ones. First, for course "Financial Management for Engineers", 61.54% scored A or A- in the flipped class (Eng_G_Flip_A) in compare to 45.45% in the lecture-based one (Eng_G_LB_F). Second, for course "Human Resources Management", the percentage was 66.67% in the flipped class (Eng_G_Flip_B) in compare to 60.00% in the lecture-based one (Eng_G_LB_G). Third, for course "Management for Engineers", the percentage was 73.07% in the flipped class (Eng_G_Flip_C) in compare to 51.72% in the lecture-based class (Eng_G_LB_H).

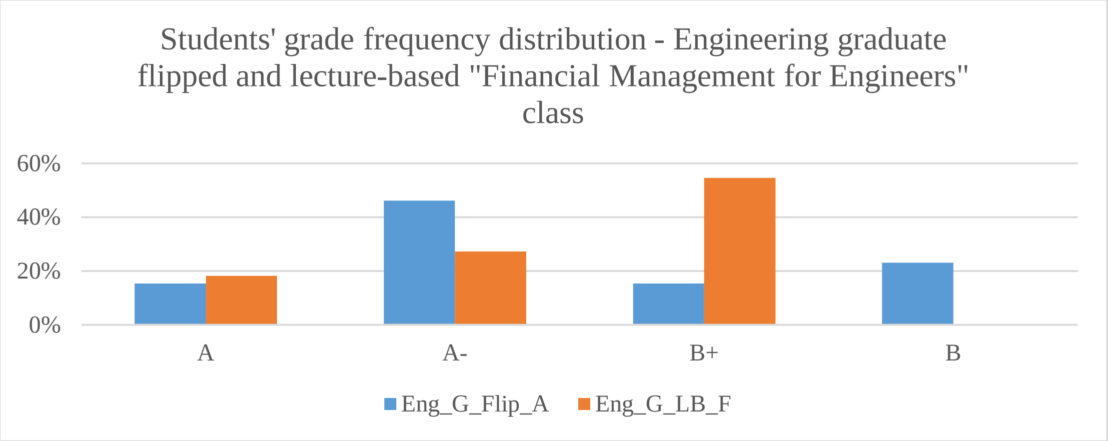

Figure 53: Students' grade frequency distribution - Engineering graduate flipped and lecture-based " Financial Management for Engineers" class

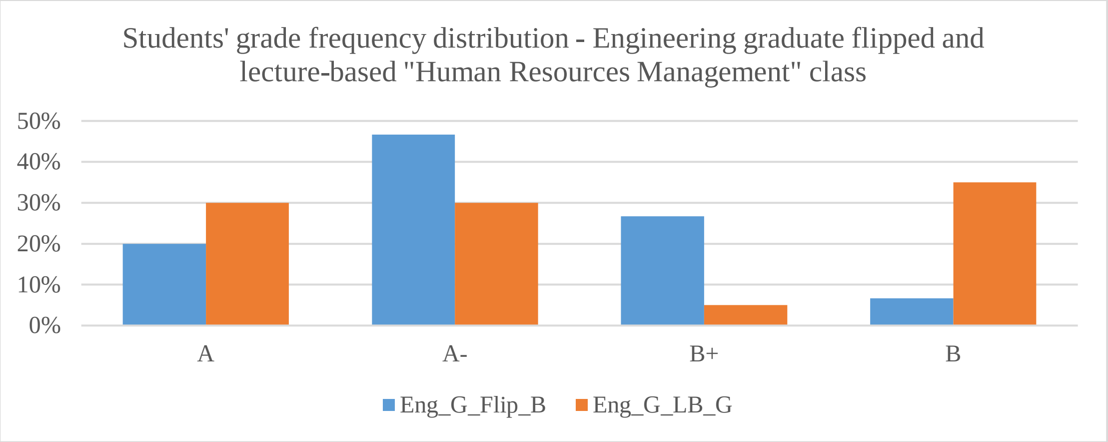

Figure 54: Students' grade frequency distribution - Engineering graduate flipped and lecture-based " Human Resources Management" class

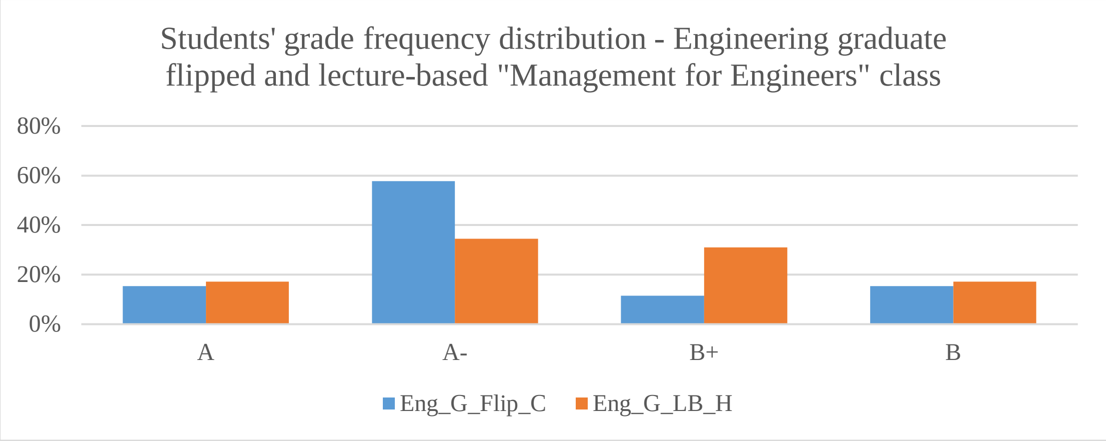

Figure 55: Students' grade frequency distribution - Engineering graduate flipped and lecture-based "Management for Engineers" class

Table 132: Students' grade frequency distribution - Engineering graduate flipped and lecture-based classes

Class Code	A	A-	B+	B
Eng_G_Flip_A	2	6	2	3
	15.38%	46.15%	15.38%	23.08%
Eng_G_LB_F	2	3	6	0
	18.18%	27.27%	54.55%	0.00%
Eng_G_Flip_B	3	7	4	1
	20.00%	46.67%	26.67%	6.67%
Eng_G_LB_G	6	6	1	7
	30.00%	30.00%	5.00%	35%
Eng_G_Flip_C	4	15	3	4
	15.38%	57.69%	11.54%	15.38%
Eng_G_LB_H	5	10	9	5
	17.24%	34.48%	31.03%	17.24%

Considering the equivalent GPA point for each letter grade, Mann-Whitney U test was conducted to check for statistical significance between the academic performance of students in the flipped classes and their contrast lecture-based ones.

Figure 56 - Figure 58 show the descriptive statistics of students' course grades for engineering graduate flipped and lecture-based classes of “Financial Management for Engineers”, “Human Resources Management”, and “Management for Engineers” sequentially.

As per the results presented in Table 133, the Mann-Whitney U test with 95% confidence interval showed that there is no statistically significant difference in the students' course grades between the flipped class and lecture-based class of any of the examined courses. For the course “Financial Management for Engineers”, the *p*-value was 1.00, with median value of (3.7 out of 4) for the flipped class (Eng_G_Flip_A) and (3.3) for the lecture-based one (Eng_G_LB_F). For the course “Human Resources Management”, the *p*-value was 0.702, with median value of (3.70) for both the flipped class (Eng_G_Flip_B) and the lecture-based one (Eng_G_LB_G). For the course “Management for Engineers”, the *p*-value was 0.352, with median value of (3.70) for both the flipped class (Eng_G_Flip_C) and the lecture-based one (Eng_G_LB_H).

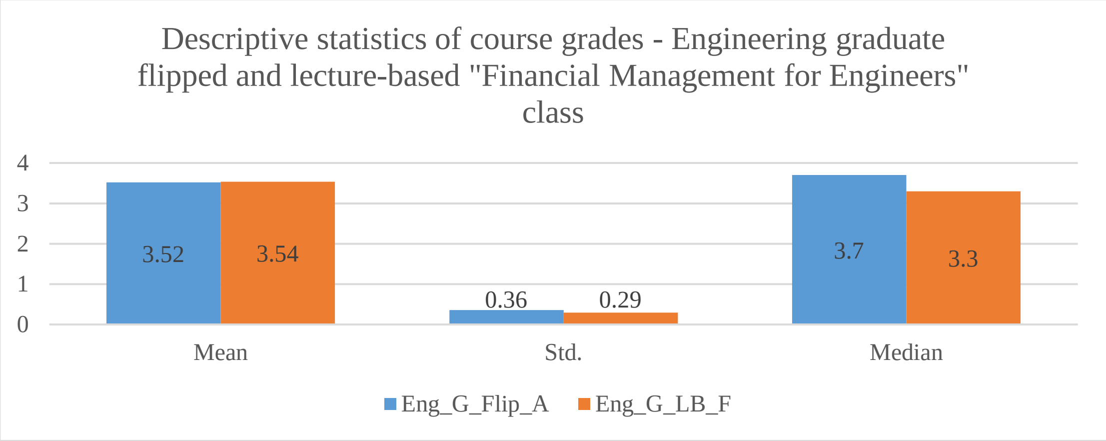

Figure 56: Descriptive statistics of course grades - Engineering graduate flipped and lecture-based " Financial Management for Engineers" class

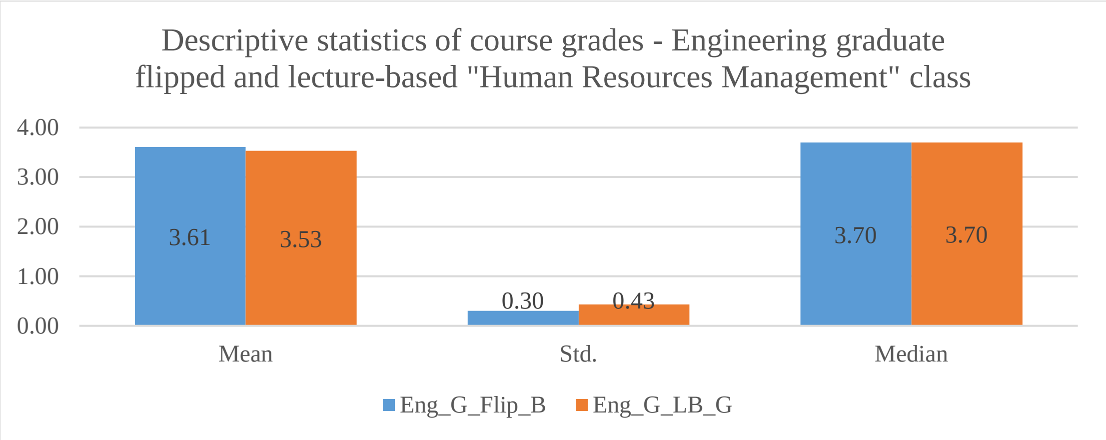

Figure 57: Descriptive statistics of course grades - Engineering graduate flipped and lecture-based "Human Resources Management" class

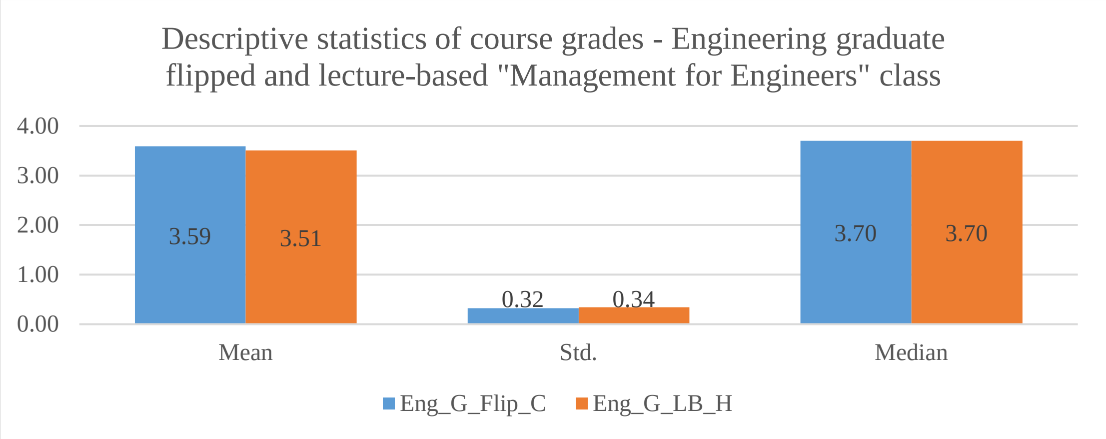

Figure 58: Descriptive statistics of course grades - Engineering graduate flipped and lecture-based "Management for Engineers" class

Table 133: Mann-Whitney U test for course grades data between flipped and lecture-based engineering graduate classes

Factor	**Eng_G_Flip_A**			**Eng_G_LB_F**			***W (p)*** **A and F**
	N	**Mean ± Std.**	**Median**	**N**	**Mean ± Std.**	**Median**	
Course grade	13	3.52 ± 0.36	3.70	11	3.54 ± 0.29	3.30	162.00 (1.00) (-0.3, 0.4)
Factor	**Eng_G_Flip_B**			**Eng_G_LB_G**			***W (p)*** **B and G**
	N	**Mean ± Std.**	**Median**	**N**	**Mean ± Std.**	**Median**	
Course grade	15	3.61 **± 0.30**	3.70	20	3.53 ± 0.43	3.70	281.50 (0.702) (-0.30, 0.30)
Factor	**Eng_G_Flip_C**			**Eng_G_LB_H**			***W (p)*** **C and H**
	N	**Mean ± Std.**	**Median**	**N**	**Mean ± Std.**	**Median**	
Course grade	26	3.59 ± 0.32	3.70	29	3.51 ± 0.34	3.70	780.50 (0.352) (0, 0.4)

6.9. Open-ended Questions

6.9.1. Flipped classes. Through open-ended questions, students were asked to report what they liked, disliked and recommend about the flipped method. Furthermore, students were asked to report their recommendations for technology tools that might improve the in-class activities. The coding of the responses was done with reference to the coding framework of [25]. Each flipped group was coded by itself

(Cal_UG_Flip_GI, Eng_UG_Flip_GI, Eng_G_Flip_A, Eng_G_Flip_GI), where the likes of the flipped method showed similar themes, but the dislikes and recommendations showed some differences. In our coding, it was taken into consideration to provide quotes from each individual class that are merged under one group.

6.9.1.1. Likes. In response to what the students like about the flipped teaching method, students reported to like mostly the engagement and collaboration that the in-class activities brought into the classroom as reported by 29.66% of respondents from all the flipped classes. Students under this theme referred to liking the increased class interaction involving student-student interaction and student-instructor interaction, the peer support, learning in groups, solving more problems in the class, sharing knowledge and learning from others through discussions, meeting new people, having fun in the class and not getting bored, feeling engaged, getting used to the class environment easily, and enhancing the social skills.

The next highly liked factor was enhanced learning as reported by 22.76% of students referring to better and faster understanding, more self-exploration and self-learning, gaining more knowledge through collaboration, reinforcement of concepts, better attention in the class, in addition to inquiring specific and deeper questions.

Next, 15.86% of students reported to like being prepared for the class. Students adored building familiarity with the content ahead of the class, mentioning that it fosters confidence, makes understanding better and deeper, and allows staying at the top of material.

Another aspect they liked reported by 8.28% of students, all from the engineering classes, is that flipped method helps in spreading out the study load over the semester and make it easier to prepare for major exams.

Students in the mathematics undergraduate classes (20.75% of them) reported to like the online learning provided to them by the availability of pre-class videos. Under this theme, students reported to like learning at their own pace anywhere and anytime, having continuous access to the video material, ability to pause and repeat for better understanding and to catch up on misunderstood ideas in addition to the advantage of review before exams.

Few students reported generally about liking the flipped method (5.52%) commenting as the flipped method is very helpful, effective and good. Three students from the mathematics undergraduate classes commented on liking the professor. Few students (3.45%) reported to not like anything or as “no benefits”.

Table 134 shows themes identified about liking the flipped method per each flipped group. Unedited students’ comments regarding what they liked about the flipped method are presented in Table 162 in Appendix F.

Table 134: Themes identified for likes about the flipped method

Likes Themes	Cal_UG _Flip_GI	Eng_UG _Flip_GI	Eng_G _Flip_A	Eng_G _Flip_GI	Total
N	53	44	11	37	145
Engagement/ Collaboration/ In-class activities	8	15	5	15	43
	15.09%	34.09%	45.45%	40.54%	29.66%
Enhanced learning	14	7	3	9	33
	26.41%	15.91%	27.27%	24.32%	22.76%
Being prepared for the class	9	6	3	5	23
	16.98%	13.64%	27.27%	13.51%	15.86%
Spread out the study load over the semester/ Ease studying for exams	-	7	1	4	12
	-	15.91%	9.09%	10.81%	8.28%
Videos/ Online learning	11	-	-	-	11
	20.75%	-	-	-	7.59%
Flipping	6	2	-	-	8
	11.32%	4.55%	-	-	5.52%
Professor	3	-	-	-	3
	5.66%	-	-	-	2.07%
No benefits/ Nothing	3	2	-	-	5
	5.66%	4.55%	-	-	3.45%
NA	11	11	1	5	28
	20.75%	25.00%	9.09%	13.51%	17.24%

6.9.1.2. Dislikes. In response to the dislikes about the flipped method, two common dislikes were identified among all our groups. First, the time demand and load caused by the flipped method as reported by 17.24% of total number of participating students. Under this theme, students commented about the time and efforts it takes to do the pre-class preparation, especially for hard topics. They also explained their concerns that they might not always have the time or desire to prepare and thus end up feeling lost in the class due to missing the pre-class preparation. Second, 7.59% of students reported to dislike the in-class group work, commenting that it is not always useful and that its efficiency depends on the group members. They also reported about some students not being prepared, some students not taking the in-class activity seriously, varying levels of knowledge of the students in the same group, and that in-class group work requires paying attention and being active all the time in the class.

Another dislike reported only by students in the engineering classes (11.72%), undergraduate and graduate, was about missing points of the material or understanding them incorrectly. Under this theme, students showed concerns that some points of the material might not be understood or got missed during the self-study time. They were also concerned that some concepts might be understood wrongly, and never corrected. No students in the mathematics undergraduate classes commented about this point, which might be due to the availability of the pre-class videos, created by the instructor, which ensures better understanding of the material. A unique dislike reported only by students in the undergraduate engineering classes, was regarding the quiz at the beginning of the class. This was reported by 27.27% of the students in the undergraduate engineering classes, which is 8.28% of the total participating students. Students in these classes perceived that the pre-class quiz is ineffective, depends on memorization and should be applied after the class discussions. They also showed concerns about its difficulty and that it leads to grade deduction. Only one student from the engineering undergraduate class commented about the fast pace of the course.

Some dislikes reported by the students in the mathematics undergraduate classes were regarding video specifications and video/ online learning. 9.43% of the students in these classes, 3.45% of total number of students, commented about the low quality of some of the videos and their length. While 7.54% of the students in these classes, 2.76% of total participants, commented about the absence of instructor during watching the videos, losing interest to coming to the class, and feeling lost in the class when missing to watch the pre-class online videos. Another dislike mentioned by two students in the mathematics undergraduate classes was about the repetition in the class time to what was watched in the pre-class video or the feeling of double class time.

On the other hand, it was welcoming that disliking “Nothing” was dominant through students’ responses across three of the involved flipped groups, forming 20.69% of the total number of participating students.

Table 135 shows themes identified about dislikes for the flipped method per each flipped group. Unedited students' comments regarding what they disliked about the flipped method are presented in Table 163 in Appendix F.

Table 135: Themes identified for dislikes about the flipped method

Dislikes Theme	Cal_UG _Flip_GI	Eng_UG _Flip_GI	Eng_G _Flip_A	Eng_G _Flip_GI	Total
N	53	44	11	37	145
Time demanding/load	6	11	3	5	25
	11.32%	25.00%	27.27%	13.51%	17.24%
In-class Group Work	2	3	2	4	11
	3.77%	6.82%	18.18%	10.81%	7.59%
Missing/ Incorrect understanding for points of material	-	6	3	8	17
	-	13.63%	27.27%	21.62%	11.72%
The quiz at beginning of the class	-	12	-	-	12
	-	27.27%	-	-	8.28%
Video specifications	5	-	-	-	5
	9.43%	-	-	-	3.45%
Video/ Online Learning	4	-	-	-	4
	7.54%	-	-	-	2.76%
In class time	2	-	-	-	2
	3.77%	-	-	-	1.38%
Speed	-	1	-	-	1
	-	2.27%	-	-	0.69%
Nothing	16	4	-	10	30
	30.18%	9.09%	-	27.03%	20.69%
NA	17	12	3	8	40
	32.07%	27.27%	27.27%	21.62%	27.59%

6.9.1.3. Recommendations. In another two open-ended questions, students were asked to mention their technology recommendations to enhance the in-class activities, and to report their recommendations to enhance the flipped teaching method. Their responses to these two questions were merged as shown in Table 136, as in many cases students only answered one of the questions.

Students recommendations came in the light of their dislikes and to overcome challenges. Two common recommendations were identified among all our groups. First, requests for some sort of online learning as reported by 17.24% of all participants. Under this theme, students requested some sort of tools and online content that facilitate online learning out of class time. This involved posting worksheets online to practice at home, online exercises/quizzes/games to check for pre-class content understanding, videos that present more problem solving, online discussion platform, google docs, YouTube streaming of videos, more online sources to study, in addition to comments about more use of the LMS. Second, students in all the involved classes requested more in-class activities, with students in the technical courses (Cal_UG_Flip_GI, Eng_UG_Flip_GI, Eng_G_Flip_A) describing it as more activities (4.14% of total participating students), while students in the conceptual courses (Eng_G_Flip_GI) requesting more real-activities such as games, visits, and workshops that simulate the practical aspects of the conceptual material they studied (5.52% of total participating students).

Another dominant request reported by 10.34% of total participants, with almost all students from the undergraduate classes, was regarding better classroom setup that fosters active learning. Suggestions involved smartboards, laptops, iPads, smartphones, clickers, bigger classroom and better classroom seating to support the in-class group work.

Students in all engineering classes, undergraduate and graduate, requested more instructor interaction during the class. Students in the undergraduate classes requested specifically to maximize the time of the class discussion with the instructor compared to the time of the students-to-students discussions as reported by 6.82% of the undergraduate engineering students, which is 2.07% of total participants. While students in graduate classes requested more interaction and guidelines from the instructor for the in-class group activity as reported by (18.18% from the Eng_G_Flip_A class, 8.11% from the Eng_G_Flip_GI classes), which is 3.45% of total participants. Another request reported by students in the engineering classes only was partial flip (4.83%). This involves requests to provide mini-lectures and to not flip all the material with specific requests to avoid flipping hard topics.

Students in the engineering technical courses only, undergraduate and graduate, requested lecture videos to understand and prepare the pre-class material, as reported by 9.09% from Eng_UG_Flip_GI classes and 36.36% from Eng_G_Flip_A class, which forms 5.52% of total participants. This request was absent in the engineering graduate conceptual classes (Eng_G_Flip_GI) despite the relatively large sample size of 37 students. On the other hand, students in the mathematics undergraduate classes, where pre-class videos were offered, requested some enhancements to the quality of videos as reported by 28.30% of them. Requests involved better quality videos, shorter ones, and to post videos on YouTube. 18.86% of students in the mathematics classes had commented about tools to enhance the video quality in response to the technology recommendations open-ended question. This involved a better camera and microphone for video recording, points based rewarding system like in Khan academics, a motion sensor to follow the professor when writing on the board, and a wider angled lens for the camera.

Unique requests by students in the engineering undergraduate classes in the light of their dislikes for the beginning of the class quiz were to apply the quiz after the class discussion, ease its questions, or make it not graded. This was reported by 13.63% of students in the engineering undergraduate classes. Only 1 student requested to give more credit for the pre-class quiz. Furthermore, 6.82% of students in these classes (3 students) requested to reduce the workload of the course. Suggestions mentioned were to reduce the frequency of flipped sessions, reduce the number of assignments or quizzes, or divide the pre-class material amongst students so each would prepare only part of the material.

Other individual requests by the students in the engineering undergraduate classes involve department support for the flipped method, slowing the pace of the course, not flipping major courses, and making it more useful for exams, where we assume the “it” refers to the method. Another individual requests by the students in the graduate conceptual courses were to provide HomeWorks, have more students in the class and use robots! 8.28% of total students commented with “no recommendation” for both open-ended recommendations questions, and 30.34% did not answer any of those questions.

Unedited students’ comments regarding what they recommend about the flipped method are presented in Table 164 in Appendix F.

Table 136: Themes identified for recommendations for the flipped method

Recommendation Themes	Cal_UG _Flip_GI	Eng_UG _Flip_GI	Eng_G _Flip_A	Eng_G _Flip_GI	Total
N	53	44	11	37	145
Online learning	15	3	1	6	25
	28.30%	6.82%	9.09%	16.22%	17.24%
More in-class activities	2	2	2	-	6
	3.77%	4.55%	18.18%	-	4.14%
Real-activities/ Game	-	-	-	8	8
	-	-	-	21.62%	5.52%
Classroom tools/ Setup	7	7	-	1	15
	13.21%	15.91%	-	2.70%	10.34%
Maximize time of class discussion with instructor	-	3	-	-	3
	-	6.82%	-	-	2.07%
More interaction and guidelines from instructor for in-class group activity	-	-	2	3	5
	-	-	18.18%	8.11%	3.45%
Partial flip	-	2	1	4	7
	-	4.55%	9.09%	10.81%	4.83%
Videos	-	4	4	-	8
	-	9.09%	36.36%	-	5.52%
Videos specifications	15	-	-	-	15
	28.30%	-	-	-	10.34%
Better camera/ Microphone to enhance video quality	10	-	-	-	10
	18.86%	-	-	-	6.90%
Ease quiz/ Apply quiz after class discussion/ Not graded quiz	-	6	-	-	6
	-	13.63%	-	-	4.14%
More credits for the beginning of the class quiz	-	1	-	-	1
	-	2.27%	-	-	0.69%
Reduce workload on student	-	3	-	-	3
	-	6.82%	-	-	2.07%
Others		4		4	
		9.09%		10.81%	
No recommendations	5	2	1	4	12
	9.43%	4.55%	9.09%	10.81%	8.28%
NA	14	15	3	12	44
	26.42%	34.09%	27.27%	32.43%	30.34%

6.9.2. Lecture-based classes. Students in lecture-based classes were also asked to report about what they liked, disliked or recommend about the lecture-based teaching method. Students' comments per study level were similar and thus merged together and reported as one group. The groups after merge involve the lecture-based mathematics undergraduate classes, engineering undergraduate classes, and engineering graduate classes.

6.9.2.1. Likes. In response to what the students like, students in all our lecture-based classes mostly commented about the content delivery style, that is, the lecturing of the instructor. This is expected as the most majority of the lecture-based class time is devoted to the instructor explaining the material or solving examples. Satisfaction toward the content delivery style was reported by 45.28% of all students in the lecture-based classes. Under this theme, students commented about liking the organized, structured, straightforward and detailed gradual explanation, the teaching style describing it as efficient, simple and convenient, the use of whiteboard to explain concepts, the course package or lectures' notes, the experience shared by the instructor reflecting on real-life problems, in addition to ensuring correct understanding of the material from the beginning.

The next dominant liked factor was the in-class activities and problem solving/examples as reported by 20.75% of students from all lecture-based classes. Students liked the solving of multiple detailed examples in the class after explaining the material, demonstration of real-life related applications, and the in-class discussions.

The third dominant reported liked factor was engagement and interaction as reported by 11.32% of students from all lecture-based classes, with half of these students' comments coming from the engineering undergraduate classes where more in-class activities were provided. This category involved students' comments about feeling interesting, engaged and not bored in the class, with students from the engineering undergraduate classes adding about liking the interaction with the teacher and peer students as a result of the group in-class activities.

Undergraduate students reported liking the open and good environment (6.92%). This involves comments about the open environment to ask questions referring mainly to the welcome of teachers to answer any doubts, the good class environment built and the good experience. Three students from the mathematics undergraduate classes commented about their familiarity with the lecture-based method as it is similar to other university classes and high school ones. Two students from the engineering graduate classes commented to like that there is no need for pre-class preparation or that the class is not taught in the flipped method because it is technical. While one student from the engineering undergraduate classes commented that the flipped method is better, coded under "Others". Two other comments from engineering classes, one from an undergraduate student and another from a graduate one, were about not generalizing the teaching methods as it depends on the material and the teacher. Two students in total reported to not like anything, and 40 students, 25.16% of students in the lecture-based classes, did not answer this question. Table 137 shows themes identified about what the students like regarding the lecture-based method per each lecture-based study level. Unedited students' comments regarding what they liked about the lecture-based method are presented in Table 165 in Appendix F.

Table 137: Themes identified for likes about the lecture-based method

Likes Themes	Cal_UG_LB_GII & Cal_UG_LB_GIII	Eng_UG_LB_C & Eng_UG_LB_D	Eng_G_LB_D & Eng_G_LB_E	Total
N	86	47	26	159
Content delivery	48	12	12	72
	55.81%	25.53%	46.15%	45.28%
In-class activities/ problem solving/ examples	8	15	10	33
	9.30%	31.94%	38.46%	20.75%
Engagement and Interaction	5	9	4	18
	5.81%	19.15%	15.38%	11.32%
Open and good environment	9	2	-	11
	10.46%	4.25%	-	6.92%
Familiarity of method	3	-	-	3
	3.48%	-	-	1.89%
No pre-class preparation/ no flip	-	-	2	2
	-	-	7.69%	1.26%
Others	-	2	1	3
	-	4.25%	3.85%	1.89%
Nothing	-	1	1	2
	-	2.13%	3.85%	1.26%
NA	25	12	3	40
	29.06%	25.53%	11.54%	25.16%

6.9.2.2. Dislikes. In response to the dislikes about the lecture-based method, 8.18% of students from all the classes reported about the fast pace of the course, and speedy explanations, with more specifying the class lectures towards the end of semester. Two dominant dislikes, the easy/little in-class problem solving and the absence of engagement, were featured across all our classes except for the engineering undergraduate class (Eng_UG_LB_C), which was featured with a lot of in-class activities and interactions. 15.72% of students from these classes reported about their dislikes for not covering a lot of problems/ examples in the class, and that the exercises being explored in the class were easy in comparison to the hard and challenging ones that were on the exam. 6.29% of students from these classes reported about the absence of engagement and in-class activities, and the feeling of being bored.

Few students commented about disliking the content delivery style describing it mainly as lecturing. This was reported by 4.40% of students, where all were from the undergraduate classes. Few students from the mathematics undergraduate classes (4 students) and one from the engineering undergraduate class (Eng_UG_LB_D) commented about disliking the lack of online learning. This mainly involves not uploading notes or part of them to the LMS. A unique dislike by students in the engineering undergraduate class (Eng_UG_LB_D) was regarding the feeling of too much or extensive materials as reported by 17.39% of students in that class. However, generally, students in this class reported the least in terms of their dislikes with 34.78% of them reported to dislike “Nothing”. This might be due to the enriched in-class activities and engagement that were featured in this class.

Considering all classes, 25.16% of all students commented about disliking “Nothing” which is a welcoming result. Other individual comments were coded under “others” category, such as the feel of demand, short class duration, and spending too much time in minimal question. 27.04% of all students did not answer this open-ended question.

Table 138 shows themes identified about dislikes regarding the lecture-based method per each lecture-based study level. Unedited students’ comments regarding what they disliked about the lecture-based method are presented in Table 166 in Appendix F.

Table 138: Themes identified for dislikes about the lecture-based method

Dislikes Theme	Cal_UG_LB_GII & Cal_UG_LB_GIII	Eng_UG_LB_C	Eng_UG_LB_D	Eng_G_LB_D & Eng_G_LB_E	Total
N	86	23	24	26	159
Speed of teaching	9	2	2	1	14
	10.47%	8.70%	8.33%	3.85%	8.18%
Little and easy in-class problem solving/ examples	13	-	6	6	25
	15.12%	-	25.00%	23.08%	15.72%
Absence of engagement/ in-class activities	4	-	3	3	10
	4.65%	-	12.50%	11.54%	6.29%
Content delivery	4	1	2	-	7
	4.65%	4.35%	8.33%	-	4.40%
Online learning	4	-	1	-	5
	4.65%	-	4.17%	-	3.14%
Extensive material	-	4	-	-	4
	-	17.39%	-	-	2.52%
Others	4	1	2	5	12
	4.65%	4.35%	8.33%	19.23%	7.55%
Nothing	22	8	2	8	40
	25.58%	34.78%	8.33%	30.77%	25.16%
NA	27	7	5	4	43
	31.39%	30.43%	20.83%	15.38%	27.04%

6.9.2.3. Recommendations. In response to recommendations for the lecture-based method, 28.30% of the students from all classes had requested more problem solving, examples, in-class activities and assessments. This was the only dominant requests across our classes. Under this theme, students were seeking more applications of the theory concepts by requesting more in-class problem solving, activities or case studies, more examples for out of the class review, in addition to more assessments such as quizzes or HomeWorks. Many students had specifically requested harder and more challenging problems or examples to prepare them better for exams, with some focusing on requesting real-life problems to give them a better understanding of the applications of the concepts.

Four students in the engineering undergraduate classes requested lab sessions to practice more on the related engineering software, with one suggesting technology-based lab sessions. Few students from mathematics undergraduate classes (3 students, 3.49%) and engineering graduate classes (2 students, 7.69%) requested more in-class students' interaction.

19.23% of the students in the engineering graduate classes suggested enhancement regarding course material such as providing more external resources, detailed lecture notes, following the book content, and providing less content but more in depth. While 4.65% of students in the mathematics undergraduate classes suggested recommendations for the content delivery style, such as avoiding the use of computers for explanation and relying more on the whiteboard, avoiding the explanation of wrong methods, and providing more resources. Four suggestions were requested by students in the mathematics undergraduate classes only. First, 10.47% of these students requested online learning asking for notes and in-class work to be uploaded online for review and self-assessment purposes. Second, 5.81% of these students requested lower speed of teaching. Third, 4 students (4.65%) requested graded homework and bonus work. Finally, 3 students (3.49%) requested the use of smartboards.

Two students from the engineering undergraduate classes requested the match of exam questions level with the level of problems or examples solved in the class. A unique request by students in the engineering undergraduate class (Eng_UG_LB_D) was to avoid having such a class at 8:00 am. This was reported by 33.33% of students in this class.

Other individual commented were categorized under "others". 14.47% of all participating students commented with "no recommendations", and 29.56% did not answer this open-ended question.

Table 139 shows themes identified about recommendations regarding the lecture-based method per each lecture-based study level. Unedited students' comments regarding what they recommend about the lecture-based method are presented in Table 167 in Appendix F.

Table 139: Themes identified for recommendations for the lecture-based method

Recommendation Themes	Cal_UG_LB_GII & Cal_UG_LB_GIII	Eng_UG_LB_C	Eng_UG_LB_D	Eng_G_LB_D & Eng_G_LB_E	Total
N	86	23	24	26	159
More problem solving/ examples/in-class activities/assessments	22	5	8	10	45
	25.58%	21.74%	33.33%	38.46%	28.30%
More lab sessions	-	2	2	-	4
	-	8.70%	8.33%	-	2.52%
More student interaction	3	-	-	2	5
	3.49%	-	-	7.69%	3.14%
Course material	-	-	-	5	5
	-	-	-	19.23%	3.14%
Content delivery	4	-	-	-	4
	4.65%	-	-	-	2.52%
Online learning	9	-	-	-	9
	10.47%	-	-	-	5.66%
Speed of teaching	5	-	-	-	5
	5.81%	-	-	-	3.14%
Rewarding/feedback/ graded homework	4	-	-	-	4
	4.65%	-	-	-	2.52%
Smartboard	3	-	-	-	3
	3.49%	-	-	-	1.89%
Match exam questions with in-class exercises	-	1	1	-	2
	-	4.35%	4.17%	-	1.26%
Better class time	-	-	8	-	8
	-	-	33.33%	-	5.03%
Others	7		4	4	15
	8.14%		16.67%	15.38%	9.43%
Nothing	10	6	1	6	23
	11.63%	26.09%	4.17%	23.08%	14.47%
NA	29	10	4	4	47
	33.72%	43.48%	16.67%	15.38%	29.56%

Chapter 7. Discussions and Recommendations

In this chapter, a discussion of the students' perceptions toward the flipped methodology will be shown in addition to providing recommendations based on it, then the perceptions and academic performance comparing flipped classes to similar lecture-based ones will be discussed.

7.1. Flipped Classes

The flipped classes investigated in this study vary in terms of study level, course nature, and delivery method. Our classes involved graduate and undergraduate study levels, technical and conceptual course natures, in addition to pre-class video-based materials and pre-class reading based materials. Our classes were categorized into three groups based on the course nature and the use of the pre-class video. First is the "Technical-video" group, the technical classes with pre-class video material. This group involved mathematics undergraduate classes (Cal_UG_Flip_GI). Second is the "Technical" group, the technical classes with pre-class reading material. This group involved engineering undergraduate classes (Eng_UG_Flip_GI) and engineering graduate class (Eng_G_Flip_A). Third is the "Conceptual" group, the conceptual classes with pre-class reading material. This group involved engineering graduate classes (Eng_G_Flip_GI).

Comparing the flipped classes to each other as per the identified categories, results showed that the reported satisfaction for teaching presence and In-class construct were statistically similar in the "Technical-video" group and "Conceptual" group (p-values ≥ 0.172), despite the fact that the "Technical-video" group involved freshman students while the "Conceptual" group involved graduate students. Furthermore, it was interesting that students within the "Technical" group, had reported similar satisfaction for teaching presence and In-class factor statistically (p-values ≥ 0.180), despite that it involves students of different levels of study and its classes were taught by different instructors. The satisfaction for teaching presence and In-class construct was statistically higher in the classes of "Technical-video" and "Conceptual" groups, in comparison to the classes of "Technical" group. The reported p-values for the related tests were 0.000.

Furthermore, cognitive presence was significantly the highest in flipped classes of the "Conceptual" group despite the absence of pre-class video with *p*-values ≤ 0.034 in comparison to other groups. Following that, the cognitive presence was significantly higher in flipped classes of the "Technical-Video" group, in comparison to flipped classes of the "Technical" group with *p*-values ≤ 0.025, despite that most of students in the "Technical-Video" group were freshmen, while students in the "Technical" group were mostly juniors or graduate students.

Through open-ended questions, students attending flipped classes of "Technical" group, both undergraduate and graduate, had requested videos for the pre-class component (Eng_UG_Flip_GI: 9.09%, Eng_G_Flip_A: 36.36%), while this request was absent in the classes of "Conceptual" group, and was admired by the students in the "Technical-Video" group (Cal_UG_Flip_GI: 20.75%).

As shown in the community of inquiry model [76], the shared function between cognitive and teaching presence is selecting content. This involves the instructional design of pre-class content to support practical inquiry during the class. Thus, in other words, the satisfaction of teaching and cognitive presence is related to the content design and consequently to the students' understanding of the content. Similarly, our custom created In-class construct is all about the impact of pre-class preparation on in-class participation and understanding. Thus, it is also related to the students' understanding of content through the pre-class material.

According to the above discussion and combining students' comments with the results of teaching, cognitive and In-class constructs, it seems that with absence of videos, students in the flipped classes of technical courses nature, the "Technical" group, are struggling to fully understand the technical material with a pre-class component that is based on reading material. Therefore, they are not able to make full benefits of the in-class activities, which illustrates the low cognitive presence in the "Technical" group in comparison to the classes of "Conceptual" or "Technical-Video" groups. As a result, teaching presence was low as well because students are missing direct instruction. Therefore, we argue that due to the absence of pre-class video materials, students in the classes of the "Technical" group perceived the flipped methodology less positively to those in the classes of the "Conceptual" or "Technical-Video" groups. The statistically higher cognitive presence reported in the "Conceptual" group in comparison to the "Technical-Video" group, can be reasoned to the graduate study level where students are more mature to benefit from the in-class activities in comparison to the freshmen students.

However, the social presence was notably reported the lowest in the "Technical-Video" group, the mathematics undergraduate classes, with mean and median values of 3.75 and 3.83, and it was statistically lower than the social presence reported in the "Conceptual" group with p-values ≤ 0.006. Students in the "Technical-Video" group had reported low satisfaction, less than 60%, regarding social presence items of SP1, SP2, and SP5, which refers to the feel of a collaborative cohesive learning environment, belonging to the course, and comfortably disagreeing with each others. This low social presence in the "Technical-Video" classes can be reasoned to the freshman study level, and that students are new to college and are probably taking the class with new classmates.

Learning presence was reported relatively low in the graduate technical class (Eng_G_Flip_A) with a mean value of 3.64, while for other groups the mean values were almost 4.00. Although there was no statistical difference, students in the graduate technical class (Eng_G_Flip_A) reported very low satisfaction regarding advancing goal settings to direct their learning (LP1: 27%). They also reported low satisfaction rates (55%) regarding items of LP2, LP3, and LP6, which refers to evaluating their learning, adapting to the course structure needs, and self-identifying what is needed to learn. This low reported learning presence in the graduate technical class (Eng_G_Flip_A) can be reasoned to the nature of the course rather than the self-regulation of students, as the course is somehow different from the other program courses as it is more about financial investments where all students are engineers and did not take a financial course ahead, and thus it affects setting the goal and objectives of learning for them. Thus, the instructor may need to clearer about the goals and objectives of the course, and continuously direct the students to them.

The correlation between RCOI constructs showed that cognitive presence is strongly correlated with the other domains of teaching, social and learning presence. The correlation values that involve cognitive presence had ranged between 0.528 and 0.707, with p-values < 0.01. This result is similar to [6], and it implies that a special focus must be placed to the design of the in-class activities that support higher order thinking to strengthen cognitive presence, which in turn will have an impact on the presence of other constructs.

On the other hand, when it comes to measuring study load and motivation factors, students in the undergraduate engineering classes were not as satisfied in comparison to other classes. Thus, for those two factors, study load and motivation, the satisfaction was not similar for students within the technical group, the undergraduate engineering students (Eng_UG_Flip_GI) and the graduate engineering ones (Eng_G_Flip_A), as it was for the RCOI and In-class constructs, with p values ≤ 0.003. The students in the undergraduate engineering classes (Eng_UG_Flip_GI) had mostly disagreed that the flipped methodology reduces study load and stress, the average reported satisfaction was (2.24 out of 5.00) with median value of (2.00 out of 5.00). Their motivation toward the flipped methodology was almost fragmented into three groups as agreeing (34.09%), neutral (36.36%) and disagreeing (27.27%) with average satisfaction value as (3.00 out of 5.00) and median value of (3.00 out of 5.00). On the other hand, students in the other classes, Cal_UG_Flip_GI, Eng_G_Flip_A, and Eng_G_Flip_GI had agreed more positively that the flipped method reduces study load and stress with average satisfaction values as 3.76, 3.27, and 3.82, and median values as 3.83, 3.67, and 4.00 sequentially. Their like of the flipped method was high with almost 90% of students in each group reporting with agreement and average satisfaction values of 4.63, 4.18 and 4.27, and median values as 5.00, 4.00 and 4.00 sequentially. However, it was notable that the majority of agreements regarding liking the flipped methodology in the undergraduate mathematics classes (Cal_UG_Flip_GI) were from the "Strongly Agree" response, while for the engineering graduate classes (Eng_G_Flip_A) and (Eng_G_Flip_GI), the majority of agreements were from the "Agree" response.

Statistically, the students in the undergraduate mathematics classes (Cal_UG_Flip_GI) reported higher than their peers in the engineering undergraduate classes (Eng_UG_Flip_GI) for both study load and motivation factors with p-values of 0.000. While the graduate classes, both of technical (Eng_G_Flip_A) and conceptual (Eng_G_Flip_GI) course nature, did not show statistical differences for the study load and motivation factors.

Looking into students' comments, a unique dislike for the engineering undergraduate classes (Eng_UG_Flip_GI) was regarding the beginning of the class quiz as reported by (27.27%) of the students. Another dominant dislike was about the time demand for the course as reported by (25.00%) of the students. Correspondingly, a unique request by a few students in these classes was to ease the quiz or apply it after the class (13.63%) and to reduce the workload of the course (6.82%).

Thus, combining students' comments with results of study load and motivation factors, we reason the report of increased study load and the fragmented motivation toward the flipped methodology for engineering undergraduate classes (Eng_UG_Flip_GI) to the difficulty level of the beginning of the class quiz and the increased load due to the assessments. As the quiz involved open-ended questions, it may be difficult to attempt and requiring too much preparation time in comparison to an MCQs-based one, as one undergraduate student mentioned the need of "memorization" to attempt the quiz. While no negative feedback was reported by students in the other classes regarding the MCQs-based quiz. Furthermore, students in the engineering undergraduate classes were requested homework along with a course project, while other classes had either a course project as in the graduate classes or no out of the class graded assessments as in the mathematics undergraduate classes.

Furthermore, students in the engineering undergraduate classes (Eng_UG_Flip_GI) showed concerns about missing points of the material or understanding them incorrectly as reported by 13.63% of them, which also plays a part in the fragmented motivation toward the flipped methodology for these students. This concern was also shared by students in the engineering graduate classes (Eng_G_Flip_A: 27.27%) and (Eng_G_Flip_GI: 21.62%), but none of the students in undergraduate mathematics classes (Cal_UG_Flip_GI) classes commented about it. Thus, we argue that this concern is what might have contributed to the lower motivation toward the flipped method in the engineering graduate classes (Eng_G_Flip_A) and (Eng_G_Flip_GI) where the majority of responses to liking the method were as "Agree", in comparison to the majority of students in the undergraduate mathematics classes (Cal_UG_Flip_GI) responding with "Strongly Agree". We attribute this concern reported in the engineering classes, both undergraduates and graduates, to the absence of videos for the pre-class material. Videos are a great way to substitute the face to face lecture and ensure the correct understanding of the material, especially when they are created by the instructor teaching the course.

Looking into the correlation of each of the survey items with the motivation toward the flipped method, teaching, cognitive and In-class constructs were at the highest correlating constructs. In particular, the clear communication of course topics and due dates, clarifying feedback, self-exploration and reflection opportunities in addition to better confidence to ask questions in the class due to preparation were at the top items per each of the highest correlation constructs, and, thus, we imply to contribute most to the effectiveness of the flipped method.

The results of the correlation of each of the survey items with the motivation toward the flipped method, supports our argument that the pre-class material had an impact on the students' motivation toward the flipped method. As, teaching, cognitive and In-class constructs are commonly impacted by the design and effectiveness of pre-class material as explained earlier. Therefore, much attention needs to be given to the design of the pre-class material to enhance the presence of teaching and cognitive constructs in addition to the impact of the pre-class material on in-class understanding and participation, which will contribute to the students' motivation to the flipped teaching method.

Regarding the use of the textbook, there was no statistical difference between classes of same study level, however, the use of the textbook in undergraduate classes was statistically higher than in the graduate classes with *p*-value = 0.000.

The majority of the students in all our classes reported to spend one to two [1-2) hours or two to three [2-3) hours on pre-class preparation, almost 50%-67% of students in each class/group. The rest of the students reported to spend either less than one hour or three to four [3-4] hours with different percentages patterns as per each class/group. Only three students from all our classes reported to spend more than four hours on pre-class preparation. In other words, we can say that almost all our participants are spending one to four hours for the pre-class preparation.

Regarding the accepted number of flipped courses to be taken at the same semester, the undergraduate students in both groups, "Cal_UG_Flip_GI" where the majority were freshman students, and "Eng_UG_Flip_GI" where the majority were junior students, had the top two responses as two or three courses, with nearly 25% agreement for each choice in each group. The rest of the responses had scattered between none, one, or more than three courses. On the other hand, for the graduate students, in both technical and conceptual classes, the top two common responses were one or two courses, keeping in consideration that the norm of the number of courses is two courses for the graduate part-time students, and three for the graduate full-time students. For the technical graduate class (Eng_G_A), the agreement for one and two courses was nearly similar and equal to 19% per each. While for the conceptual classes (Eng_G_Flip_GI), the majority agreement was for two courses (35%), with (19%) responding with one course. Thus, considering all graduate students, the majority agreement for the number of flipped courses to be taken at the same semester is two courses.

The majority of students in each class/group preferred the partial flipped classes, that is 50% lecture, 50% in-class activities. Considering all students in all classes, 76.55% of our participants had selected partial flip as their rank 1, 11.03% selected 100% lecture, and 9.66% selected 100% in-class activities. The top four reasons for the students' preference of partial flipped across all our classes were: the benefits of the 50% in-class lecture component, partial flip is more interesting, engaging, and provides reasonable interaction, flipped method is useful for better understanding, and the benefits of 50% in-class activities component.

Based on students' comments among all open-ended questions, we identified 10 benefits for the flipped method from students' perspective as follows:

1. Increased confidence to ask in-class questions due to pre-class study.
2. Staying at the top of the material due to pre-class study.
3. Increased engagement and collaboration in the class.
4. Increased student-student and student-instructor interaction.
5. Increased peer support and knowledge sharing.
6. Enhanced social skills.
7. Solving more examples and problems in the class.
8. Enhanced learning, better and faster understanding.
9. Spreading out the study load over the semester and make it easier to prepare for major exams.

10. learning at own pace anywhere and anytime with the availability of pre-class video material.

Based on the students' comments among all open-ended questions, we identified 5 challenges of the flipped method from students' perspective as follows:

1. Increased study load and time demanding.
2. Not all students come prepared.
3. Coping with the dynamics of in-class group work.
4. Missing points of material or wrongly understanding them with the absence of pre-class video material.
5. Quality of pre-class video.

Based on the interview with the three instructors teaching flipped courses, we identified 8 benefits for the flipped method from the instructors' perspective as follows:

1. Getting the chance to know the students more and faster in terms of their understanding levels and personalities.
2. Students are more engaged and asking more challenging questions.
3. Students' level of participation is much more.
4. Ability to see the personal development of the students.
5. Ability to check students' understanding ongoing in the class and correct mistakes immediately because students are solving with the supervision and support of the instructor.
6. Students tend to solve more problems. For some, they tend to solve more advanced problems.
7. The feeling of one to one or personalized teaching in the class
8. Ability to cover the material faster than in lecture-based class. This gives the chance to provide a one-week review before the final exam for one of the courses.

Based on the interview with the three instructors teaching the involved flipped courses, we identified 5 challenges of the flipped method from the instructors' perspective as follows:

1. Short class time when it is a scheduled 50-minute classes.
2. Students' resistance.
3. Lack of depth in the pre-class reading material by the students.

4. Variation of students' discussions and understanding of the pre-class material which intimidates some students.
5. Sometimes it is hard to control the students after the group work to provide an explanation to the class as students tend to be talking and in fun mode of the group work.

The above identified benefits and challenges from students and instructors are consistent with what was reported earlier in the literature review.

Based on the reported satisfaction for all constructs, the satisfaction rates per each item, and the students' comments among all open-ended questions, we identified 10 recommendations for designing the flipped class as following:

1. Provide pre-class multimedia-based learning materials that explain the lecture

The results of this research showed that students attending flipped classes of a technical course nature struggle with understanding the course concepts with pre-class reading learning material. This was shown through their requests for pre-class videos (Eng_UG_Flip_GI: 9.09%, Eng_G_Flip_A: 36.36%), concerns about misunderstanding concepts (Eng_UG_Flip_GI: 13.63%, Eng_G_Flip_A: 27.27%), in addition to reporting significantly lower teaching (mean: 3.82 ± 0.71, median: 3.90) and cognitive presence (mean: 3.71 ± 0.73, median: 3.78) compared to students in the "Conceptual" and "Technical-Video" groups. Although none of the students in the flipped classes of a conceptual nature had requested pre-class videos, they showed concerns about misunderstanding concepts (Eng_G_Flip_GI: 21.62%). These concerns were absent from the classes where students were provided with pre-class video material. Thus, providing multimedia-based learning materials would substitute the face to face instruction, and ensures the correct understanding of the course concepts. Furthermore, it provides students with the ability to review the videos learning material multiple times, pause and replay as needed, which will reinforce concepts. As shown in the literature, earlier research showed that students value the pre-class video learning material [20], [9], [46], [84], [85], [86]. In an earlier study at AUS [85], students reported to prefer custom videos created by the instructor which was the case for the videos provided in our examined flipped classes. Thus, when it comes to creating pre-class videos, [116] had suggested 12 principles for creating multimedia learning materials that can be a good reference to consider. Those principles address Coherence, Signaling, Redundancy, Spatial Contiguity, Temporal Contiguity, Segmenting, Pre-training, Modality, Multimedia, Personalization, Voice, and Image.

2. Provide an encouraging mechanism to assess student preparation

Some students complained about some peers not doing the pre-class preparation. This was featured under students' dislikes of the in-class group activity (7.59%). As expressed by a student in the graduate classes (Eng_G_Flip_GI): "sometimes, some of the students do not discuss and stay quiet but it's because they probably did not read about it in advance". Few had clearly reported on not preparing before the class, total four (2.76%), despite the fact that the pre-class preparation was mandatory in all the classes. Thus, the success of a flipped class depends highly on students being prepared and having a good understanding of the pre-class material in order to effectively participate in the in-class activities. Providing formative assessment is an effective way to ensure that students prepare before the class. However, students in the undergraduate engineering classes reported to dislike the beginning of the class quiz (27.27%) referring to it as being hard to attempt and thus this would result in demotivating them at the beginning of the class. Given that the quiz in these classes involved open-ended questions along with MCQs ones, it seems that students found it hard to attempt with one student describing the need of "memorization" to attempt the quiz. There was no negative feedback from the other classes adopting MCQs-based quiz. Thus, to avoid these complains, it is recommended to provide low stakes and easy formative assessment where it will be a motivation for the students and a way to ensure their preparation. MCQs-based quizzes and notes taking were found to be accepted by our students in our study. Similarly [6] adopted MCQs-based simple quizzes.

3. Provide a mechanism to monitor group dynamics and individual contributions

Students from all our classes reported to dislike the in-class group work (7.59%). The main theme was complaining that some students in the group play the role of "easy riders", so they do not participate in the activity or take it seriously and instead they depend on others to explain and work. Therefore, students were commenting that the efficiency of the in-class group work depends on the group members. Thus, we are recommending four strategies in this regard adopting it from

[117]. First, orienting students about collaborative learning and preparing them for the group work. This involves introductions about collaborative learning, icebreakers activities, in addition to introducing the course policies and procedures. This helps create an atmosphere for students to work together in group. Second, providing a grading model that reflects a combination of individual and group performance to provide individual accountability while still encouraging the group interconnection. This can be achieved by requesting individual work as an outcome of the learning task along with a group outcome. For example, in a "test-taking teams" activity, students could be asked to individually attempt to answer a test or set of questions and then attempt to answer the same test in a group. Both individual and group attempts can be graded with different weights. Third, clearing out the grading criteria and expectations for any activity. Rubrics can be used to achieve this. Fourth, including peer evaluation in the assessment cycle as students are more aware about what is going on during a group work. This would be more useful for the project-based classes where the groups last for a whole semester. Furthermore, we recommend providing a variety of in-class activities as it helps to keep the students motivated to participate and avoid being bored by the end of the activity. Plenty of collaborative learning activities with the use of each can be found in [117].

4. Provide students with self-assessments

Students from all our classes had requested more online learning (17.24%) where requests for online exercises or quizzes was a main theme. As explained by a student in the undergraduate mathematics classes (Cal_UG_Flip_GI): "There should be online exercises as well once watching the videos is complete.". Thus, providing opportunities for students to self-assess their understanding of the material before the class can be effective. Self-assessments can be easily created within a learning management system such as Blackboard with automatic constructive feedback. They can also be configured as anonymous, so students will not have the fear of instructor judgment on their performance. Furthermore, instructors can adopt publishers' content made available through LMS integration, which provides access to many assessments with engaging material. Examples of the STEM publishers' content that provides online learning assessments are McGraw-Hill and Pearson.

5. Provide ongoing feedback and supportive interaction

Students in all engineering classes, undergraduate and graduate, had requested more instructor interaction, expressing it as increasing the time of class discussions with the instructor (Eng_UG_Flip_GI: 6.82%) or clearly requesting more guidelines and interaction from the instructor during the in-class group work (Eng_G_Flip_A: 18.18%, Eng_G_Flip_GI: 8.11%). Furthermore, students in the undergraduate engineering classes (Eng_UG_Flip_GI) showed a great need for clarifying feedback that would assist them in a better understanding of the content as satisfaction rate regarding this TP item was very low (TP10: 34.09%). It was also found that providing constructive feedback is highly correlated with motivation toward the flipped method (Gamma values of TP10 in all classes: 0.78, 0.60, 0.81, 0.41). Thus, students need on-going feedback and interaction from the instructor to direct their progress toward better understanding of the course content and applications. As noted by [117], it is important that instructor interaction is supportive rather than directive, so the learning will be a mutual responsibility for the instructor and students. Some mentioned strategies by [117] for supportive interaction are: pulling together ideas by pointing out relationships of course concepts to something familiar by the students, summarizing the group's major views before moving to a class discussion, energizing students by using humor and asking for additional contributions specially when they struggle with complex concepts, stopping by groups to elaborate on a student's statement, compliment insightful comment or suggest a new perspective, paraphrasing the student contribution to clarify it more to other students, in addition to being available to answer questions and clarify instructions.

6. Provide online communication channels

Many students requested an online discussion platform to communicate before or after the class. This was featured under their requests for online learning (17.24%). As expressed by a student in the undergraduate engineering classes (Eng_UG_Flip_GI) requesting "online database for the class to post comments and ask questions after the class". Thus, providing an online communication channel is effective to increase peer support and allow for instructor support out of class time. Furthermore, it will make it more effective to ensure the mobility support of the discussion platform where students can easily participate and comment on each other using their phones or tablets. Learning management systems like Blackboard can be used to achieve this as it supports online discussion boards along with mobile application to access and participate.

7. Ensure accessibility of pre-class material

Although only one student commented about issues in accessing the pre-class materials expressing that "Videos were too long to load at home", it is always important to design the flipped class with accessibility matters in consideration. Every student needs to be able to access the pre-class materials anytime and anywhere to facilitate their learning. Many students requested the use of LMS under the theme of online learning requests (17.24%). This was requested more by the graduate engineering students as the pre-class material was communicated through emails. Thus, it makes it easier from a student's perspective to locate the pre-class materials through the LMS in one concise place. Furthermore, when videos are adopted, it is important to ensure that students can load the videos with their home connection or mobile devices.

8. Provide a clear description about course goals, topics and activities

Looking into the correlation between each of the survey items and the motivation toward the flipped method, teaching presence items were found at the highest of these correlations (21 significant TP associations). Instructors need to clearly communicate course goals, important topics, instructions for the in-class activities, due dates and time frames in addition to continuously guide and encourage students, as their presence through these tasks contributes highly to the students' motivation.

9. Support the flipped classroom with active learning tools and structure

10.34% of the participating students, mostly from the undergraduate classes, requested a better classroom setup that supports the adoption of flipped methodology. This involved, requests for smart-boards, seating structure that ease the in-class group work, in addition to active learning tools such as iPads, laptops and clickers.

10. Partially flipping the classes

The majority of the students from all classes preferred partial flipped classes compared to 100% flipped or 100% lecture classes (76.55%). Students valued the in-class activities while at the same time showed their desire for a short lecture. Thus, instructors can design the class time such as to provide a mini-lecture to fill in gaps and ensure correct understanding along with the in-class activities to practice and apply higher order thinking.

Three of our recommendations were also recommended by [6]: provide an encouraging mechanism to assess student preparation, provide ongoing feedback, and ensure accessibility of the pre-class material.

7.2. Flipped Versus Lecture-based Classes

In order to provide additional insight into the impact of flipped methodology, we compared the flipped classes to similar lecture-based ones using post-test quasi-experimental design.

For mathematics undergraduate classes, the "Technical-video" group, students in the flipped classes, the treatment group, reported statistically higher teaching presence (p-values ≤ 0.019), cognitive presence (p-values ≤ 0.038), and liking of the teaching method (p-values ≤ 0.026), compared to students in the lecture-based classes, the control group. While social presence, learning presence, confidence to ask questions in the class, and the use of textbook carried no statistical differences. Regarding in-class understanding, students in the flipped classes reported statistically higher than their peers in lecture-based classes (Cal_UG_LB_GIII) with (p-value= 0.010), while there was no statistical difference in comparison to the lecture-based classes (Cal_UG_LB_GII).

For engineering undergraduate technical classes belonging to the "Technical" group, students in the flipped classes, the treatment group, reported statistically lower teaching presence and liking of the teaching method (p-values ≤ 0.018) compared to their peers in both lecture-based classes, the control group, and they reported statistically lower cognitive presence, students' confidence to ask in-class questions and in-class understanding (p-values = 0.000) in comparison to the lecture-based class (Eng_UG_LB_C), but there was no significant difference in comparison to the lecture-based class (Eng_UG_LB_D). On the other hand, the use of textbook was statistically higher in the flipped classes in comparison to each of the lecture-based ones with p-values of 0.000. Social and learning presence showed no statistical difference between the two teaching methods.

For engineering graduate technical classes, belonging to the “Technical” group, students in the flipped class, the treatment group, had reported similarly to their peers in each of the compared lecture-based classes, the control group, according to all constructs. It was only TP that showed slightly significant difference in comparison to one of the lecture-based classes (Eng_G_LB_E), with *p*-values of 0.069, 0.035, and the in-class confidence construct that showed slightly significant difference in comparison to one lecture-based class, (Eng_G_LB_D), with *p*-value of 0.081.

The undergraduate students in the mathematics flipped classes, the “Technical-video” group, reported either higher or similar satisfactions compared to their peers in lecture-based classes. While the engineering undergraduate students in the flipped classes, belonging to the “Technical” group, reported either lower or similar satisfaction in comparison to their peers in lecture-based classes. On the other hand, engineering graduate students in the flipped technical class, belonging to the “Technical” group, reported similar satisfaction to their peers in the lecture-based classes. In other words, for undergraduate students, the flipped experience with pre-class video material was superior to a lecture-based method. While the lecture-based method with in-class activities was superior to the flipped method with the absence of pre-class video material. For graduate students of technical course nature, the lecture-based method with in-class activities was similar to the flipped method with the absence of pre-class video material.

When it comes to the study practices, majority of students from all the classes, both flipped and lecture-based, reported to usually prepare “Only few days before the midterm or quiz”. Thus, pre-class preparation assists in keeping the students on top of the material.

Looking into students’ responses to the open-ended questions provided to students in both flipped and lecture-based classes, the main reason reported regarding high confidence level to ask questions in the class by students in the flipped classes was the pre-class preparation (Cal_UG_Flip_GI: 18.86%, Eng_UG_Flip_GI: 4.55%, Eng_G_Flip_GI: 13.51%), while students in the lecture-based classes reported their confidence to ask questions mostly to the instructor willingness to answer them (Cal_UG_LB_GII & Cal_UG_LB_GIII: 11.63%, Eng_UG_LB_C & Eng_UG_LB_D: 19.15%, Eng_G_LB_D & Eng_G_LB_E: 26.92%) or to their personality as being comfortable to ask (Cal_UG_LB_GII & Cal_UG_LB_GIII: 8.14%, Eng_UG_LB_C & Eng_UG_LB_D: 10.64%). These comments were infrequently mentioned by the students in the flipped groups (6 students) who are at the same age and majors. Thus, this means that the flipped methodology brings a new reason to boost students' confidence to ask questions. Having students asking questions in the class is important for their learning journey as it allows them to get answers in the early stages to their questions and benefit their classmates listening to these questions, instead of having the questions raised during the office hours with the absence of classmates.

The top three mentioned factors that the students liked in the flipped classes were: engagement, collaboration and in-class activities (29.66%), enhanced learning (22.76%), and being prepared for the class (15.86%). While students in the lecture-based classes notably reported the most satisfaction on the content delivery method (45.28%), and then to in-class activities and problem-solving (20.75%), and engagement and interaction (11.32%). Thus, the flipped method brought new aspects to the students to note and like through their learning progress.

The flipped method also brought new challenges to the students as reported by their dislikes, where the top three challenges were: the time demand (17.24%), dynamics of in-class group work (7.59%), and wrongly understanding points of the material or missing them (11.72%). Those challenges can however be addressed through the recommendations mentioned earlier which accommodate students' requests. On the other hand, the top three challenges faced by the students in the lecture-based classes can be solved in the light of the flipped method. These include: little and easy in-class problem solving (15.72%), speed of teaching (8.18%), and absence of engagement and in-class activities (6.29%).

Looking into comparisons regarding academic performance, students in the mathematics undergraduate flipped treatment group (Cal_UG_Flip_GI) reported statistically higher course grades than their peers in the each of the control lecture-based groups (Cal_UG_LB_GII and Cal_UG_LB_GIII), with p values: 0.057, 0.043. The estimated course grade median deference is 0.3 with 95% confidence interval for the median difference as (0 – 0.7). Considering that the course grade involved in this study is the GPA point of the letter grade, then a difference of 0.3 is equivalent to one letter grade difference (see Appendix H). Failure rate was lower in the flipped group with about 10% in comparison to each of the lecture-based groups. Furthermore, the percentage of scores between A and B- was higher in the flipped group with about 18% in comparison to the lecture-based groups. Given that the groups were homogeneous, and the assessments were the same across all classes, then this result is significant. Thus, this result matches our earlier discussions about the flipped classes, which shows that students in the mathematics undergraduate flipped classes with pre-class video material had clearly benefited from the flipped method as their reported satisfaction through the survey element were high. This significantly higher course grades in the flipped group compared to the lecture-based classes matches earlier research shown in the literature review [7], [27], [68].

On the other hand, there was no statistical difference between the course grades of students in each of the engineering undergraduate flipped classes (Eng_UG_Flip_A and Eng_UG_Flip_B) and the lecture-based class (Eng_UG_LB_E). However, the failure rate was zero in the lecture-based class, in comparison to 21.21% and 5.41% in the flipped ones. Furthermore, the percentage of scores between A and B- was higher in the lecture-based class in comparison to each of the flipped ones with around 19% and 23% differences. Although these differences can be attributed to not having exactly the same assessments across the examined classes, having the students in the lecture-based class performing better than each of the flipped classes might be questionable, given that homogenous of students' demographics were validated. Thus, it might be reasons that the flipped method was not implemented as effectively as it can be, as students in the engineering undergraduate flipped classes, "Technical" group, reported less satisfaction through the survey elements compared to the "Technical-video" and "Conceptual" groups as shown earlier in the discussion about the flipped classes. This result contradicts with earlier research reported in the literature for school-wide implementation of the flipped method in engineering classes [25], where students performance in the flipped classes was either similar or statistically higher in comparison to their peers in the lecture-based ones.

For the engineering graduate classes, both technical and conceptual, there was no statistical difference regarding course grades between the flipped class and the lecture-based class of any of the three examined courses. This finding is similar to earlier research reporting no statistical difference for academic performance between flipped and lecture-based classes for some of the examined engineering courses [25]. However, the percentage of scores of A or A- was higher in all the flipped classes compared to the lecture-based ones with different values of 16.09% for the technical class and 6.67%, 21.35% for the conceptual ones. Although that the students' satisfaction in the engineering graduate technical class through the survey element was less in comparison to the students in the engineering graduate conceptual classes, they reported higher satisfaction than the engineering undergraduate technical classes who are also part of the "Technical" group, in terms of motivation and study load constructs as discussed before. Thus, despite the similar challenges they had regarding the absence of pre-class videos, their motivation might be a factor for the positive impact of the flipped method on their academic performance. Thus, this finding from three different courses can be considered welcoming for the impact of the flipped method on the academic performance positively, given that the flipping of the class can be better through the use of pre-class video material in addition to adopting other mentioned recommendations in section 7.1.

Chapter 8. Conclusion, Limitations and Future Work

This study investigated students' perceptions of flipped method in undergraduate and graduate classes at American University of Sharjah. Students' perceptions from lecture-based classes were investigated as well to provide an additional insight into the flipped method perceptions by comparing both methodologies. The RCOI framework was used as the underlying analysis factor along with custom designed items and open-ended questions. Furthermore, academic performance data of students was collected and analyzed for both flipped and lecture-based classes.

This study addressed the following objectives, how instructors at AUS are implementing the flipped method as shown in chapter 4, the impact of flipped method on students' perceived learning experience and the most contributing factors to its effectiveness as explained in section 7.1, and finally the impact of flipped method on students' perceived learning experience and academic performance in comparison to lecture-based method as explained in section 7.2.

Students' perceptions of flipped method were not similar based on the study level as one may expect, but rather they were related to the course nature and techniques employed, that is, the use of pre-class video learning material. Generally, in our study, the undergraduate students in the classes of the "Technical-video" group, the technical classes with pre-class video material, perceived flipped method similarly to the graduate students of the "Conceptual" group, conceptual classes with the absence of pre-class video. While students in the classes of "Technical" group, the technical classes with the absence of pre-class video, both undergraduate and graduate, had perceived the flipped method similarly and were less satisfied than the students in the "Technical-video" and "Conceptual" groups.

When comparing the flipped classes to the lecture-based ones, the undergraduate students' satisfaction in the flipped classes of the "Technical-video" group were statistically higher or similar to their peers in lecture-based classes. They also reported statistically higher course grades. While the undergraduate students in the "Technical" group had reported lower or similar satisfaction to their peers in lecture-based classes, with no statistical difference in the course grades. On the other hand, the graduate students in the “Technical” class reported statistically similar to their peers in the lecture-based classes considering all factors and the course grades. In our study, there was no graduate lecture-based classes of a conceptual nature to compare to the flipped classes in the “Conceptual” group. However, we expect that the students’ perceptions in the flipped classes would be higher or similar to the lecture-based ones.

Constructs of teaching presence, cognitive presence, social presence, learning presence and in-class, were found to relate to the nature of the course and the use of pre-class video. While the study-load and motivation were found to relate to the difficulty level of the beginning of the class quiz and amount of assessments. Furthermore, the use of pre-class video material was also related to higher motivation toward the flipped method.

In this study, we recommended 10 design principles for the flipped classroom driven from students’ comments and survey responses. We also showed the benefits and challenges of flipped method from students’ and instructors’ points of views. As shown earlier in the discussions section, many of our recommendations can be easily adopted through the use of technology, the LMS such as Blackboard, and the STEM publishers’ online learning materials, such as McGraw-Hill and Pearson. Thus, the use of technology will make it easier for the instructor to provide students with collaboration channels, keep them engaged and provide them with more chances of mastery.

In conclusion, based on this study’s results and discussions, students in both flipped and lecture-based methodologies perceive their learning experience positively according to RCOI constructs overall. It is worthy to note that there is no one size fits all, as described by one of the students in the engineering undergraduate classes “lecturing is not a good or bad thing. Educational method should be based on the course material and not generalized.”. Thus, both methods are working when they are implemented to the best need of the material and students. However, our study showed that students are very positively viewing the flipped method benefits despite the multiple challenges they are facing. Thus, by incorporating the design principles recommendations that were derived from students’ responses and comments, flipped method would potentially be more promising for STEM education and STEM students.

This study can be helpful for instructors or instructional designers engaged in flipped method, or administrators looking to adopt flipped method into their colleges.

The limitations of this research were, first, the research only addressed the flipped method instances at AUS, and did not consider other higher education institutions at UAE. Second, courses used in the comparison of academic performance were either taught at different semesters but with the same instructor or taught at the same semester but with different instructors. Therefore, we could only fix one element at a time; the teaching semester or the instructor. Third, courses used in the comparison of perceived learning experience for engineering classes were not the same and offered by different instructors, but all at the same semesters and from the same program and study level. This is due to individual section offering for engineering major courses.

For future work, we suggest involving a larger sample size of each of the explored groups, “Technical”, “Technical-Video”, and “Conceptual”. We also suggest conducting student interviews as a third type of data source, in addition to considering other analysis frameworks such as College and University Classroom Environment Inventory (CUCEI), and Teaching Dimensions Observation Protocol (TDOP). Furthermore, we suggest looking into the continued impact of the flipped method on the subsequent courses, and comparing the academic performance of students who passed the pre-course with a flipped setting to those with a non-flipped one.

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Appendices

Appendix A: Checklist of F-L-I-P pillars

Table 140: Checklist of F-L-I-P pillars

Pillar	Check list
Flexible Environment	**F.1** I establish spaces and time frames that permit students to interact and reflect on their learning as needed
	F.2 I continually observe and monitor students to make adjustments as appropriate.
	F.3 I provide students with different ways to learn content and demonstrate mastery.
Learning Culture	**L.1** I give students opportunities to engage in meaningful activities without the teacher being central.
	L.2 I scaffold these activities and make them accessible to all students through differentiation and feedback.
Intentional Content	**I.1** I prioritize concepts used in direct instruction for learners to access on their own.
	I.2 I create and/or curate relevant content (typically videos) for my students.
	I.3 I differentiate to make content accessible and relevant to all students.
Professional Educator	**P.1** I make myself available to all students for individual, small group, and class feedback in real time as needed.
	P.2 I conduct ongoing formative assessments during class time through observation and by recording data to inform future instruction.
	P.3 I collaborate and reflect with other educators and take responsibility for transforming my practice.

Appendix B: Protocol for instructor perception about flipped classrooms

Protocol for instructor perception about flipped classrooms

1) Describe the Flipped classroom in-/out-class activities:
    a. What students should do before the class
    b. Type of material viewed before the class (reading lectures, videos, etc.)
    c. What activities are implemented into the class and how students participate in it
    d. Role of instructor
2) What are the issues and challenges you encounter and how you dealt with them?
3) What are benefits you noticed?
4) Did you adopt a technology tool to support the implementation of flipped classroom?
5) Suggestions and recommendations

Appendix C: Survey to collect students' perceptions of flipped classes at AUS

You are invited to participate in a research study investigating the impact of flipped methodology on students' academic performance, and their perceived learning experience in compare to lecture-based method. The purpose of this study is to learn more about the flipped method impact at AUS and gather your suggestions for improving teaching and learning experience at the university level. This study is part of fulfillment of Master degree in Engineering Systems Management and your contribution is highly appreciated.

Your feedback will be taken into consideration, thus you may see improvements you wish in future AUS classes !

- Total number of questions: 59
- It would take you no more than 15 minutes to complete it.

Please note that:

- Your participation is voluntary.
- You have the right to withdraw your consent or discontinue participation at any time without penalty or loss of benefits.
- You have the right to refuse to answer particular questions.
- Your individual privacy will be maintained in all published and written data resulting from the study.

Terms Meaning:

- Learning activities refer to in-class activities like discussions or presentations, course project, case studies, and exercises.
- Community refer to group of students learning together.
- Flipped learning is a learning pedagogy where the typical lecture and homework elements are reversed. Students review content before the class on their own, while the class time is devoted for activities.

☐ Based on above, I agree to participate in this survey and that my feedback can be used in future publications.

Demographic Questions				
1. Gender	☐ Male		☐ Female	
2. Class level	☐ Freshman	☐ Sophomore	☐ Junior	☐ Senior
3. Age:	**4.** Midterm Grade(s) of this course:		**5.** GPA:	

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Part I					
6. The instructor clearly communicated important course topics.	☐	☐	☐	☐	☐
7. The instructor clearly communicated important course goals.	☐	☐	☐	☐	☐
8. The instructor provided clear instructions on how to participate in course learning activities.	☐	☐	☐	☐	☐
9. The instructor clearly communicated important due dates/time frames for learning activities.	☐	☐	☐	☐	☐
10. The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.	☐	☐	☐	☐	☐
11. The instructor helped to keep students engaged and participating in productive dialogue.	☐	☐	☐	☐	☐
12. The instructor encouraged students to explore new concepts in this course.	☐	☐	☐	☐	☐
13. Instructor actions reinforced the development of a sense of community among students.	☐	☐	☐	☐	☐
14. The instructor helped to focus discussion on relevant issues in a way that helped me to learn.	☐	☐	☐	☐	☐
15. My Instructor provided clarifying explanations or other feedback that allowed me to better understand the content of the course.	☐	☐	☐	☐	☐
Part II					
16. Getting to know other students gave me a sense of belonging in the course.	☐	☐	☐	☐	☐
17. I was able to form distinct impressions of some students.	☐	☐	☐	☐	☐
18. I felt comfortable participating in the course discussions.	☐	☐	☐	☐	☐
19. I felt comfortable interacting with other students.	☐	☐	☐	☐	☐
20. I felt comfortable disagreeing with other students while still maintaining a sense of trust.	☐	☐	☐	☐	☐
21. I felt that my point of view was acknowledged by other students.	☐	☐	☐	☐	☐
Part III					
22. In-class group activities increased my interest in the course	☐	☐	☐	☐	☐
23. I felt motivated to explore content related questions.	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
24. I used a variety of information sources to deepen my understanding in this course.	☐	☐	☐	☐	☐
25. Brainstorming and finding relevant information helped me resolve content related questions.	☐	☐	☐	☐	☐
26. Combining new information helped me answer questions raised in course activities.	☐	☐	☐	☐	☐
27. Learning activities helped me construct explanations/solutions.	☐	☐	☐	☐	☐
28. Reflection on course content and discussions helped me understand fundamental concepts in this class.	☐	☐	☐	☐	☐
29. I can describe ways to test and apply the knowledge created in this course.	☐	☐	☐	☐	☐
30. I can apply the knowledge created in this course to my work or other non-class related activities.	☐	☐	☐	☐	☐
Part IV					
31. When I study for this class, I set goals for myself in order to direct my activities in each study period.	☐	☐	☐	☐	☐
32. I ask myself questions to make sure I understand the material I have been studying in this class.	☐	☐	☐	☐	☐
33. I try to change the way I study in order to fit the course requirements and instructor's teaching style.	☐	☐	☐	☐	☐
34. I worked hard to get a good grade even when I was not interested in some topics.	☐	☐	☐	☐	☐
35. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.	☐	☐	☐	☐	☐
36. Before I begin studying I think about the things I will need to do to learn.	☐	☐	☐	☐	☐
37. When studying for this course I try to determine which concepts I don't understand well.	☐	☐	☐	☐	☐
Part V					
38. The pre-class preparation helps me better understand the course materials in compare to other courses.	☐	☐	☐	☐	☐
39. The pre-class preparation makes me more engaged and less bored in the class time in compare to other courses.	☐	☐	☐	☐	☐
40. The pre-class preparation inspired me to ask more deep questions about this course in compare to other courses.	☐	☐	☐	☐	☐
41. I felt the flipped methodology helps me develop the knowledge of the course material gradually in a better way in comparison with lecture based methodology.	☐	☐	☐	☐	☐
42. The pre-class preparation helps me better participate and ask questions at the	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
class in compare to my participation in other courses?					
43. At the class time, I feel confident asking questions about the lecture topic. Please explain briefly your selection.	☐	☐	☐	☐	☐
44. Generally, at the end of the class, you feel you have understood everything	☐	☐	☐	☐	☐
Part VI					
45. I felt the pre-class preparation distribute the study load of this course over the semester but didn't create extra study load for me in total?	☐	☐	☐	☐	☐
46. Studying for the midterm/final exam of this course requires me less efforts in compare to other courses?	☐	☐	☐	☐	☐
47. Studying for the midterm/final exam of this course, I was more confident and less stressful in compare to other courses?	☐	☐	☐	☐	☐
48. I liked the teaching style/method of this course?	☐	☐	☐	☐	☐

Part VII			
49. In a non-flipped class I usually prepare	☐ As early as possible after the class time	☐ As early as possible before the class time	☐ Only few days before the midterm or quiz
50. Did you use the textbook	☐ Yes		☐ No
51. Does flipped methodology improves your study habits for other non-flipped courses?	☐ Yes		☐ No
52. Comparing two methods, I believe that:	☐ Flipped method is superior to the lecture-based method	☐ About the same	☐ The flipped method is inferior to the lecture-based method.
Part VIII			
Please answer the following questions:			

53. In average, how many hours do you spend in preparing ahead for this class?
54. Rank your preferred class method (Rank using 1,2,3 where 1 is the most preferred).
☐ 100% Lecture ☐ 50% Lecture, 50% in-class activities (Partial Flipped) ☐ 100% in-class activities (Flipped)
Please explain your choices

55. In your opinion, what is the accepted number of courses to be taken in the flipped methodology at the same semester? Select from (1, 2, 3, 4, 5, 6, 7, 8, all courses). Describe the reason of your selection.

56. What do you like about the teaching method of this course, the flipped method?

57. What do you dislike about the teaching method of this course, the flipped method?

58. Describe any technology tool that might improve the flipped classroom activities

59. What are your recommendations to improve learning through the flipped method at this course?

Appendix D: Survey to collect students' perceptions of lecture-based classes at AUS

You are invited to participate in a research study that aim to enhance the teaching and learning experience at AUS. We would like to know your viewpoint about the learning experience at this class. This study is part of fulfillment of Master degree in Engineering Systems Management and your contribution is highly appreciated.

Your feedback will be taken into consideration, thus you may see improvements you wish in future AUS classes !

- Total number of questions: 46
- It would take you no more than 15 minutes to complete it.

Please note that:

- Your participation is voluntary.
- You have the right to withdraw your consent or discontinue participation at any time without penalty or loss of benefits.
- You have the right to refuse to answer particular questions.
- Your individual privacy will be maintained in all published and written data resulting from the study.

Terms Meaning:

- Learning activities refer to in-class activities like discussions or presentations, course project, case studies, and exercises.
- Community refer to group of students learning together.

☐ Based on above, I agree to participate in this survey and that my feedback can be used in future publications.

Demographic Questions					
1. Gender		☐ Male		☐ Female	
2. Class level		☐ Freshman	☐ Sophomore	☐ Junior	☐ Senior
3. Age:	**4.** Midterm Grade(s) of this course:			**5.** GPA:	

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Please answer the questions below, rating yourself on each of the criteria shown					
Part I					
6. The instructor clearly communicated important course topics.	☐	☐	☐	☐	☐
7. The instructor clearly communicated important course goals.	☐	☐	☐	☐	☐
8. The instructor provided clear instructions on how to participate in course learning activities.	☐	☐	☐	☐	☐
9. The instructor clearly communicated important due dates/time frames for learning activities.	☐	☐	☐	☐	☐
10. The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.	☐	☐	☐	☐	☐
11. The instructor helped to keep students engaged and participating in productive dialogue.	☐	☐	☐	☐	☐
12. The instructor encouraged students to explore new concepts in this course.	☐	☐	☐	☐	☐
13. Instructor actions reinforced the development of a sense of community among students.	☐	☐	☐	☐	☐
14. The instructor helped to focus discussion on relevant issues in a way that helped me to learn.	☐	☐	☐	☐	☐
15. My Instructor provided clarifying explanations or other feedback that allowed me to better understand the content of the course.	☐	☐	☐	☐	☐
Part II					
16. Getting to know other students gave me a sense of belonging in the course.	☐	☐	☐	☐	☐
17. I was able to form distinct impressions of some students.	☐	☐	☐	☐	☐
18. I felt comfortable participating in the course discussions.	☐	☐	☐	☐	☐
19. I felt comfortable interacting with other students.	☐	☐	☐	☐	☐
20. I felt comfortable disagreeing with other students while still maintaining a sense of trust.	☐	☐	☐	☐	☐
21. I felt that my point of view was acknowledged by other students.	☐	☐	☐	☐	☐
Part III					
22. In-class group activities increased my interest in the course	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
23. I felt motivated to explore content related questions.	☐	☐	☐	☐	☐
24. I used a variety of information sources to deepen my understanding in this course.	☐	☐	☐	☐	☐
25. Brainstorming and finding relevant information helped me resolve content related questions.	☐	☐	☐	☐	☐
26. Combining new information helped me answer questions raised in course activities.	☐	☐	☐	☐	☐
27. Learning activities helped me construct explanations/solutions.	☐	☐	☐	☐	☐
28. Reflection on course content and discussions helped me understand fundamental concepts in this class.	☐	☐	☐	☐	☐
29. I can describe ways to test and apply the knowledge created in this course.	☐	☐	☐	☐	☐
30. I can apply the knowledge created in this course to my work or other non-class related activities.	☐	☐	☐	☐	☐
Part IV					
31. When I study for this class, I set goals for myself in order to direct my activities in each study period.	☐	☐	☐	☐	☐
32. I ask myself questions to make sure I understand the material I have been studying in this class.	☐	☐	☐	☐	☐
33. I try to change the way I study in order to fit the course requirements and instructor's teaching style.	☐	☐	☐	☐	☐
34. I worked hard to get a good grade even when I was not interested in some topics.	☐	☐	☐	☐	☐
35. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.	☐	☐	☐	☐	☐
36. Before I begin studying I think about the things I will need to do to learn.	☐	☐	☐	☐	☐
37. When studying for this course I try to determine which concepts I don't understand well.	☐	☐	☐	☐	☐
Part V					
38. At the class time, I feel confident asking questions about the lecture topic. Please explain briefly your selection.	☐	☐	☐	☐	☐
39. Generally, at the end of the class, you feel you have understood everything	☐	☐	☐	☐	☐
40. I liked the teaching style/method of this course.	☐	☐	☐	☐	☐

Part VI			
41. I usually prepare	☐ As early as possible after the class time	☐ As early as possible before the class time	☐ Only few days before the midterm or quiz
42. For this class, I usually prepared	☐ As early as possible after the class time	☐ As early as possible before the class time	☐ Only few days before the midterm or quiz
43. Did you use the textbook	☐ Yes		☐ No

Part VII
Please answer the following questions:

44. What do you like about the teaching method of this course, lecture-based method where you are exposed to lecture first time at the class time with the instructor lecturing it?

45. What do you dislike about the teaching method of this course, lecture-based method where you are exposed to lecture first time at the class time with the instructor lecturing it?

46. What are your recommendations to improve learning through this course?

Appendix E: Survey Items Division

RCOI framework items

Table 141: Teaching presence items

Item code	Flipped and Lecture-based Classroom
TP1	**6.** The instructor clearly communicated important course topics.
TP2	**7.** The instructor clearly communicated important course goals.
TP3	**8.** The instructor provided clear instructions on how to participate in course learning activities.
TP4	**9.** The instructor clearly communicated important due dates/time frames for learning activities.
TP5	**10.** The instructor was helpful in guiding the class towards understanding course topics in a way that helped me clarify my thinking.
TP6	**11.** The instructor helped to keep students engaged and participating in productive dialogue.
TP7	**12.** The instructor encouraged students to explore new concepts in this course.
TP8	**13.** Instructor actions reinforced the development of a sense of community among students.
TP9	**14.** The instructor helped to focus discussion on relevant issues in a way that helped me to learn.
TP10	**15.** My Instructor provided clarifying explanations or other feedback that allowed me to better understand the content of the course.

Table 142: Social presence items

Item code	Flipped and Lecture-based Classroom
SP1	**16.** Getting to know other students gave me a sense of belonging in the course.
SP2	**17.** I was able to form distinct impressions of some students.
SP3	**18.** I felt comfortable participating in the course discussions.
SP4	**19.** I felt comfortable interacting with other students.
SP5	**20.** I felt comfortable disagreeing with other students while still maintaining a sense of trust.
SP6	**21.** I felt that my point of view was acknowledged by other students.

Table 143: Cognitive Presence items

Item code	Flipped and Lecture-based Classroom
CP1	**22.** In-class group activities increased my interest in the course
CP2	**23.** I felt motivated to explore content related questions.
CP3	**24.** I used a variety of information sources to deepen my understanding in this course.
CP4	**25.** Brainstorming and finding relevant information helped me resolve content related questions.
CP5	**26.** Combining new information helped me answer questions raised in course activities.
CP6	**27.** Learning activities helped me construct explanations/solutions.
CP7	**28.** Reflection on course content and discussions helped me understand fundamental concepts in this class.
CP8	**29.** I can describe ways to test and apply the knowledge created in this course.
CP9	**30.** I can apply the knowledge created in this course to my work or other non-class related activities.

Table 144: Learning presence items

Item code	Flipped and Lecture-based Classroom
LP1	**31.** When I study for this class, I set goals for myself in order to direct my activities in each study period.
LP2	**32.** I ask myself questions to make sure I understand the material I have been studying in this class.
LP3	**33.** I try to change the way I study in order to fit the course requirements and instructor's teaching style.
LP4	**34.** I worked hard to get a good grade even when I was not interested in some topics.
LP5	**35.** I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.
LP6	**36.** Before I begin studying I think about the things I will need to do to learn.
LP7	**37.** When studying for this course I try to determine which concepts I don't understand well.

Table 145: In-class understanding and participation items

Item code	Flipped Classroom
In-class1	**38.** The pre-class preparation helps me better understand the course materials in compare to other courses.
In-class2	**39.** The pre-class preparation makes me more engaged and less bored in the class time in compare to other courses.
In-class3	**40.** The pre-class preparation inspired me to ask more deep questions about this course in compare to other courses.
In-class4	**41.** I felt the flipped methodology helps me develop the knowledge of the course material gradually in a better way in comparison with lecture based methodology.
In-class5	**42.** The pre-class preparation helps me better participate and ask questions at the class in compare to my participation in other courses?
In-class6	**43.** At the class time, I feel confident asking questions about the lecture topic. Please explain briefly your selection. (open-ended)
In-class7	**44.** Generally, at the end of the class, you feel you have understood everything
Item code	**Lecture-based Classroom**
In-class6	**38.** At the class time, I feel confident asking questions about the lecture topic. Please explain briefly your selection. (open-ended)
In-class7	**39.** Generally, at the end of the class, you feel you have understood everything

Table 146: Study load items

Item code	Flipped Classroom
SL1	**45.** I felt the pre-class preparation distribute the study load of this course over the semester but didn’t create extra study load for me in total?
SL2	**46.** Studying for the midterm/final exam of this course requires me less efforts in compare to other courses?
SL3	**47.** Studying for the midterm/final exam of this course, I was more confident and less stressful in compare to other courses?
SL4	**53.** In average, how many hours do you spend in preparing ahead for this class? (open-ended)
SL5	**55.** In your opinion, what is the accepted number of courses to be taken in the flipped methodology at the same semester? Select from (1, 2, 3, 4, 5, 6, 7, 8, all courses). Describe the reason of your selection. (open-ended)

Table 147: Study practices items

Item code	Flipped Classroom			
Study1	**49.** In a non-flipped class I usually prepare	☐ As early as possible after the class time	☐ As early as possible before the class time	☐ Only few days before the midterm or quiz
Study2	**50.** Did you use the textbook	☐ Yes	☐ No	
Study3	**51.** Does flipped methodology improves your study habits for other non-flipped courses?	☐ Yes	☐ No	
Item code	**Lecture-based Classroom**			
Study1	**41.** I usually prepare	☐ As early as possible after the class time	☐ As early as possible before the class time	☐ Only few days before the midterm or quiz
Study2	**43.** Did you use the textbook	☐ Yes	☐ No	
Study4	**42.** For this class, I usually prepared	☐ As early as possible after the class time	☐ As early as possible before the class time	☐ Only few days before the midterm or quiz

Table 148: Motivation toward the teaching method items

<table>
<tr><th>Item code</th><th colspan="3">Flipped Classroom</th></tr>
<tr><td>M1</td><td colspan="3">48. I liked the teaching style/method of this course?</td></tr>
<tr><td>M2</td><td colspan="3">52. Comparing two methods, I believe that:</td></tr>
<tr><td></td><td>☐ Flipped method is superior to the lecture-based method</td><td>☐ About the same</td><td>☐ The flipped method is inferior to the lecture-based method.</td></tr>
<tr><td>M3</td><td colspan="3">54. Rank your preferred class method (Rank using 1,2,3 where 1 is the most preferred).</td></tr>
<tr><td></td><td colspan="3">☐ 100% Lecture
☐ 50% Lecture, 50% in-class activities (Partial Flipped)
☐ 100% in-class activities (Flipped)</td></tr>
<tr><td></td><td colspan="3">Please explain your choices (open-ended)</td></tr>
<tr><th>Item code</th><th colspan="3">Lecture-based Classroom</th></tr>
<tr><td>M1</td><td colspan="3">40. I liked the teaching style/method of this course?</td></tr>
</table>

Table 149: Open-ended questions

Item code	Flipped Classroom
OE1	**56.** What do you like about the teaching method of this course, the flipped method?
OE2	**57.** What do you dislike about the teaching method of this course, the flipped method?
OE3	**58.** Describe any technology tool that might improve the flipped classroom activities
OE4	**59.** What are your recommendations to improve learning through the flipped method at this course?
Item code	**Lecture-based Classroom**
OE1	**44.** What do you like about the teaching method of this course, lecture-based method where you are exposed to lecture first time at the class time with the instructor lecturing it?
OE2	**45.** What do you dislike about the teaching method of this course, lecture-based method where you are exposed to lecture first time at the class time with the instructor lecturing it?
OE4	**46.** What are your recommendations to improve learning through this course?

Appendix F: Unedited Students' Comments

Table 150: Students' comments for high confidence level of asking in-class questions – Flipped classes

Identified Reason	Unedited students' comments
Pre-class study	**Cal_UG_Flip_GI**
	"I know what to ask because I saw the pre-class and I am sure I need to have an answer",
	"I know what the topic is about and the hard or tricky parts that I need help in, rather than waiting until the end of class",
	Eng_UG_Flip_GI
	"Since a brief background about the topic was analyzed, asking question is much easier in this case",
	Eng_G_Flip_GI
	"Because I already prepared the lectures and I already thought about the questions that I need to ask",
	"Due to the preparation before the class, I fell that the basic understanding of the topic makes me go in depth",
class environment	**Cal_UG_Flip_GI**
	"Class environment allows you to participate with no fear from being mocked by other students",
	Eng_UG_Flip_GI
	"I feel confident to ask compared to other courses because I feel there is a bond between me, classmate and prof."
	Eng_G_Flip_A
	"Engaging with other students and discussing",
	Eng_G_Flip_GI
	"Everybody knows everyone. We actually are like a family (extremely internal)"
professor welcomes questions	**Cal_UG_Flip_GI**
	"Professor is always ready to answer them in different ways in order to understand."
	Eng_UG_Flip_GI
	"The professor is open for any kind of question."
	"Professor always allow and encourages question."
I am comfortable to ask	**Eng_UG_Flip_GI**
	"Not shy. Irrelevant to flipped (unaffected by flipped)."
	"If I don't understand I ask."
	"No reason. Asking questions is normal."

Table 151: Students' comments for selecting accepted number of flipped courses in the same semester to be none or within 1 to 4 courses – Undergraduate flipped classes

Identified Reason	Cal_UG_Flip_GI	Eng_UG_Flip_GI
Study Load	"1, it feels like it is double the class time. 40 minutes videos for every class and a 50-minute class." "3, as it will take a lot of time at home"	"1,2 max. if more, it will be too much work outside class especially INE courses have projects. With quizzes and homework, flipped for more than 2 courses would be an OVERLOAD!" "Maximum of 3. more than that would be too much."
Not suitable for all courses	"3, some courses that are easy for students to learn through flipped method should be offered like that, though courses that are hard or a professor that does not know how to prepare/explain a flipped class session requires all the attention of mine to focus." "4, because not all courses suit the flipped methodology"	"2-3 courses. only theory-based courses." "3. I just think it's a good balance since not all courses are eligible to be taught using flipped learning in my opinion."
The must of traditional courses/ New to approach	"2-3, some courses require 100% lecture, so each student can ask their own questions on the spot." "2, because I need to get used to flipped method gradually."	-
For calculus and physics	"2, I only need it for 2 courses because math and physics are my weak spots." "2, physics and math, for understanding then practice"	-
The must of flipped method to have a change	"3 of 5 courses in a semester should at least adopt flipped methodology to engage students in their studies to make classes entertaining and less boring" "1-2, so it changes our mood mixed with lectures."	-
Others	"4, I have tested it before and believe it works."	"3 courses. Having more than 3 courses … could result in loss of grades." "2 maximum, …TBH sometimes students are not even interested to discuss, they just chit chat and

		they don’t take this seriously and sometimes one student might want to share their ideas but others don’t listen because they are busy chit chatting so I do think that flipped cannot work for all courses because of all those reasons.”

Table 152: Students’ comments for selecting accepted number of flipped courses in the same semester to be equal to or greater than 5 courses – Undergraduate flipped classes

Identified Reason	Cal_UG_Flip_GI	Eng_UG_Flip_GI
Better understanding/Improve study habits/Availability of online video lectures/it's good	“All courses, I understand better with this method than normal teaching method.” “All courses, since it would break down my lazy habits and encourage me to study more before-hand for all courses and it would allow me to fully understand ideas/concepts as a result of reviewing.” “All courses, as the lectures are always available to know the material if I am not available.”	“All courses, it keeps the students up-to-date and fully committed to all courses with a balance instead of procrastination or undivided attention to courses.”
It doesn't increase study load	“5-6, Flipped method does not increase workload.” “5, I don't expect that much load from it.” “5-6, because it would be easier since you don't spend hours studying for them.”	-

Table 153: Students' comments for the selected number of accepted flipped courses in the same semester – Graduate flipped classes "Eng_G_Flip_A" & "Eng_G_Flip_GI"

Response	**Identified Reason**	**Eng_G_Flip_A**	**Eng_G_Flip_GI**
1 or 2	**Study Load**	"25% of the semester course, not more, because the load is more on the students." "2, as you are the one teaching yourself." "Half of the course is acceptable, because we will have time for other projects. If more than one, we will spend the whole week studying for pre-quizzes."	"1, it requires a lot of effort." "2, for a full-time employee, I think more than two courses will be very stressful" "2, would be more than enough since it requires time."
1	**New to method**	"1 partial flip, because it is a new method and need time to adapt with and also it needs time to prepare for the flipped method."	-
2	**Better engagement**	-	"2, more interactive." "2, reduce the loads, mixture of both so it will be less boring."
2 or theoretical courses	**Suits theory courses**	-	"2, Depending on the content of the course. if it was a math related course then no need for the flipped methodology .in management courses where no math is required then 2 out of 3 for example." "Depends on the type of course takes, in theoretical courses it is preferred to take all using the flipped learning method while for more analytical or statistical course, lectures are more convenient."
3 or all courses	**Easier to handle & understand/ more effective**	-	"3, because it is easy to handle." "3, makes sense." "All courses, because it helps understanding more easily."

			“All courses, because it is more effective.”
2, 3 or all courses	**Other (Depends on student registration (part/full) - Partial flip)**	-	“2 for master students (part time students)/ 3 or 2 for master (full time students).” “All courses, provided that the flipped method is half and not full.”

Table 154: Students’ comments for partial flip class preference

Identified Reason	**Unedited students’ comments**
50% lecture benefits	Cal_UG_Flip_GI
	“Having a teacher explain the lesson fully is essential before attempting to solve questions with others”
	“I like that the professor quickly summarizes the videos in class, it helps to fully grasp the ideas, theories and formulas.”
	“Sometimes you don't get time to watch the video before the class”
	“In case I don't know an idea in the video, the prof. will be explaining it again”
	Eng_UG_Flip_GI
	“Flipped learning lessons are good due to the interaction, however, I feel like since the professor doesn’t explain it himself, students could conclude or understand things incorrectly while thinking they know it correctly. Also, it wastes a lot of time and a lot of time I have to revise once again after the flipped learning because I get confused.”
	“50% lecture and 50% class activities is the best way that could be applied, because students can't understand everything on their own”
	Eng_G_Flip_A
	“I feel if the whole class was flipped then we can do it anywhere anytime. I need the doctor's knowledge.”
	“Sometimes you may not get the chance to prepare for the flip methodology. Also, sometimes the materials are difficult and need to be explained first”
	Eng_G_Flip_GI
	“Because its more interesting to have class activities but at the same time we need to make sure what we understand is right”
	“If we don't understand something from the group discussion so we can still have a chance to understand from lecture”
100% lecture is boring/ Partial flip is more Interesting, more engaging and provides	**Cal_UG_Flip_GI**
	“Makes it more interesting”
	“You can engage in class with other students. This helps you notice your mistakes as well”
	“I get bored in 100% lecture and not interested in 100% activities”,
	Eng_UG_Flip_GI

reasonable interaction	"… there should be in-class activities to kill the boredom that arise from a 1-hour lecture"
	"Keeps things serious with some interactions between students ==> the lecture doesn't become boring"
	Eng_G_Flip_GI
	"Interaction in a reasonable amount is advantageous"
	"Having little discussions helps me avoid boring …"
Flipped method help in better learning and understanding, develop skills and help in exam/ Pre-class study is useful for learning	**Cal_UG_Flip_GI**
	"I have grown to appreciate the flipped class method as it introduces us to the concept prior to class, allowing us to develop our skills and deepen our understanding in class."
	"I like combining the two because it's more interesting, and I also think flipped method makes me learn better."
	"You need the lecture but the flipped helps in exams more"
	Eng_UG_Flip_GI
	"Many students may keep everything last minute with a 100% lecture based, so a 50% actually reinforces learning. But a 100% flipped is demanding and stressing to students"
	"As the prof said, if it's 100% lecture it gets boring and I tend to get lost. However, if there is flipped I study and prepare questions, and walk out knowing at least 75%"
	Eng_G_Flip_A
	"I believed that studying or at least know a little about the topic before coming to the class will have a great impact on my understanding during the lecture"
	Eng_G_Flip_GI
	"Flipped learning enable us to know the important concepts before the class"
	"Encourages more understanding of the course materials"
50% in-class activities benefits	**Cal_UG_Flip_GI**
	"50% lecture to understand the material and solving method more and 50% in-class activities to put those knowledge into practice"
	"Partially flipped classes is my preference because it provides us with more questions to solve"
	Eng_UG_Flip_GI
	"Partial flipped: both gain knowledge + clarification. 100% lecture: boring. 100% in-class activities: study load will be too much"
	Eng_G_Flip_GI
	"50-50 gives you best experience from my point of view since you get to do your own thinking and analysis and then share it with your group, then hear what the professor has to say and the experience he shared and finally compare your analysis with explanation and come to conclusions"
	"The class activities helped me to understand the lecture"
Combination of both gives better experience	**Cal_UG_Flip_GI**
	"Half-Half is always better"
	"To balance each other out"
	Eng_G_Flip_A

	"Works better"
	Eng_G_Flip_GI
	"Combination of both gives better experience"
	"It allows us to combine between the modern educational strategies and apply the traditional style in an effective way"
100% flip is time demanding and stressing/partial flip reduce study load	**Eng_UG_Flip_GI**
	"50% lecture,50% in class activities is better since it distributes the workload on the professor as well as the students. also, the student shouldn't be expected to understand everything as their own …"
	"Flipped is okay but time consuming. Effectiveness is less than time spend on it. It results in the course moving at a fast pace that students don't get time to comprehend or like the material",
	Eng_G_Flip_GI
	"As a full-time employee, this puts less load on me before the class (flipped) while maintaining some aspects of an interesting and useful teaching method"
100% flip: don't understand everything/ not used to it/ not interested in it	**Cal_UG_Flip_GI**
	"3 (100% flip) Students might not understand"
	"I get bored in 100% lecture and not interested in 100% activities",
	Eng_G_Flip_GI
	"A middle ground is always better especially that 100% in class activities approach is something most students not used to"
	"Sometimes you don't want to talk or to be included in discussion all the time"
100% lecture: don't understand everything/ feel shy to ask	**Eng_UG_Flip_GI**
	"3 (100% lecture) it is actually boring, you don't understand everything feel shy to ask but in some concepts it is preferred to have full lecture class"
To have videos for review	**Cal_UG_Flip_GI**
	"To have videos to go back and look at it if I don't understand a concept"

Table 155: Students' comments for 100% lecture class preference

Identified Reason	Unedited students' comments
Effectiveness of flipped session depends on the class and group members/professor have better knowledge	Cal_UG_Flip_GI
	"I do not learn anything in calculus activities because in our class it's every student for himself"
	Eng_UG_Flip_GI
	"the professor has better knowledge in the course"
	"I prefer a mainly lecture based learning because It's better when the professor explains and then we can go and study based on what we took and attend help sessions, if I were to just depend on flipped then this would be limited to what me and others understand of the lecture based on the resources we can find on the selected topics (sometimes I find videos/ppt that really help to understand and sometimes I Don't)"
	Eng_G_Flip_GI
	"This what I prefer and not all classes can have a well-organized and interesting in-class as well as the ambiance of class affects"
Some points may be misunderstood with flipped session	**Cal_UG_Flip_GI**
	"1 (100% lecture): Fully understand topics, 2 (partial flip): unanswered and doubts about certain material, 3 (100% flip): might not fully understand topics on my own"
	Eng_UG_Flip_GI
	"Some flipped sessions are confusing because when you discuss a point with them, they have wrong understanding of that point and since it is the first time for us view this point, the wrong answer will stick in our mind"
Dislike the pre-class quiz/ flip bring more pressure and lower the grades	**Eng_UG_Flip_GI**
	"Flipped sessions have a huge disadvantage because we take a quiz before it and I don't always get the answers right because there are things that I didn't understand correctly. If there is a need to apply make the quiz after the session"
	"It is more pressure and lowers the grade"
Can't access pre-class material at home	**Cal_UG_Flip_GI**
	"Videos does not work at home. I can only watch them at uni."

Table 156: Students’ comments for 100% flip class preference

Identified Reason	Unedited students’ comments
Less boring, more interesting and engaging	Cal_UG_Flip_GI
	“Not boring”
	Eng_UG_Flip_GI
	“50% lecture is very boring, and some information is passed on or discussed of no importance. Easily distracted and unfocused.”
	“I feel bored in lectures. Flipped is more fun”
	Eng_G_Flip_A
	“I think the fully flipped method is more comfortable and make the learning process more interesting and the class less boring and less formal”
	Eng_G_Flip_GI
	“90% of the class is sleeping in the lecture, but in class activities force the class to discuss ,interact and think about the topic”
It’s working and effective for learning	**Cal_UG_Flip_GI**
	“We watched vides at home then we solve problems in class”
	“Flipped experience is the most effective way of learning that I have experienced”
	Eng_UG_Flip_GI
	“Higher in class activities encourages student to communicate with one another that facilitates their learning. also, in a sense it creates a constructive competition among students that motivates me to study harder”

Table 157: Students' comments for high confidence level of asking in-class questions– Flipped and lecture-based mathematics undergraduate classes

Identified Reason	Cal_UG_Flip_GI	Cal_UG_LB_GII & Cal_UG_LB_GIII
Pre-class study	"I know what to ask because I saw the pre-class and I am sure I need to have an answer" "I know what the topic is about and the hard or tricky parts that I need help in, rather than waiting until the end of class"	-
Class environment	"Class environment allows you to participate with no fear from being mocked by other students."	"The environment in class allows one to ask"
Professor welcomes questions	"Professor is always ready to answer them in different ways in order to understand"	"The instructor happily and confidently accepted questions" "I know the professor will make sure my question is answered"
I am comfortable to ask	-	"I feel comfortable asking questions in class about a problem I did not understand." "I am not a shy person."

Table 158: Students' comments for low confidence level of asking in-class questions - Flipped and lecture-based mathematics undergraduate classes

Identified Reason	Cal_UG_Flip_GI	Cal_UG_LB_GII & Cal_UG_LB_GIII
I don't ask in-class questions	"I just focus in class and understand what is given to us" "I prefer asking during office hour"	"I never ask questions" "I just listen in class and take notes. I don't ask questions"
I did not need to ask that much due to Pre-class study	"I understand clearly from the videos that I did not need to ask that much"	-
I don't feel confident to ask questions	-	"I don't feel confident asking questions as I ask a lot which makes instructor annoyed" "very shy to ask"

Table 159: Students' comments for high confidence level of asking in-class questions – Flipped and lecture-based engineering undergraduate classes

Identified Reason	Eng_UG_Flip_GI	Eng_UG_LB_C & Eng_UG_LB_D
Pre-class study	"When you come prepared you will know what to ask" "Since a brief background about the topic was analyzed, asking question is much easier in this case"	-
Class environment	"I feel confident to ask compared to other courses because I feel there is a bond between me, classmate and prof"	"The class environment and the professor's way of answering the questions make students more comfortable to ask"
Professor welcomes questions	"The professor is open for any kind of question" "Professor always allow and encourages question"	"The professor is very friendly and answers any doubts really well and patiently" "The professor helps in encouraging Qs"
I am comfortable to ask	"Not shy. Irrelevant to flipped (unaffected by flipped)" "If I don't understand I ask" "No reason. Asking questions is normal"	"I feel comfortable pointing out what I don't understand" "I am not a shy person" "I just ask what is on my mind"

Table 160: Students' comments for low confidence level of asking in-class questions - Flipped and lecture-based engineering undergraduate classes

Identified Reason	Eng_UG_Flip_GI	Eng_UG_LB_C & D
Community concerns	"Some students do not like it when others keep asking questions, so I try to not ask and instead search it online but it's not very helpful." "I sometimes feel the prof will judge me if the question is too silly" "I'm shy" "The class environment is stiff and tense"	"Sometimes I feel like everyone knows the answer of my question, so its silly to ask"
I don't know what to ask	"Honestly, sometimes I don't know what to ask even though I know there is for sure some concepts that I don't really understand"	-

Table 161: Students' comments for high confidence level of asking in-class questions – Flipped and lecture-based engineering graduate technical classes

Identified Reason	Eng_G_Flip_A	Eng_G_LB_D & Eng_G_LB_E
Class environment	"Engaging with other students and discussing."	"Class environment encourages questions, instructor is knowledgeable and provide answers to all my question"
Professor welcomes questions	-	"The professor is open to questions all the time" "Professor is understanding and emphasize on sharing thought, so I felt confident asking even if I go way off topic" "Professor answers questions and is open to questions"

Table 162: Students' comments for what they liked about the flipped method

Likes Themes	Unedited Students' Comments
Engagement/ Collaboration/ In-class activities	**Cal_UG_Flip_GI**
	"Class interaction"
	"It gives me a chance to participate more"
	"It helps me in interact with other students and solve any question I doubt, …"
	"You don't get bored in class"
	Eng_UG_Flip_GI
	"It creates discussion between students. interaction decreases boredom"
	"It made me engage with classmates and it made it really easy to get used to the class's atmosphere"
	"Not as boring and full as lecture. Get to know and speak to peers which enhances social skills"
	"That we learn in groups and we can participate in the learning process"
	Eng_G_Flip_A
	"1) learning from each other. 2) conversation + discussions"
	"interaction with professor and other students.
	"the ability to share my knowledge and learn from others"
	Excitement in the class, not boring"
	Eng_G_Flip_GI
	"a lot of interaction between dr. and student"
	"engaged in fruitful class discussion"
	"interaction and non-steady theme. Removes Boredom"
	"it's informal, makes us discuss and share ideas and interact on the topic and think about it from different perceptions"

Enhanced learning	**Cal_UG_Flip_GI**
	"gives double chance in understanding the material"
	"it helps us understand better"
	"It strengthen my knowledge."
	"it's helpful for understanding faster"
	Eng_UG_Flip_GI
	"it helps me understand the material more, since I study it on my own and then technically revise it when I discuss it with my peers"
	"it is hard to lose the information since you come across it more than once"
	"learn and explore more about the topics in comparison to just listening to a lecture, …"
	Eng_G_Flip_A
	"1) it makes understanding easier. 2) it allows me to ask deeper questions. 3) it allows to explore more about topics."
	"I like this method because … in some cases we need to study some related websites to get more knowledge regarding the lecture"
	"it was effective"
	Eng_G_Flip_GI
	"discussing helps us learn more"
	"I understand the lectures better when I prepare before class"
	"useful to ease the learning process"
	"You understand the topic prior to class discussion and highlight the unclear concepts to ask specific questions in class"
Being prepared for the class	**Cal_UG_Flip_GI**
	"…, I come to class prepared so I have more background and knowledge about what the professor is explaining"
	"Build familiarity with the topic before the class lecture"
	"It makes us to understand this course and have an idea for what to do in class and also keeps us ahead in portion."
	"That you enter the class having an idea on what's going to be learned"
	Eng_UG_Flip_GI
	"I like that it encourages me to come to class prepared , therefore helping me to study more regularly"
	"it gives me a general idea about what will the professor discuss in the class"
	"studying the theory part of the course prepares us for what is going to be taught further in class …"
	Eng_G_Flip_A
	"…I come to class and I have an idea what the class will be about …"
	"I can follow the prof during the class since I read the material before"
	"I like this method because we should prepare ourselves"

	Eng_G_Flip_GI
	"… give me the chance to analyze beforehand"
	"I am familiar with the material when we start discussing it, it makes more involved than other times where I receive the info for the first time"
	"you have an idea about what are going to do in the class"
Spread out the study load over the semester/ Ease studying for exams	**Eng_UG_Flip_GI**
	"… helps in preparing for quizzes – midterms"
	"… save time when studying for the midterm"
	"it forced us to study"
	"Take less time to study for a quiz or a midterm because I already have an idea about what I will study"
	"that I get to study the lectures before the exams in a long period"
	Eng_G_Flip_A
	"…The idea of the quiz for the lesson (undiscussed topic) made us study and read even if we don't want and made it less headache for midterms"
	Eng_G_Flip_GI
	"flipped, because it is demanding if everything compiles before the midterm"
	"makes you spend less time studying for midterms and quizzes"
	"spreads out the studying period over the entire semester …"
Videos / Online learning	**Cal_UG_Flip_GI**
	"I can study wherever and anytime I want"
	"I have access to the videos whenever in doubt"
	"I like that I don't have to spend hours of studying if I didn't hear my prof clearly or didn't take notes because the lecture videos are always there"
	"Professors can upload their lectures online and can let student watch their videos whenever they want and wherever they want.
	Can easily review the course material before midterms and finals"
Flipping	**Cal_UG_Flip_GI**
	"the teaching technique is very good and helps in loving the subject"
	"it is very effective"
	Eng_UG_Flip_GI
	"smart idea, greatly implemented"
	"good"
Professor	**Cal_UG_Flip_GI**
	"Not any prof. is able to control this method, however prof. … did an amazing job"
	"The prof. is very helpful"
	"The best professor ever"
	Cal_UG_Flip_GI

No benefits/ Nothing	"It did not work with me very well. I feel giving the whole lecture at class is better"
	"teaching method: I am able to fully understand the course material.
	Flipped method: doubts about certain topics"
	Eng_UG_Flip_GI
	"Nothing"

Table 163: Students' comments for what they disliked about the flipped method

Dislikes Themes	Unedited Students' Comments
Time demanding/ load	**Cal_UG_Flip_GI**
	"I don't have time to watch the videos sometimes, as I have other courses to study for"
	"take a lot of time to prepare"
	"Time demanding"
	Eng_UG_Flip_GI
	"demanding and stressing"
	"it takes a lot of time to prepare for the flipped learning quizzes"
	"sometimes I don't have time for it"
	"the workload of the course is too much compared to others"
	Eng_G_Flip_A
	"not a good idea if I have personal problems or low on energy"
	"studying before the class"
	"the demand, preparation ahead of time searching new terminology to understand the topic"
	Eng_G_Flip_GI
	"as a graduate student, sometimes you can't find the time to properly read and analyze the lecture which might result in wasting time during the lecture doing all the reading or messing up in a quiz"
	"preparing"
	"requires time ahead"
In-class Group Work	**Cal_UG_Flip_GI**
	"how other students skip and depend on their classmates to explain everything"
	"yes and group work"
	Eng_UG_Flip_GI
	"my peers don't take it as serious as I do, which decrease my possible benefit"
	"That some students don't take it seriously and that we don't always understand everything from just using flipped"
	"the class discussion (between students) are not that useful"

	Eng_G_Flip_A
	"not all the students are coming prepared"
	"sometimes feeling you know nothing when compared with others"
	Eng_G_Flip_GI
	"it depends on the student group you are working with, so you cannot be sure that the discussed opinions are true"
	"It requires the student to be active and pay attention throughout the entire class"
	"sometimes, some of the students do not discuss and stay quiet but it's because they probably did not read about it in advance"
Missing/ Wrong understanding for points of material	**Eng_UG_Flip_GI**
	"… I feel like since the professor doesn't explain it himself, students could conclude or understand things incorrectly while thinking they know it correctly. Also it wastes a lot of time and a lot of time I have to revise once again after the flipped learning because I get confused."
	"…, some points maybe not understood"
	"At times, the material to be studied before class was excessive for one to understand on his/her own."
	Eng_G_Flip_A
	"prof does not go through all the slides"
	"sometimes the instructor miss some topics from the material if no one asked about"
	"Sometimes, some points are missed"
	Eng_G_Flip_GI
	"it can leave you not understanding few concepts"
	"sometimes I understand the material based on my perception and it sticks in my mind and sometimes it could not be the right understanding especially if it was not highlighted in the discussion"
	"sometimes, group members explain wrong things to each other"
The quiz at beginning of the class	**Eng_UG_Flip_GI**
	"… Flipped sessions have a huge disadvantage because we take a quiz before it and I don't always get the answers right because there are things that I didn't understand correctly. If there is a need to apply, make the quiz after the session"
	"I don't like because honestly I think it depends on memorization, because every flipped session we will have a quiz"
	"the pre test is before the discussion which is wrong"
Video specifications	**Cal_UG_Flip_GI**
	"Videos were too long to load at home"
	"some of the videos are burred and need to be fixed"
	"nothing, but sometimes the videos were not clear"
Video/ Online Learning	**Cal_UG_Flip_GI**
	"We can only ask questions in class …"

	“sometimes it doesn't make sense so you need to see the professor”
	“I lost the interest to come to class”
	“if you don't watch the videos for any personal reason, you end up lost in class”
In class time	**Cal_UG_Flip_GI**
	“That we repeated many questions from the video in class, I felt that we should tackle more advanced questions in class”
	“Double class time which takes up the time I can use to also study for other courses”
Speed	**Eng_UG_Flip_GI**
	“fast paced class”
Nothing	**Cal_UG_Flip_GI**
	“Nothing, I think all math-heavy courses should do it”
	Eng_UG_Flip_GI
	“no dislikes”
	“it is very good method that makes the learning process much more fun”

Table 164: Students' comments for recommendations for the flipped method

Recommendation Themes	Unedited Students’ Comments
Online learning	**Cal_UG_Flip_GI**
	“maybe have interactive game or quiz after the video (before class). (online questions)”
	“posting worksheets to practice at home and improve my knowledge.”
	“There should be online exercises as well once watching the videos is complete.”
	Eng_UG_Flip_GI
	“it would be useful for students to do online activities”
	“online database for the class to post comments and ask questions after the class”
	“providing all the sources needed to study”
	Eng_G_Flip_A
	“1) a discussion platform through I learn (active) …”
	Eng_G_Flip_GI
	“ilearn groups and discussions”
	“ilearn”
	“online quiz”
More in-class activities	**Cal_UG_Flip_GI**
	“more class discussions on our chapter”

	“Make the student more cooperative”
	Eng_UG_Flip_GI
	“more in- class activities”
	“real life applications/ case studies/ online or continuous research that will implement what we learn in class”
	Eng_G_Flip_A
	“… 3) do more class works and short presentations”
	“instead of giving quizzes, maybe having some exercises with example will be more efficient”
Real-activities/ Game	**Eng_G_Flip_GI**
	“technology==> do an HR game. take more cases from reality HR”
	“Occasional debates in the class between two opposing views teams”
	“outside activities, company visits”
	“simulation games, … involve more interesting workshop (as much as possible)”
Classroom tools/ Setup	**Cal_UG_Flip_GI**
	“Same technology we use now, laptops, smartphones, etc.”
	“to use bigger classroom because sometimes the professor is stuck in small place”
	“use interactive board”
	Eng_UG_Flip_GI
	“better seating in classroom. These ones don't allow for efficient flipped session”
	“clicker method (used in US universities)”
	“ipad”
	“small boards for students to write what they studied most important points each group of 6 aboard so me optimize”
	“smart classroom. change seating arrangement”
	Eng_G_Flip_GI
	“computers to look at prof notes”
Maximize time of class discussion with instructor	**Eng_UG_Flip_GI**
	“minimize student discussion / maximize class discussion with the instructor.”
	“If the time for the discussion between students is less will be better because usually we all understand in the same level and we need more discussion between students and the professor”
More interaction and guidelines from instructor	**Eng_G_Flip_A**
	“better interactive of student and instructor enforcement to engage student to discussion”

for in-class group activity	"more interactions from professor by providing guidelines for us, because I dislike everyone working on their own way, while the doctor has the best way"
	Eng_G_Flip_GI
	"make sure that all students really understand what they meant to learn"
	"motivating discussion in groups"
	"The professor be more involved in directing the ongoing student-student discussion and helps steer those discussions so as the students don't feel lost"
Partial flip	**Eng_UG_Flip_GI**
	"have partial flipped sessions"
	"depending on the lecture density, apply the flipped session. If the density is low then apply"
	Eng_G_Flip_A
	"50% lecture based / 50% flipped. Difficult chapters must be taught in a lecture manner"
	Eng_G_Flip_GI
	"to have it as it is but, not to depend on it 100% for all the material throughout the course"
	"1) read slides pre-class. 2) prof lectures 3) in class activities"
	"go through each slide again"
Videos	**Eng_UG_Flip_GI**
	"recorded professor video lectures"
	"more videos"
	Eng_G_Flip_A
	"videos to be send to students to give a glimpse and prepare them for the class"
	"I wish if the professor used some videos to understand the topic."
Videos specifications	**Cal_UG_Flip_GI**
	"Better quality videos"
	"Make them more HD and interactive. Better sound quality."
	"post you videos in youtube. Easy views = easy money."
	"short videos (5-7 mins max) that are modified"
	"Shorter, more concise videos rather than ones where I am viewing an actual class room. So it feels more like tutoring I guess."
Better camera/ Microphone to enhance video quality	**Cal_UG_Flip_GI**
	"better microphone,
	"H.D quality cameras to take videos as some videos are not as clear"
	"Motion sensor to follow where the professor is writing on the board and a wider angled lens for the camera."

	"Points bases systems where watching videos like in khan academics"
	Camera. streamed on youtube"
Ease quiz/ Apply quiz after class discussion/ Not graded quiz	**Eng_UG_Flip_GI**
	"applying flipped quizzed at the end of the class or after class discussions"
	"do not grade it"
	"I recommend that it is given as extra points to the students"
	"the pre-test should be all multiple choices for better performance, the students will also be more motivated when they get good grades in them, so it will encourage students to study harder"
More credits for the beginning of the class quiz	**Eng_UG_Flip_GI**
	"more grades to be put towards the pre-test"
Reduce workload on student	**Eng_UG_Flip_GI**
	"… rather than the whole class doing a flipped learning session, a group of students can learn it thoroughly and present it while the class interacts. That way they interact, learn and since it's being presented in front of the professor; any possible misinformation can be rectified"
	"Maybe portions can be assigned to different groups … then after each group has prepared the portion they have been assigned they split again to different groups (each new group has a member with a certain portion they have studied), …"
	"reduce the frequency at which the flipped sessions are held OR reduce the other things we have to do in the course such as number of assignments or quizzes"
Others	**Eng_UG_Flip_GI**
	"make it more useful for midterm/final"
	"slow the pace of course"
	"the department should provide more resources to professor"
	"Would be useful if it was a physics or calculus course instead of a major course"
	Eng_G_Flip_GI
	"assign some homework and give extra credits on it (bonus)"
	"homework"
	"robots. more students in class with group based discussion"
No recommendations	**Cal_UG_Flip_GI**
	"it doesn't need any improvements"
	Eng_UG_Flip_GI
	"nothing"
	Eng_G_Flip_A
	"none"
	Eng_G_Flip_GI

	“I think we got everything already”
	“nothing, the slides are enough”

Table 165: Students' comments for what they liked about the lecture-based method

Likes Themes	Unedited Students’ Comments
Content delivery	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	“objectives are clearly stated. concepts are reinforced to ensure that they are clear …"
	“it's step by step you don’t move to a higher step in the ladder before finishing the previous”
	“… The lectures were clear organized and helped me understand most of the topic”
	“the professor summarized everything on the board, which makes it easier to understand”
	“the course is straight forward and the instructor gets straight to the point”
	“detailed concept lecture; helps to understand the concept w/o much difficulty”
	“the instructor provided course pack that was very useful in teaching rather than the 900 page book”
	Eng_UG_LB_C & Eng_UG_LB_D
	“the teaching method is amazing, …”
	“professor is easy going. Does not complicate the method”
	“simple, convenient”
	“the instructor is very detailed and knowledged about what he teaches”
	“having a clear idea on what to focus or where to start”
	“the professor only teaches you what you need to know while in other courses somethings would unnecessary”
	Eng_G_LB_D & Eng_G_LB_E
	“It gives you time to process the basic methods of learning”
	“it allows the prof. to speak and explain topics out of personal experience and relate it to real life problems. This give me the chance to allow the idea or the fundamental concept to sink in before moving forward to a case study or something similar which help in practicing what I just learned”
	“I like this style of teaching as its very structured and it allows you to be clear on what to expect every class”
	“1) clarity with no misunderstanding 2) I am sure whether I understood the materials or not”
	“I don’t know what is the subject about, so when the prof. explains it he toggles the correct points in the right time so that I do understand what the subject is about”

In-class activities/ problem solving/ examples	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"…several examples of distinct ideas are solved on each topic"
	"I like the fact that she explains how this lecture or topic will help us later on"
	"he gives real life examples"
	Eng_UG_LB_C & Eng_UG_LB_D
	"…I also like the fact that we solved multiple examples on each topic"
	"that we did many class activities which helps me understand concepts better in general, …"
	"the in-class activities helped enhance my understanding"
	"many examples to work with"
	"solving a lot of examples provided by professor was very helpful in understanding the lecture. Solving a lot of examples helps a lot rather than theoretical"
	Eng_G_LB_D & Eng_G_LB_E
	"Discussion of the course material during the class is what I like about the method"
	"The problems which the Dr is providing to students to link them to a real cases"
	"I like that the teaching style is mainly based on applying the lecture taught using the relevant program on the computer"
	"very simple with example that clearly communicate the idea of the lecture information flipping for each class/week between assignment submission and quizzes test"
	"I like doing homeworks because I can apply my knowledge and understandings of the course"
Engagement and Interaction	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"class participation is great & question are answered in class"
	"the interaction between teacher and students"
	"… the class is fun not boring whatsoever"
	Eng_UG_LB_C & Eng_UG_LB_D
	"I liked the interaction the most, I get distracted when it's just the professor talking. The more the interaction the better"
	"…the class interaction made some concepts easier to understand"
	"how it is very interesting and fun"
	"engaging learning method"
	"the instructor helped us interact with each other"
	Eng_G_LB_D & Eng_G_LB_E
	"That it encourage to work and study by yourself since the way of teaching this course makes interested in knowing more and understand the concepts"
	"The way of teaching is interesting and attracts me to understand and ask."

	"it is very efficient and interesting"
	"interesting, has a lot of numbers and a lot of solving"
Open and good environment	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"I like the availability of open questioning in the area of the subject of interest"
	"caring, good environment built"
	".. the environment of class help in loving to attend the class & gain the knowledge"
	"teaching method is good as the professor answers questions and give us a background of what may come in the exam. The professor is enthusiastic …"
	Eng_UG_LB_C & Eng_UG_LB_D
	"chilled and relaxed"
	"I like how the instructor encourage questions and does not mind repeating parts over and over."
Familiarity of method	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"It's similar to all my other courses."
	"the course fits my learning methods."
	"similar to high school classroom setting, it was familiar and comfortable"
No pre-class preparation/ no flip	**Eng_G_LB_D & Eng_G_LB_E**
	"I like it since I don't have to prepare anything beforehand since available time is an issue"
	"specially for technical topics, it is difficult to have flip method/ only preparation way to read text book which in NA or with relative YouTube teaching videos before or even after the class when I don't grasp specific subject"
Others	**Eng_UG_LB_C & Eng_UG_LB_D**
	"in my opinion, flipped sessions are better than regular lectures."
	"lecturing is not a good or bad thing. Educational method should be based on the course material and not generalized"
	Eng_G_LB_D & Eng_G_LB_E
	"This method mainly depends on the lecture's ability to keep the class engaged and this is not an easy job for anyone. If I am engaged and interested in the course content, then I don't mind this method"
Nothing	**Eng_UG_LB_C & Eng_UG_LB_D**
	"I don't like the course, I don't like the way it is taught and don't understand anything"
	Eng_G_LB_D & Eng_G_LB_E
	"nothing"

Table 166: Students' comments for what they disliked about the lecture-based method

Dislikes Themes	Unedited Students' Comments
Speed of teaching	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"maybe too fast, I try to catchup after class"
	"All the end of the semester, the lecture tend to be hurried up"
	"Some topics required more time to be explained but were skimmed through quickly"
	"the instructor explains too fast"
	Eng_UG_LB_C
	"the speed of teaching is a bit fast"
	"the prof is a bit fast in teaching"
	Eng_UG_LB_D
	"the pace of the professor is quite fast"
	"being too fast in explanation, …"
	Eng_G_LB_D & Eng_G_LB_E
	"pacing (either fast or slow)"
Little and easy in-class problem solving/ examples	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"examples given are always easy and straight forward"
	"the example's used by the professor were not challenging enough therefore not having the real idea of the exam"
	"the professor doesn't give as challenging enough questions to do by ourselves"
	"there are no enough examples; I mean that the examples that are provided are very basic and simple compared to the questions in the midterms and review sheets"
	"Midterms can be frustrating, the instructor can solve harder examples"
	"there is less time to ask questions as question arise after the lecture"
	Eng_UG_LB_D
	"is that only the easy examples are teached, then in the midterms we find problems that exceed our thinking"
	"Like tbh, I don't know what's wrong but the problem we take in class are easier than what we get in exam, we have to cover more"
	"I find it very hard to understand the course. the quizzes and exams are not like the explanation in class"
	Eng_G_LB_D & Eng_G_LB_E
	"no real life examples that I can relate to and read to solve more Problems"
	"some technical subject needs extra efforts to understand. I have solve more practice problems to make sure of my understanding"
	"…class or lecture is given about a topic right before its case study which makes it easier to know how to solve it. while in the exam you get stuck on what to go for while studying the problem."

	“I think it limits your way of thinking, where you only focus on the cases you have”
Absence of engagement/ in-class activities	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	“no activities”
	“I dislike nothing but sometimes it gets boring”
	“too long”
	“the period long time”
	Eng_UG_LB_D
	“could have little interaction with the students, …”
	“very dry and one-sided”
	“boring on MWs (long lectures)”
	Eng_G_LB_D & Eng_G_LB_E
	“we only learn what we are given from the slides and the professor while if the class was discussion based, we can learn from other students and other points of view”
	“very boring, one-sided”
	“teacher-centered method”
Content delivery	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	“I don’t understand it if it is a lecture based”
	“I disliked method of teaching that relays on instructor notes while teaching.”
	“some concepts are only slightly explained with no variations”
	“I dislike the way that the professor shows us the wrong methods first instead of explaining the idea”
	Eng_UG_LB_C
	“lecturing”
	Eng_UG_LB_D
	“sometimes confusing”
	“some topics are not suitable to be learned through lecturing or are too boring to listen to”
Online learning	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	“the notes were not digital & Uploaded”
	“the instructor does not upload notes for self revision”
	“I feel that the professor should post notes regularly before class so that students know what to expect”
	“… if notes could be uploaded”
	Eng_UG_LB_D
	“the solutions aren't always available on Ilearn or some slides only have partial solutions or missing parts”
Extensive material	**Eng_UG_LB_C**
	“too many slides”
	“it has too much theory”

	"a lot of long theory"
	"the method is too much compared to how easy it is in class"
Others	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"I didn't like recitations/labs"
	"sometimes we spend too much time in minimal question"
	"Some material is designated for the recitation. we could learn technology based aspect of calculus in recitation instead"
	"It can be demanding and hard to fit in with other courses. Lecture wise I do not dislike anything"
	Eng_UG_LB_C
	"it should not be lecture-based less talking more interactions"
	Eng_UG_LB_D
	"not enough time because each example took around 30-45 mins"
	"very slow sometimes, therefore lose focus"
	Eng_G_LB_D & Eng_G_LB_E
	"it is more demanding …"
	"limited time to cover the full lecture"
	"… The lectures are not systematic with the book but all are described in the book …"
	"load per class"
	"I don't like preparing for the lecture note before the class"
Nothing	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"I didn't find anything which I tend to dislike about the method of teaching"
	"there is not anything that I dislike about this course"
	"nothing. Everything is good when it come to teaching"
	Eng_UG_LB_C
	"nothing"
	Eng_UG_LB_D
	"nothing"

Table 167: Students' comments for recommendations for the lecture-based method

Recommendation Themes	Unedited Students' Comments
More problem solving/ examples/ in-class activities/ assessments	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"Provide problems not only in class give homework in ilearn …"
	"more practice questions and solutions on ilearn"
	"Give harder questions in the class to get use of to the midterm difficulty"
	"Solving more challenging problems in class rather than easy ones"
	"more practice in class."
	"solve higher levels of questions"
	"I would recommend giving us worksheets in class to solve that are optional as calculus needs practice."
	"solving more examples"
	"more real life examples"
	Eng_UG_LB_C
	"more outside of the class trip. more group classwork …"
	"more quizzes"
	"more class activities"
	"less theory, more practical"
	"more homeworks, and quizzes"
	Eng_UG_LB_D
	"more examples."
	"I would suggest engaging more challenging questions to be solved in class, so students will got an insight of all real-time problems"
	"practice and apply more examples in class"
	"more real-life application"
	"more quizzes and in-class assignments to help engage students"
	Eng_G_LB_D & Eng_G_LB_E
	"explore different solutions to the same problems …"
	"more quizzes need to be conducted"
	"More application and solving to help students in better understand and be exposed to different question methods"
	"…add as much cases as possible as its only way (personally) that would help in further understanding the core concepts of the course and know how to actually solve a given problem"
	"more problems to solve"
More lab sessions	**Eng_UG_LB_C**
	"technology based session softwares teaching"
	"since this course has a lot of softwares that could benefit us. I believe that a session (lab session) to practice on these software rather than just being lectured about them"

	Eng_UG_LB_D
	"maybe give workshops or review session for lingo program"
	"offer recitations and practice sessions"
More student interaction	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"…increase students interactions"
	"more class participation"
	"more interaction with students"
	Eng_G_LB_D & Eng_G_LB_E
	"maybe more interactions with the students could help make the course more enjoyable"
	"more students interaction"
Course material	**Eng_G_LB_D & Eng_G_LB_E**
	"… more external resources …"
	"… follow the book content …"
	"less content in the classes. More depth rather than breadth"
	"… 2) Providing details on the lecture notes"
	"1) provide reliable media resources before class. (i.e technical videos or lectures) …"
Content delivery	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"I like the lecture but prefer the use the of the board and markers more than powepoints."
	"adjust the way of answering student questions"
	"to use more resources"
	"the learning through this course is great but I recommend that the professor start to explain the idea only and do not talk about the wrong methods"
	"don't use the computer for math"
Online learning	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"writing the notes on the smart board and then uploading them into ilearn"
	"posting video lectures"
	"upload class notes for self assessment and revision purposes"
	"Posting lecture notes and more practice questions with solutions too"
Speed of teaching	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"Spend more time on each chapter"
	"… teaching in a bit slower way"
	"slow down"
Rewarding/feedback/ graded homework	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"Bonus work …"
	"… we should be graded on do the hw. this way we can ask and learn more"

	"give us bonus marks please"
	"homeworks"
Smartboard	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"I recommend using the smart board"
	"Have a smart board and save note online"
Match exam questions with in-class exercises	**Eng_UG_LB_C**
	"getting midterm questions that
	are directly related to what we have studied in class"
	Eng_UG_LB_D
	"I recommend that when we take questions in class and solve them the exact ones should come in the exam otherwise there is no point in going to class"
Better class time	**Eng_UG_LB_D**
	"this course should not be taught at 8:00 AM"
	"the course was generally good, but the time was too early"
Others	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"Increase class timing"
	"less study material. less deadlines. more time to study"
	"…might ease down the grading a bit tho."
	"To stay on track and don't leave anything till last minute"
	"longer class time …"
	"change the grading criteria, the marks are very low for the class …"
	"I don't know, really, I just wanaa graduate"
	"project distributed over the semester not last 3 weeks"
	Eng_G_LB_D & Eng_G_LB_E
	"Narrow down the course project to something already under research. creating a chance for students to publish if possible."
	"it is recommended that this course be taught to students who has been pursuing the program for several semesters not the first time (not a first semster course)"
	"…More time for office hours (evening) to provide match with working student hours."
	"… 3) chance to discuss with previous student who took the course and got high grade.
	4) random group selection for project and assignments."
Nothing	**Cal_UG_LB_GII & Cal_UG_LB_GIII**
	"just keep doing what you're doing it's great."
	"no recommendations"
	Eng_UG_LB_C
	"everything is perfect"
	"all good"
	Eng_UG_LB_D

	“nothing”
	Eng_G_LB_D & Eng_G_LB_E
	“I think that there is nothing to be done to make this course better …”
	“I liked the way the prof is teaching this course”

Appendix G: Goodman and Kruskal's gamma Test Results

Table 168: Goodman and Kruskal's gamma test between survey items and motivation toward the flipped method item (M1)

Item	**Cal_UG_Flip_GI**		**Eng_UG_Flip_GI**		**Eng_G_Flip_A**		**Eng_G_Flip_GI**	
	Z (p)	*Gamma*	*Z (p)*	*Gamma*	*Z (p)*	*Gamma*	*Z (p)*	*Gamma*
TP1	-1.77 (0.076)	0.52	-3.95 (0.000)	0.78*	-1.36 (0.173)	0.64*	-2.37 (0.018)	0.70*
TP2	-2.62 (0.009)	0.69*	-3.12 (0.002)	0.53	-0.53 (0.595)	0.33	-1.71 (0.087)	0.52
TP3	-2.96 (0.003)	0.64*	-2.86 (0.004)	0.43	0.65 (0.514)	0.22	-2.41 (0.016)	0.66*
TP4	-2.78 (0.005)	0.73*	-4.01 (0.000)	0.64*	-0.43 (0.666)	0.20	-2.86 (0.004)	0.79*
TP5	-3.21 (0.001)	0.80*	-4.71 (0.000)	0.81*	0.76 (0.448)	0.33	-1.70 (0.089)	0.50
TP6	-3.15 (0.002)	0.75*	-2.72 (0.007)	0.49	0.00 (1.000)	*	-2.32 (0.020)	0.75*
TP7	-3.92 (0.000)	0.77*	-1.34 (0.179)	0.20	-1.83 (0.068)	0.82*	-1.91 (0.056)	0.57
TP8	-1.67 (0.094)	0.41	-3.88 (0.000)	0.68*	-0.33 (0.742)	0.18	-1.53 (0.127)	0.47
TP9	-2.36 (0.018)	0.66*	-3.81 (0.000)	0.64*	-0.33 (0.742)	0.18	-1.40 (0.160)	0.42
TP10	-3.14 (0.002)	0.78*	-3.44 (0.001)	0.60*	1.59 (0.113)	0.81*	-1.30 (0.193)	0.41
SP1	-0.03 (0.975)	0.04	-2.37 (0.018)	0.37	1.49 (0.135)	0.58	-0.23 (0.816)	0.10
SP2	-1.13 (0.258)	0.26	-2.58 (0.010)	0.43	0.27 (0.789)	0.25	-1.20 (0.230)	0.34
SP3	-0.87 (0.385)	0.30	-2.84 (0.005)	0.45	-0.76 (0.448)	0.50	-1.22 (0.221)	0.37
SP4	-0.17 (0.866)	0.16	-2.22 (0.027)	0.44	-0.45 (0.651)	0.20	-0.93 (0.351)	0.27
SP5	-2.22 (0.026)	0.46	-1.83 (0.067)	0.32	-0.83 (0.408)	0.39	-1.79 (0.073)	0.50
SP6	-2.61 (0.009)	0.51	-2.36 (0.018)	0.42	-0.73 (0.464)	0.38	-1.78 (0.076)	0.52
CP1	-2.52 (0.012)	0.54	-4.22 (0.000)	0.71*	0.62 (0.532)	0.03	-1.36 (0.175)	0.39
CP2	-2.78 (0.005)	0.57*	-4.66 (0.000)	0.83*	-1.28 (0.202)	0.25	-1.08 (0.281)	0.32
CP3	-1.39 (0.166)	0.21	-2.95 (0.003)	0.48	-1.77 (0.077)	0.65	-0.34 (0.738)	0.09

CP4	-1.96 (0.050)	0.37	-3.22 (0.001)	0.55	0.55 (0.584)	0.27	-0.61 (0.540)	0.25
CP5	-2.16 (0.031)	0.42	-2.35 (0.019)	0.42	-2.34 (0.019)	0.91*	-0.67 (0.501)	0.29
CP6	-2.14 (0.032)	0.35	-4.57 (0.000)	0.72*	0.93 (0.353)	0.33	-1.14 (0.252)	0.37
CP7	-2.46 (0.014)	0.44	-3.21 (0.001)	0.60*	-0.84 (0.400)	0.60*	-0.21 (0.831)	0.20
CP8	-3.07 (0.002)	0.65	-2.89 (0.004)	0.51	-	-	0.20 (0.783)	0.07
CP9	-2.91 (0.004)	0.59	-2.98 (0.003)	0.48	0.23 (0.816)	0.11	-1.09 (0.277)	0.35
LP1	-0.76 (0.450)	0.21	-2.30 (0.021)	0.43	0.66 (0.508)	0.33	0.75 (0.454)	0.13
LP2	-0.91 (0.361)	0.19	-1.27 (0.205)	0.30	-1.01 (0.313)	0.42	1.26 (0.208)	0.28
LP3	-3.01 (0.003)	0.68*	-2.25 (0.025)	0.33	1.64 (0.100)	0.74*	1.30 (0.195)	0.28
LP4	0.59 (0.553)	0.01	-0.56 (0.574)	0.06	1.64 (0.100)	0.74*	0.84 (0.398)	0.07
LP5	-0.46 (0.643)	0.09	-3.51 (0.000)	0.64*	0.13 (0.897)	-0.08	-1.57 (0.116)	0.49
LP6	-0.88 (0.376)	0.20	-2.02 (0.043)	0.28	0.69 (0.491)	0.28	-0.47 (0.637)	0.21
LP7	-0.71 (0.477)	0.18	-0.97 (0.331)	0.17	-0.66 (0.510)	0.27	0.28 (0.778)	0.05
In-class1	-1.93 (0.053)	0.53	-4.32 (0.000)	0.68*	0.76 (0.447)	0.05	-1.58 (0.115)	0.52
In-class2	-3.48 (0.000)	0.75*	-2.91 (0.004)	0.45	0.78 (0.434)	0.06	-1.81 (0.070)	0.55
In-class3	-2.00 (0.045)	0.44	-3.67 (0.000)	0.57	-0.46 (0.645)	0.18	-2.14 (0.033)	0.68*
In-class4	-2.83 (0.005)	0.63*	-3.51 (0.000)	0.53	-0.13 (0.895)	0.05	-1.05 (0.292)	0.28
In-class5	-3.15 (0.002)	0.70*	-4.40 (0.000)	0.73*	0.00 (1.000)	*	-2.33 (0.020)	0.69*
In-class6	-2.49 (0.013)	0.59	-1.86 (0.063)	0.30	0.00 (1.000)	*	-0.87 (0.385)	0.34
In-class7	-2.30 (0.021)	0.54	-3.97 (0.000)	0.64*	0.65 (0.518)	0.44	-1.03 (0.305)	0.46
SL1	-2.64 (0.008)	0.56	-2.72 (0.007)	0.43	-0.64 (0.522)	0.50	-1.59 (0.112)	0.59
SL2	-2.70 (0.007)	0.51	-2.59 (0.010)	0.55	-0.56 (0.577)	0.22	-1.55 (0.120)	0.42
SL3	-2.14 (0.032)	0.48	-3.10 (0.002)	0.56	-1.47 (0.141)	0.75*	-2.41 (0.016)	0.53

* *Gamma ≥ 0.6*

Appendix H: Equivalent GPA points of letter grade

The GPA is based on a four-point scale. The minimum passing grade for any undergraduate course taken at AUS is C-. The minimum passing grade for any graduate course taken at AUS is B. The following system presented in table [] is used at AUS.

Table 169: Equivalent GPA points of letter grade

Letter	**GPA Points**
A	equals 4.00 grade points
A-	equals 3.70 grade points
B+	equals 3.30 grade points
B	equals 3.00 grade points
B-	equals 2.70 grade points
C+	equals 2.30 grade points
C	equals 2.00 grade points
C-	equals 1.70 grade points
D	equals 1.00 grade points
F	equals 0.00 grade points

Appendix I: Examples of Tests Output

Reliability Test Results for TP in Eng_G_Flip_A

Item Analysis of Q6, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q14, Q15
Correlation Matrix

	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Q7	0.428								
Q8	0.698	0.130							
Q9	0.436	-0.140	0.457						
Q10	0.408	0.262	0.513	0.000					
Q11	0.577	0.000	0.726	0.756	0.354				
Q12	0.516	0.141	0.249	0.563	-0.211	0.596			
Q13	0.599	0.117	0.517	0.653	0.000	0.692	0.712		
Q14	0.000	-0.056	0.273	-0.157	0.293	0.415	-0.045	0.209	
Q15	-0.344	-0.080	-0.039	-0.338	0.632	0.000	-0.597	-0.524	0.449

Cell Contents

Pearson correlation

Item and Total Statistics

Variable	Total Count	Mean	StDev
Q6	11	4.000	0.775
Q7	11	4.182	0.603
Q8	11	3.636	0.924
Q9	11	4.000	1.183
Q10	11	4.000	0.632
Q11	11	4.000	0.447
Q12	11	4.182	0.751
Q13	11	4.273	0.647
Q14	11	4.091	0.539
Q15	11	4.182	0.751
Total	11	40.545	4.108

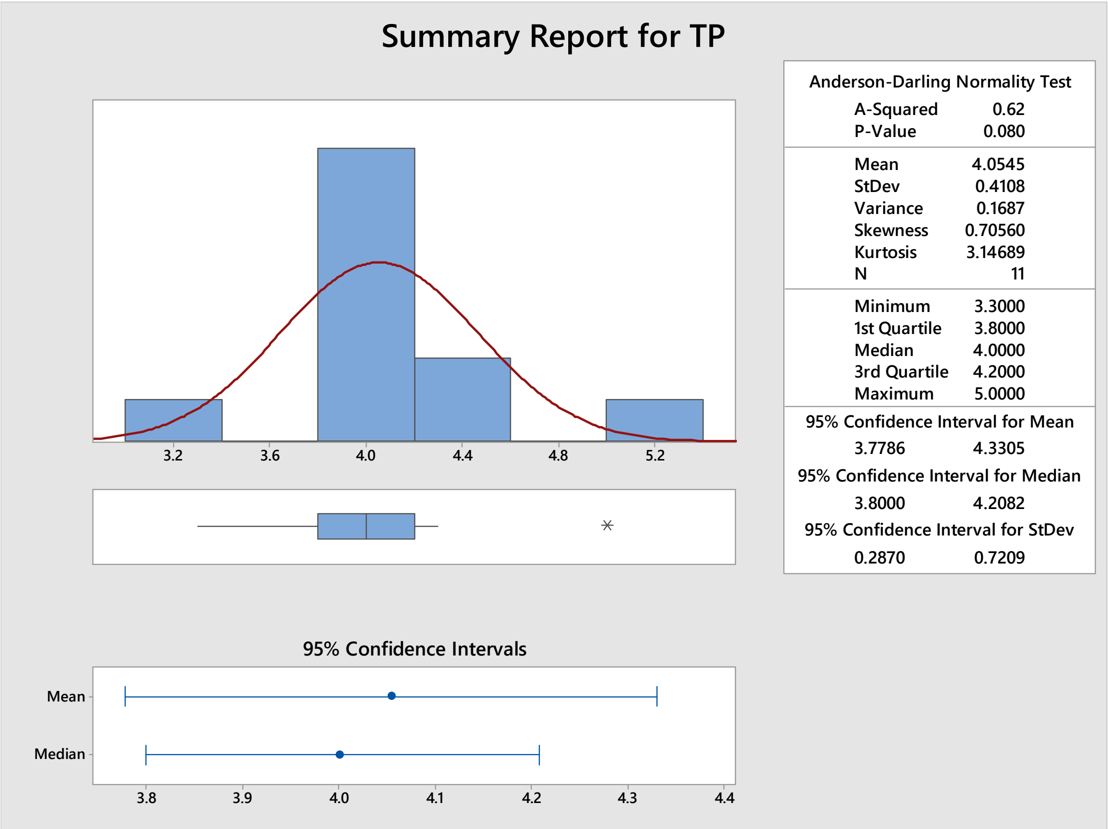
Cronbach’s Alpha

Alpha
0.7387

Omitted Item Statistics

Omitted Variable	Adj. Total Mean	Adj. Total StDev	Item-Adj. Total Corr	Squared Multiple Corr	Cronbach's Alpha
Q6	36.545	3.532	0.6945	0.9167	0.6691
Q7	36.364	3.982	0.1363	0.4138	0.7496
Q8	36.909	3.390	0.7224	0.9825	0.6551
Q9	36.545	3.446	0.4415	0.9953	0.7219
Q10	36.545	3.804	0.4156	0.9302	0.7166
Q11	36.545	3.698	0.9071	0.9985	0.6762
Q12	36.364	3.749	0.4005	0.9909	0.7175
Q13	36.273	3.663	0.6409	0.9179	0.6860
Q14	36.455	3.959	0.2129	0.9867	0.7400
Q15	36.364	4.202	-0.2133	0.9887	0.8006

Normality Test for TP in Eng_G_Flip_A



Descriptive Statistics of RCOI Constructs in Eng_G_Flip_A

Descriptive Statistics: TP, SP, CP, LP
Statistics

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
TP	11	0	4.055	0.124	0.411	3.300	3.800	4.000	4.200	5.000
SP	11	0	3.833	0.180	0.596	2.333	3.667	4.000	4.000	4.500
CP	11	0	3.909	0.128	0.424	3.333	3.667	3.889	4.111	4.667
LP	11	0	3.636	0.196	0.650	2.857	3.143	3.429	4.286	4.714

Levene's Test for TP between Eng_G_Flip_A and Eng_G_Flip_GI

Test for Equal Variances: TP_Eng_G_Flip_A, TP_Eng_G_Flip_Group I
Method

Null hypothesis	All variances are equal
Alternative hypothesis	At least one variance is different
Significance level	$\alpha = 0.05$

95% Bonferroni Confidence Intervals for Standard Deviations

Sample	N	StDev	CI
TP_Eng_G_Flip_A	11	0.410764	(0.192380, 1.10150)
TP_Eng_G_Flip_Group I	37	0.389405	(0.340621, 0.47388)

Individual confidence level = 97.5%

Tests

Method	Test Statistic	P-Value
Multiple comparisons	—	0.780
Levene	1.33	0.256

Test for Equal Variances: TP_Eng_G_F_1, TP_Eng_G_F_2

Two independent samples t-test for TP between Eng_G_Flip_A and Eng_G_Flip_GI

Two-Sample T-Test and CI: TP, Grad (Tech. Conept)
Method

μ_1: mean of TP when Grad (Tech. Conept) = Eng_G_Flip_A

μ_2: mean of TP when Grad (Tech. Conept) = Eng_G_Flip_GI

Difference: $\mu_1 - \mu_2$

Equal variances are assumed for this analysis.

Descriptive Statistics: TP

Grad (Tech. Conept)	N	Mean	StDev	SE Mean
Eng_G_Flip_A	11	4.055	0.411	0.12
Eng_G_Flip_GI	37	4.495	0.389	0.064

Estimation for Difference

Difference	Pooled StDev	95% CI for Difference
-0.440	0.394	(-0.713, -0.168)

Test

Null hypothesis	$H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis	$H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-3.25	46	0.002

Mann-Whitney test for TP between Eng_G_Flip_A and Eng_G_Flip_GI

Mann-Whitney: TP_Eng_G_A, TP_Eng_G_Group I

Method

η_1: median of TP_Eng_G_A

η_2: median of TP_Eng_G_Group I

Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
TP_Eng_G_A	11	4.0
TP_Eng_G_Group I	37	4.5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.5	(-0.8, -0.1)	95.03%

Test

Null hypothesis	$H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis	$H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	155.50	0.005
Adjusted for ties	155.50	0.005

One-Way ANOVA for TP – Flipped classes after grouping as per course nature and use of pre-class video

One-way ANOVA: TP versus Nature-Video

Method

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	α = 0.05

Equal variances were not assumed for the analysis.

Factor Information

Factor	Levels	Values
Nature-Video	3	Conceptual, Tech, Tech-Video

Welch's Test

Source	DF Num	DF Den	F-Value	P-Value
Nature-Video	2	92.5508	26.00	0.000

Model Summary

R-sq	R-sq(adj)	R-sq(pred)
31.50%	30.53%	28.75%

Means

Nature-Video	N	Mean	StDev	95% CI
Conceptual	37	4.4946	0.3894	(4.3648, 4.6244)
Tech	55	3.8164	0.7123	(3.6238, 4.0089)
Tech-Video	53	4.6377	0.4658	(4.5093, 4.7661)

Games-Howell Pairwise Comparisons

Grouping Information Using the Games-Howell Method and 95% Confidence

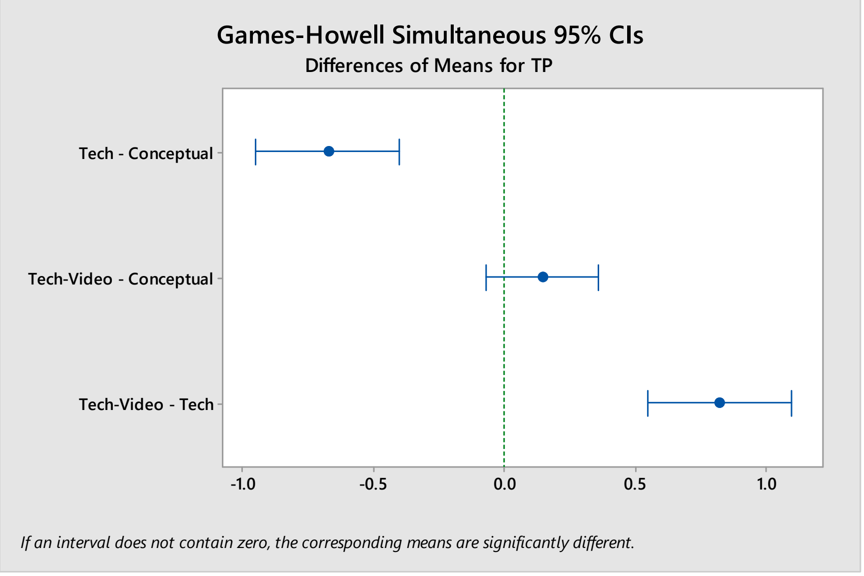
Nature-Video	N	Mean	Grouping	
Tech-Video	53	4.6377	A	
Conceptual	37	4.4946	A	
Tech	55	3.8164		B

Means that do not share a letter are significantly different.

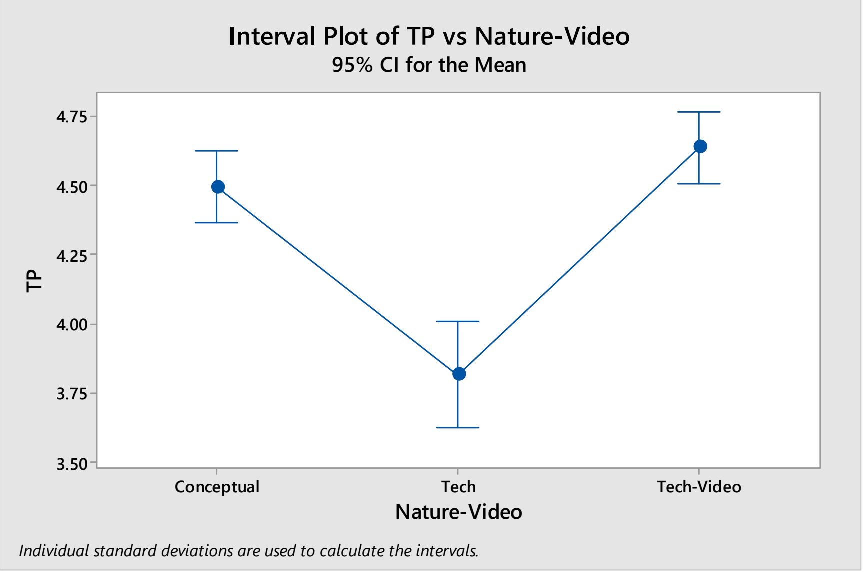
Games-Howell Simultaneous Tests for Differences of Means

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
Tech - Conceptual	-0.678	0.115	(-0.953, -0.403)	-5.88	0.000
Tech-Video - Conceptual	0.1431	0.0905	(-0.0725, 0.3588)	1.58	0.259
Tech-Video - Tech	0.821	0.115	(0.546, 1.096)	7.12	0.000

Games-Howell Simultaneous 95% Cis



Interval Plot of TP vs Nature-Video



One-Way ANOVA for CP – Flipped classes after grouping as per course nature and use of pre-class video

One-way ANOVA: CP versus Nature-Video

Method

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Nature-Video	3	Conceptual, Tech, Tech-Video

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Nature-Video	2	8.560	4.2802	9.22	0.000
Error	142	65.953	0.4645		
Total	144	74.513			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.681510	11.49%	10.24%	7.87%

Means

Nature-Video	N	Mean	StDev	95% CI
Conceptual	37	4.3243	0.5247	(4.1028, 4.5458)
Tech	55	3.7051	0.7306	(3.5234, 3.8867)
Tech-Video	53	4.0021	0.7235	(3.8170, 4.1872)

Pooled StDev = 0.681510

Fisher Pairwise Comparisons

Grouping Information Using the Fisher LSD Method and 95% Confidence

Nature-Video	N	Mean	Grouping		
Conceptual	37	4.3243	A		
Tech-Video	53	4.0021		B	
Tech	55	3.7051			C

Means that do not share a letter are significantly different.

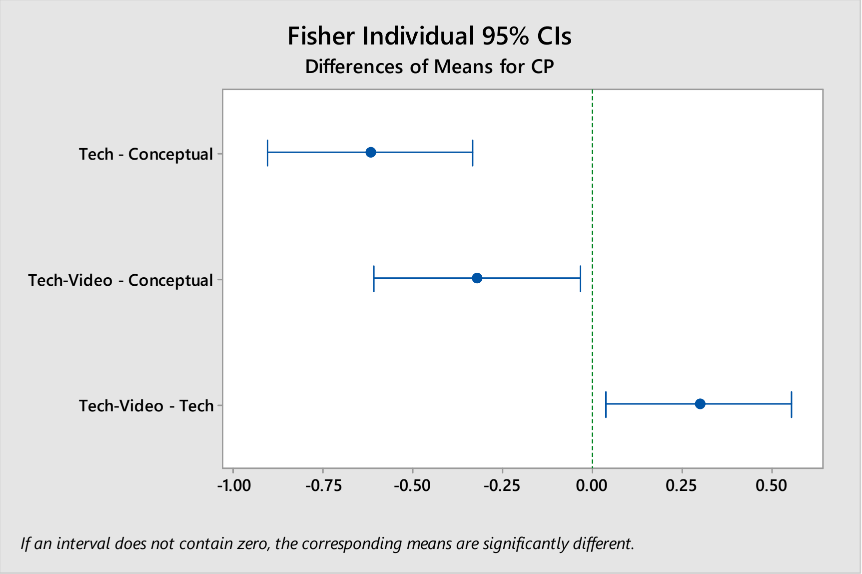
Fisher Individual Tests for Differences of Means

Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value

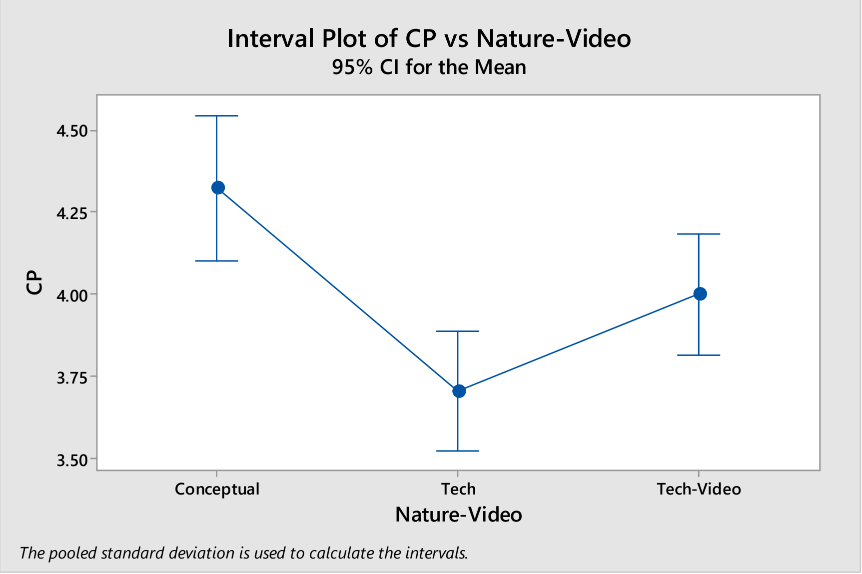
Tech - Conceptual	-0.619	0.145	(-0.906, -0.333)	-4.27	0.000
Tech-Video - Conceptual	-0.322	0.146	(-0.611, -0.034)	-2.21	0.029
Tech-Video - Tech	0.297	0.131	(0.038, 0.556)	2.26	0.025

Simultaneous confidence level = 87.83%

Fisher Individual 95% CIs



Interval Plot of CP vs Nature-Video



Kruskal-Wallis test for TP – Flipped classes after grouping as per course nature and use of pre-class video

Kruskal-Wallis Test: TP versus Nature-Video

Descriptive Statistics

Nature-Video	N	Median	Mean Rank	Z-Value
Conceptual	37	4.5	83.4	1.74
Tech	55	3.9	44.3	-6.43
Tech-Video	53	4.9	95.5	4.90
Overall	145		73.0	

Test

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	43.20	0.000
Adjusted for ties	2	44.08	0.000

Kruskal-Wallis Multiple Comparison test for TP – Flipped classes after grouping as per course nature and use of pre-class video

Kruskal-Wallis: All Pairwise Comparisons

Comparisons: 3
Ties: 120
Family Alpha: 0.2
Bonferroni Individual Alpha: 0.067
Bonferroni Z-value (2-sided): 1.834

Standardized Absolute Mean Rank Differences
|Rbar(i)-Rbar(j)| / Stdev

Rows: Group i = 1,...,n
Columns: Group j = 1,...,n
1. Table of Z-values

Data

Tech-Video	0.00000	*	*
Tech	6.33764	0.00000	*
Conceptual	1.35132	4.37578	0

Adjusted for Ties in the Data

1. Table of Z-values

Data

Tech-Video	0.00000	*	*
Tech	6.40190	0.00000	*
Conceptual	1.36502	4.42014	0

2. Table of P-values

Data

Tech-Video	1.00000	*	*
Tech	0.00000	1.00000	*
Conceptual	0.17225	0.00001	1

Data

Sign Confidence Intervals controlled at a family error rate of 0.2

Desired Confidence: 80.529

Method

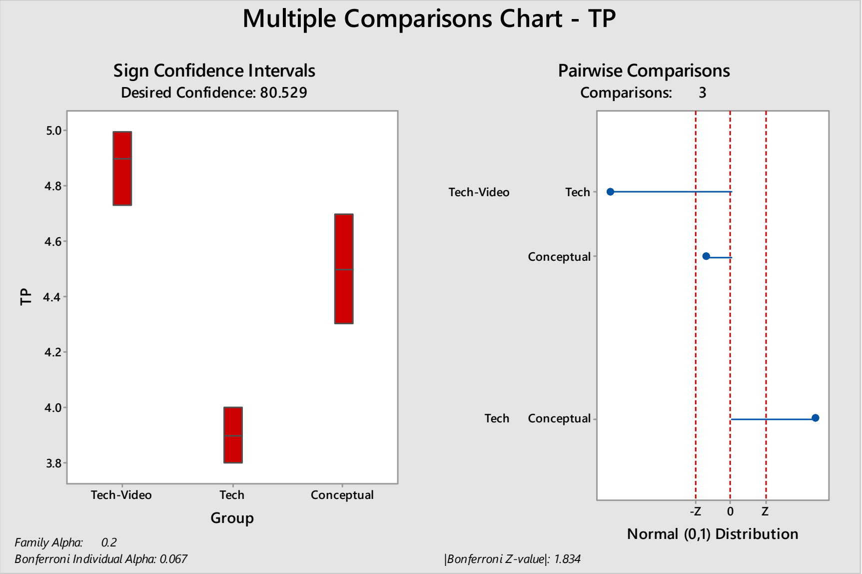
η: median of TP_Tech-Video, TP_Tech, TP_Conceptual

Descriptive Statistics

Sample	N	Median
TP_Tech-Video	53	4.9
TP_Tech	55	3.9
TP_Conceptual	37	4.5

80.5291% Confidence Interval for η

Sample	CI for η	Achieved Confidence	Position
TP_Tech-Video	(4.8, 5)	72.82%	(23, 31)
	(4.73148, 5)	80.53%	Interpolation
	(4.7, 5)	83.04%	(22, 32)
TP_Tech	(3.8, 4)	71.93%	(24, 32)
	(3.8, 4)	80.53%	Interpolation
	(3.8, 4)	82.25%	(23, 33)
TP_Conceptual	(4.4, 4.7)	67.60%	(16, 22)
	(4.30732, 4.7)	80.53%	Interpolation
	(4.3, 4.7)	81.23%	(15, 23)



Chi-Square Test for Use of Textbook (Study2) between undergraduate and graduate flipped classes

Chi-Square Test for Association: Study Level, Textbook Use

Rows: Study Level   Columns: Textbook Use

	No	Yes	Missing	All
Graduate	39	9	0	48
	25.33	22.67		
Undergraduate	37	59	1	96
	50.67	45.33		
All	76	68	*	144

Cell Contents

Count

Expected count

Chi-Square Test

	Chi-Square	DF	P-Value
Pearson	23.420	1	0.000
Likelihood Ratio	24.857	1	0.000

Fisher's Exact Test for Use of Textbook (Study2) between Eng_G_Flip_A and Eng_G_LB_E

Tabulated Statistics: A vs. E, Textbook Use_1
Rows: A vs. E   Columns: Textbook Use_1

	No	Yes	Missing	All
Eng_G_Flip_A	10	1	0	11
	10.120	0.880		
	0.001423	0.016364		
Eng_G_LB_E	13	1	2	14
	12.880	1.120		
	0.001118	0.012857		
All	23	2	*	25

Cell Contents
Count
Expected count
Contribution to Chi-square

Chi-Square Test

	Chi-Square	DF
Pearson	0.032	1
Likelihood Ratio	0.032	1

1 cell(s) with expected counts less than 1.
Chi-Square approximation probably invalid.
2 cell(s) with expected counts less than 5.

Fisher's Exact Test

P-Value
1

Goodman and Kruskal's gamma test TP1 item and motivation toward the flipped method item (M1) in Eng_G_Flip_A

Ordinal Logistic Regression: Q48 versus Q6
Link Function: Logit
Response Information

Variable	Value	Count
Q48	3	1
	4	7
	5	3
	Total	11

Logistic Regression Table

Predictor	Coef	SE Coef	Z	P	Odds Ratio	95% CI Lower	Upper
Const(1)	2.63616	3.66495	0.72	0.472			
Const(2)	6.51913	4.26265	1.53	0.126			
Q6	-1.34474	0.986729	-1.36	0.173	0.26	0.04	1.80

Log-Likelihood = -8.300

Test of All Slopes Equal to Zero

DF	G	P-Value
1	2.319	0.128

Goodness-of-Fit Tests

Method	Chi-Square	DF	P
Pearson	3.04212	3	0.385
Deviance	3.27824	3	0.351

Measures of Association:

(Between the Response Variable and Predicted Probabilities)

Pairs	Number	Percent	Summary Measures	
Concordant	18	58.1	Somers' D	0.45
Discordant	4	12.9	Goodman-Kruskal Gamma	0.64
Ties	9	29.0	Kendall's Tau-a	0.25
Total	31	100.0		

Vita

Raghad Nihlawi was born in 1991, and she is Syrian, raised in the United Arab Emirates. She received her primary and secondary education in Sharjah, UAE. She completed her Bachelor of Science degree in Computer Engineering from the University of Sharjah and graduated with rating of Highest Honors in 2013.

Ms. Nihlawi worked as Instructional Technologies Officer at University of Sharjah from March 2014 to August 2018. Then, she joined Higher Colleges of Technology as Specialist - Teaching with Technology in the department of Education Technologies.

In September 2015, she joined the Engineering Systems Management master's program in the American University of Sharjah. During her master's study, she co-authored two papers in the area of flipped learning which were presented in international conferences; International Conference of Education, Research and Innovation, and Institute of Electrical and Electronics Engineers conference. She completed SAP TERP10_67 and became SAP Certified Application Associate – Business Process Integration with SAP ERP 6.07 as a follow up to the course ESM 625 – Enterprise Resource Planning System. Her research interests are in flipped learning and educational technology.