

Modifying the flipped experience to enhance the learning of calculus in the United Arab Emirates

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Abstract

A 'flipped' or 'inverted' teaching approach (Lage et al., 2000) reverses the traditional use of in- and out-of-class time, delivering instructional input to students before class and devoting classroom time to applying this input in small group tasks. This study investigates the use of videoed lectures and attitudes to in-class activities among undergraduate students in first year Calculus classes using either a lecture-based or a 'flipped classroom' approach. Survey results indicate that while the majority of the students embrace the flipped experience and more specifically the in-class group work activities, they lacked the confidence in their self-learning abilities to completely part with an instructor-led class. This finding and its impact on implementing a flipped classroom supports concerns found in the literature that first- and second-year students may need more guidance from their professors before they can truly benefit from the flipped learning model of instruction.

يقلب منهج التدريس "المقلوب" أو "المعكوس" (ليج وزملانه، 2000) التوظيف التقليدي للوقت داخل الصف وخارجه إذ يزود الطالب بالمواد التعليمية قبل بدء الصف ويخصص وقت اللقاء الصفّي لتطبيق ما تعلمه الطالب وذلك ضمن مجموعات تعلم صغيرة هادفة. تتناول هذه الدراسة توظيف محاضرات الفيديو ومواقف الطلبة من الأنشطة الصفية بين طلاب السنة الجامعية الأولى الملتحقين بمساقات حساب التفاضل والتكامل (كالكولس)، وذلك انطلاقاً من منهج يعتمد إما المحاضرات أو الصفوف المقلوبة. وتشير نتائج المسح إلى أنه في حين يقبل أغلب الطلاب على تجربة الصف المقلوب، وعلى وجه التحديد أنشطة العمل الجماعي داخل الصف، غير أنهم يفتقرون إلى الثقة في قدراتهم على التعلم الذاتي إلى حد يجعلهم غير قادرين على التخلي تماماً عن صف محوره الأستاذ. وتساند هذه النتيجة وتأثيرها على تنفيذ صفوف دراسية مقلوبة المخاوف الموجودة في الأدبيات ومفادها أن طلاب السنة الأولى والثانية قد يحتاجون إلى مزيد من التوجيه من أساتذتهم قبل أن يتمكنوا من الاستفادة حقا من نموذج التعلم المقلوب في التدريس.

Introduction

The use of the 'flipped classroom' in higher education has been well-documented in recent years (see for example, Bretzmann, 2013; Boulton, 2014; Chen, et al., 2015; O'Flaherty and Phillips, 2015). In the flipped, or inverted, classroom, direct instruction is usually delivered to the students via short information videos that are made available for students to view before coming to class. Class time is then devoted to group discussion, in-class problem solving or other small group tasks. As Kensington-Miller et al (2016) note, there is no agreed upon definition of a flipped classroom, but

the most common characteristic from the many definitions is the presence of interactive activities inside the classroom involving student-centered learning methods. (p. 2)

The emphasis on engaging students in a student-centered classroom to create an active learning environment is not new to higher education; but putting active learning techniques into practice, including the use of the flipped classroom, is still not widespread in Science, Technology, Engineering and Mathematics (STEM) teaching. This is changing in some STEM disciplines but according to Kensington-Miller et al.,

despite a growing quantity of accumulated research on flipped teaching practice in physics, engineering, chemistry and information technology, there are few published studies concerning mathematical disciplines at the undergraduate level. (2016, p. 3)

One reason for this could be, as Sahin et al (2015) point out, that despite all the opportunities new technologies offer to help professors move away from the use of the traditional lecture, many professors are still reluctant to do so. They go on further to state that the lack of studies into the flipped classroom in university mathematics classes, especially calculus, is

notable because calculus is one of the core subjects [...] that are especially important for those planning to proceed in STEM-related fields. (p. 145)

Findings regarding the flipped classroom and its impact on student learning vary. Kadry and El Hami (2014), Blair et al. (2015) and Flores et al (2016) all found some improvement in academic performance among students participating in a flipped classroom. O'Flaherty and Phillips (2015), in their extensive review of the literature surrounding the use of the flipped classroom, found that numerous studies have shown that the flipped model has many benefits for the students including better problem solving and communication skills.

However, Jensen et al (2015) found no significant learning differences between the students in flipped classrooms and non-flipped classrooms where active-learning techniques were employed in each; they conclude that it is the emphasis on active learning, rather than flipping the classroom, that benefits students. O'Flaherty and Phillips (2015) found similar results in their scoping review of 28 articles from five countries. Unlike a traditional lecture class, the flipped classroom allows time for students to apply new knowledge and solve assigned problems at their own pace in the classroom. The professor is readily available to the students to offer clarification and guidance, to fill in gaps in their knowledge or to correct misconceptions. By discussing and solving problems, students are more actively involved in the learning process, allowing them to move from surface learning to deeper learning.

As Johnson, et al. (2016) note, as we prepare our students for the workforce in our classes,

the goal is to move away from rote learning towards experiences that cultivate a genuine curiosity in students so they are excited to explore subjects further. Deeper learning ultimately emphasizes a shift in pedagogy; instead of instructors dispensing information they are becoming flexible guides and coaches, brainstorming alongside students and modeling inquisitive behavior (p. 34).

One of the techniques associated with the flipped classroom is the use of videos, either instructor prepared, packaged with a textbook or available on YouTube. Students are expected to view the videos before attending class and then participate in group activities or in-class problem solving with little or no further lecturing from the professor. This approach offers another advantage, which is the accessibility of the lecture videos anytime and anywhere. Students can pause, rewind, and watch lectures repeatedly at their own pace. This can be especially advantageous for students who are studying in a language other than their first language and need the extra time to process both the language and the content. In this way, the availability of the videos has similar benefits to the students that researchers have found regarding lecture capture (Al Nashash and Gunn, 2013; Shaw and Molnar, 2011).

There are, of course, problems associated with using videos as a teaching tool – whether they are posted after the class, as in the case with lecture capture, or before the class, as is the case with the flipped classroom. The main issue revolves around students not viewing the videos. This can be very problematic in the flipped classroom as, unlike lecture capture, the success of the class is dependent on the students coming to class prepared. With regards to students accessing the videos when posted after the class, researchers have noted that views by students peak at exam time (Brady et al, 2013) with

minimal ongoing viewing throughout the semester. However, in addition to spikes in viewing the videos around exam times, Al Nashash and Gunn (2013) also found regular and steady viewing by students throughout the semester. Dickson et al (2012) found the videos were accessed more by graduate students than undergraduate students.

Another feature of the flipped classroom that it encourages students and gives them the opportunity to take control of their learning (Boulton, 2014; O’Flaherty and Phillips, 2015). This feature has proven to be both beneficial and problematic. For example, in order to exercise such control, students must “prepare more carefully for classroom experiences [and] this is met with mixed reviews” (Boulton, 2014). Although taking more responsibility for their learning seems to be more readily accepted by senior or graduate students than freshmen and juniors (Hao, 2016), other studies have shown that the sooner the students can be introduced to the flipped model, i.e., in their freshman year, the more chance of success it has (O’Flaherty and Phillips, 2015).

Introducing something new in the classroom often does not come without risks. As O’Flaherty and Phillips note,

both students and staff are dependent on the lecture method because it is familiar, comfortable, instructor centered and requires little active student participation. (2015, p. 89)

Strayer’s (2012) study with students in an introductory statistics class found that the students stated they preferred a traditional, lecture-based classroom over the flipped classroom. However, moving both students and teachers outside their comfort zones can result in greater learning opportunities. The use of the flipped model with freshman students enables professors

to provide their students with more of the benefits now found primarily in graduate study, such as guided problem-solving and connected, personalized work with ... faculty who explore and learn in the company of their students. (Dede, 2013, p. 48)

In addition to learning from their professors in a more relaxed, informal way, introducing group work and problem solving activities in class also allows for more student-student interaction, whereby students can discuss the problems and learn from each other.

As shown in the literature, the use of the flipped classroom model is still in need of more research especially in STEM. The focus on calculus classes is reiterated by Sahin et. al (2015) who note that students in STEM related fields must have a strong understanding of calculus to succeed in their discipline specific courses; and, as such,

a close attention to the effectiveness of the flipped classroom at the undergraduate level of calculus teaching is vital. (p. 145)

This paper, one of the first systematic studies of the flipped classroom in the UAE, strives to fill a gap in the literature on studies in the use of the flipped classroom in university Calculus classes as well as add to the discussions involving freshmen students in the flipped classroom.

Context and data collection instrument

The research was carried out at American University of Sharjah (AUS). Before introducing the students to the flipped classroom, the authors first set out to determine the students’ video preferences when given a choice of information videos explaining Calculus concepts prepared by their instructor or videos prepared by someone else on found on YouTube. The students strongly stated that they preferred videos prepared by their instructor (Gouia & Gunn, 2016). Armed with this information, the authors moved on to a two-part research project to determine firstly whether students in a lecture class viewed

recorded videos of their class as a necessary support to their learning after class; and then the views of students in a flipped classroom (accessing video lectures before class) regarding the value of this approach for their learning of calculus. The first stage was conducted in all 2015 with 65 students (24 females and 41 males) enrolled in MTH 103, *Calculus for Engineers*. The second stage was conducted in Spring 2016 with 29 students (13 females and 16 males), also enrolled in MTH 103.

AUS is a private, co-educational university with a student body of approximately 6,000 undergraduate and graduate students representing more than 90 nationalities. English is the language of instruction and students must have a minimum TOEFL score of 5.5 to enroll directly into their majors. Most of the students, regardless of nationality, have lived in the UAE for much of their lives and come to AUS from a number of different educational backgrounds including the local UAE school system, the Indian School system, the British system and the American system. As such, the students have varying levels of math preparation. Many of them have been taught in a traditional teacher-centered classroom where there has been little, if any, emphasis on student participation in the classroom.

In both stages of the research, data was collected through student surveys designed by the authors. The surveys had a mix of Likert scale questions, and open-ended questions to get both quantitative and qualitative data. The surveys can be found in Appendix A and Appendix B.

Stage 1: preparing for the flipped classroom

Procedure

During the Fall 2015 semester the students were informed that each class was going to be video recorded. Students who did not want to appear in the video were advised to sit in the back of the room. The camera was mounted on the ceiling and set to focus on the instructor and the whiteboard but there was a chance that some of the students sitting in the front of the class would appear in the video. The 50-minute class recordings of 22 classes were not edited. After the class, they were stored on the university's video portal and a link to the recording was then posted on the learning management system (LMS) for the students to easily access. In this phase of the research, viewing of the videos was optional. However, information taken from the LMS showed that every video was visited (and presumably watched at least in part) by at least 87% of female students and 85% of male students.

In addition to the students in the lead author's own class, other students from other sections of MTH 103 started watching the videos. Some of these students approached the lead author informally to talk about the videos and some of her own students told her that their friends had asked to watch the videos. From the statistics tracking report available via the course management system, Blackboard (referred to at AUS as "ilearn"), it could be seen that over 8,000 views of the 22 class videos were logged over the course of the 16 week semester.

Discussion of findings

To answer the research questions, *Do students view recorded class videos as a necessary support to enhance their learning? Why or why not?* the students were asked to fill out a short survey at the end of the course. The students did not know their final grades when they filled out the survey. 41 male students and 24 female students filled out the survey. All 65 students agreed that the videos were useful and 93% of them viewed the videos as a necessary support to enhance their learning.

Their reasons for viewing the videos were varied and, as shown in **Figure 1**, included improving their understanding, catching up after being absent, completing their notes and reviewing for quizzes and exams.

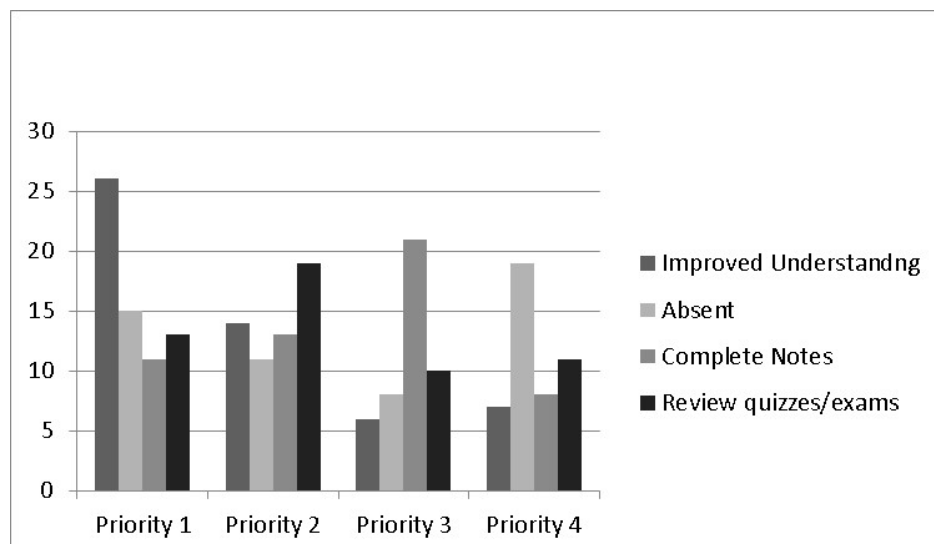


Figure 1: Number of students and their stated reasons for viewing the videos.

Unedited comments from the Professor's student evaluations echo the findings from the survey:

The videos that she posted for us was absolutely crucial and beneficial for students to further understand the subject, and for students who could not make it to class can in fact sit down and watch the video with its perfected quality, as if they were present in class. The videos that she posts, illustrates determination, passion, and love towards the subject and teaching it to other aspiring students.

The recorded lectures that are posted on ilearn are very helpful, as watching them helps understand topics that didn't seem clear in class.

The positive feedback from the students, and the high percentage of students who viewed the optional videos after the class, was very encouraging and motivating for the authors to proceed with step two of the research and introduce students in spring, 2016 to the flipped classroom. Since the success of the flipped classroom is dependent on the students watching the pre-class videos and engaging in and actively participating in class problem solving and other activities, the second part of the research was guided by the following research questions:

1. What are the students' reasons for watching the pre-class videos?
2. What are the students' reasons for not watching the pre-class videos?
3. To what extent, if any, did the students find the pre-class videos useful?
4. To what extent, if any, did the students find the in-class activities useful?
5. What is the students' preferred type of class format?

Stage 2: Implementing the flipped classroom

Procedure

The class chosen was again MTH 103, *Calculus for Engineers*. The original videos from fall, 2015 were full-length lecture captures and included class discussions and semester-specific information such as upcoming exam dates, homework due dates, etc. Thus, the videos were edited to remove any distracting information so that the videos would focus on the professor's lecture of the content.

The students were informed that their class would be conducted differently for six weeks, starting in week four of the semester. The concept behind the flipped classroom was explained to them and they were made aware that over the course of the flipped classroom experience they were expected to watch 12 pre-class videos and come to class prepared to participate in group work or in-class problem solving. At the end of the flipped classroom trial period the students were asked to fill out a survey on the experience. The data from the survey, as well as some unsolicited emails from students were used to answer the research questions.

Very early on in the flipped experience experiment the professor realized that the students were not watching the videos before coming to class. In class she noticed that the students were struggling with the in-class problem solving exercises; and based on the statistics tracking report available via the course management system, she could see that after two classes, only approximately 25% of the students had watched the videos. As noted in the literature, the success of the flipped classroom relies on students coming to class prepared. Rather than giving up on the flipped classroom or continuing in the knowledge that almost 75% of the class was not coming prepared and truly benefiting from the flipped classroom, the professor decided to modify the flipped experience. The pre-class videos were still posted and the students were reminded to watch them. However, the structure of the class was modified to include a short lecture by the professor. For example:

- 15-25 minutes: Start the class by listing the session objectives and giving a brief review of the materials covered in the videos. The time for this depended on the complexity of the topic being covered.
- 20-30 minutes: The students were put into groups to work on problem solving activities (drawn from the textbook or prepared by the professor).
- 5 minutes: The professor concluded the class by solving the problems on the board and summarizing the session.

During the group work activities, the professor walked around the class answering questions, explaining concepts and providing individual help as needed. As a result of the introduction of the brief review all the students, whether they had watched the pre-class video or not, were now able to participate in the in-class activities. They were actively working on problems, participating in class discussions and interacting with their peers, thus fulfilling one of the objectives of the flipped classroom to move from instructor-centered teaching to student-centered teaching where the classroom is adjustable in real time to the students' level.

Other steps taken to ensure that the students were not missing out on any content as a result of the introduction of the flipped classroom included the use of weekly quizzes to test the retention of concepts and an extra optional review session and extra office hours at the end of trial period of the flipped classroom experience before the second exam to accommodate any potential increase in student need for extra-support.

Discussion of findings

At the end of the six-week trial period the students were asked to fill out a survey on their experience. The students knew their midterm grades when they filled out the survey. Out of the 29 students enrolled in the class, 28 students (15 males, 13 females) filled out the survey. The tracking report on the LMS showed that the videos were being accessed; however, we were also interested in the students' report of how many videos they watched. One male student said he had not watched any of the videos; 10 students said they had watched between 1 and 7 of the videos; 10 said they had watched 8-12 of the videos and 7 students (3 females, 4 males) said they had watched all the videos. The percentage of the students' viewing practice can be seen in Figure 2.

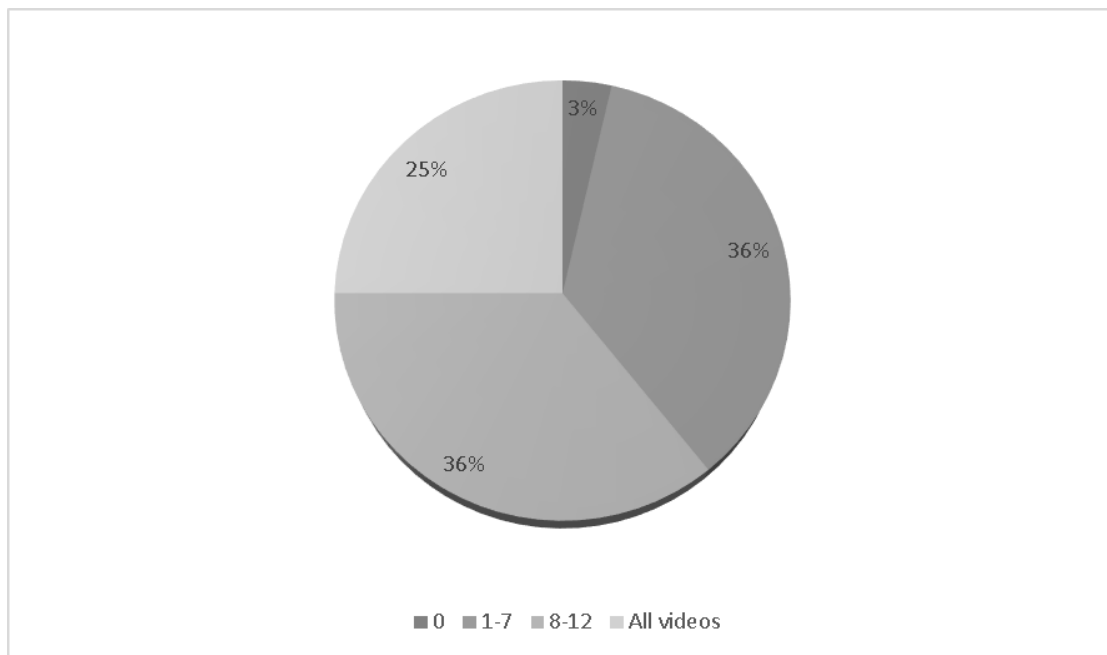


Figure 2: Students' reported viewing of the videos.

All the students (including the one who had not watched any of the pre-class videos) stated that they thought the videos were useful and that they thought the videos helped them understand better. The videos were available after the class as well as before the class, and several students mentioned the usefulness of watching the videos after the class and before the exam and quizzes. They also mentioned that the videos were useful for students who missed classes. The reasons given for not watching any or just a few of the videos related to lack of time, forgetting about them and as one student said: "I already know the lesson".

22 students stated they had found the in-class activities useful; they commented on how they learned more and increased their understanding through the practice activities and problem solving exercises. As one student noted,

they make the student engage more in class problems to increase the understanding of a specific topic.

while another student wrote:

they are useful because when I do not understand how to complete solving my partner will explain how and instead of solving the homework at home and getting stuck at home not knowing how to solve it and stopping.

Several other students noted that in addition to helping them learn, the in-class activities kept the class from being “boring”. Two students stated they thought the in-class activities were not always useful and four students stated they thought they were not useful at all because they felt too much time gets wasted when working in groups.

The use of the flipped classroom is new to many of the students in STEM classes at AUS. In order to help the lead author better understand the students’ class expectations, the students were asked to rank their preferred type of class and explain their ranking. They were given five choices as shown in **Figure 3**.

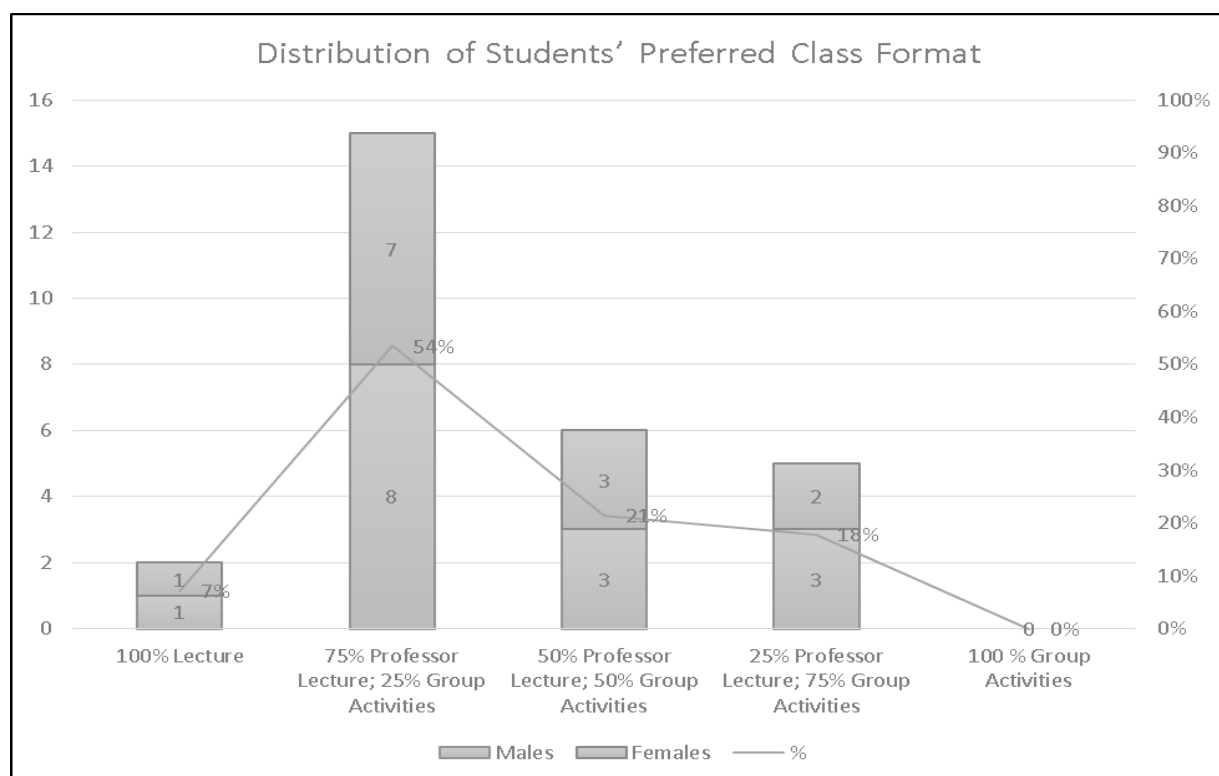


Figure 3: Distribution of students' preferred class format.

The reasons given for their choices are illustrated in some selected, unedited comments from the student surveys. A female student who noted that she had watched all the videos and preferred a class made up of 100% lecture stated, “I prefer being lectured than group activities. I feel I understand better when being lectured.” In contrast, a male student who noted that he had watched between 8 and 12 of the lectures and preferred a class combination of 25% Professor Lecture/ 75 % Group Activities wrote:

Practice is more important than lecture because when you make the mistake while solving you will never do it again.

The students who preferred a class format of 75% Lecture/ 25% Group Activities also commented on the importance of having the professor’s input and guidance before solving the problems in a group. As one female student wrote, “It is better to count on your prof more, and little bit on your classmates to learn more”. A male student noted:

I find it difficult to understand the material solely based on videos and group activities therefore I prefer lecture explanation and a bit of group activities to practice the material.

A male student who noted that he had watched all of the videos stated that he prefers a combination of 75% Lecture/ 25% Group Activities “to optimize my understanding and get some practice to be able to solve later on my own.” In contrast, another male student who noted that he had watched 8-12 of the videos and prefers a class format of 25% Professor Lecture and 75% lecture stated:

Group activities helped me understand better than examples shown and solved on the board. A bit of both is good but group activities were better.

The comments and the students’ ranking of the class format suggest that the lead author made the right choice to modify the flipped classroom experience for these freshmen students in order to allow them to fully benefit from and enhance their learning in the flipped classroom.

Limitations of the study

The number of participants in the study can be seen as a limitation. Participation was dependent on the number of sections of Calculus the lead author was teaching so by the final step in the research the number was reduced to 28 participants. Although there was a satisfactory gender distribution for engineering classes in the UAE, a larger sample is needed to more accurately determine the students’ preferred type of class. A larger sample would also allow for a quantitative analysis of the data and perhaps make the findings more relevant to contexts outside of the UAE. In future studies, the inclusion of focus group or individual interviews would also allow for a more robust qualitative analysis.

Conclusion: the need to modify the flipped experience in the UAE

The findings of this study indicate that many of the freshman students involved can see the value of the flipped classroom and the videos to help them learn but they still need and want guidance from their professor. As the first lecture-based stage of this research process demonstrated, the students watch the videos after the class and feel they benefit from watching them; many of the students stated that they felt access to the videos after the class was a necessary support to help them learn.

During the implementation of the flipped classroom, the students also noted they felt watching the videos after the class was useful for them and preferred to watch the videos after, rather than before, the class. As such, since the concept of the flipped classroom and active learning is still very new to many of the students, to be effective, the flipped classroom needs to be modified for these students. As one student commented, for her, the modified flipped classroom was the most effective way of helping her learn because

adding to the videos, the class lecture is a review on the topic before starting to solve the group activities. The class isn’t boring and we get more practice.

For all the students involved in the flipped format, the pre-class videos were seen as a useful tool to help them learn, but they do not want to have to rely on them alone to learn the material. Their preference is to have a balance of lecture and group work activities in class. In this way, they can gain the benefits associated with flipped learning but also be reassured that they will continue to benefit from their instructor’s expertise and guidance in class.

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Appendix A : Survey for students in the lecture based class

Gender: Female ☐ Male ☐ Midterm grade: _____

Did you watch the videos? Yes ☐ No ☐

If No, why not?

If Yes, did you watch the videos: (rank them 1to 4)

☐ To better understand the material

☐ Because you were absent

☐ To complete your notes

☐ To review for quiz/exam

Other reason (please list)

Are they useful? Yes ☐ No ☐

Are they necessary support for the class? Yes ☐ No ☐

Please explain your answer.

If your class was recorded, did this have an impact on your viewing of the video?

Please explain your answer.

If your class was not recorded, did this have an impact on your viewing of the video?

Please explain your answer.

How many times you watch the video per week? _____

What did you like about it?

Do you have any other comments about the videos?

Thank you.

Appendix B : Survey for students in the flipped class

Gender: Female ☐ Male ☐

How many of the 12 pre-class videos did you watch?

1 -7

8- 12

All

None

If you did not watch the videos, please explain why.

Did you find the videos useful?

Why or why not?

Do you have any other comments about the videos?

Did you find the in-class activities useful?

Why or why not?

Please rank your preferred type of class

100% Lecture

75% Professor Lecture; 25% Group Activities

50% Professor Lecture; 50% Group Activities

25% Professor Lecture; 75% Group Activities

100 % Group Activities

Please explain your answer

Thank you.