Pavements Course: Is the Flipped Classroom Model Effective in All Cases? A Case Study in a Developing Country

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Abstract: The flipped classroom model is one of the active learning techniques which has depicted good results worldwide when applied to university education, especially in developing countries. This technique has been employed in several areas of knowledge; however, its application within a Pavements course has not been reported yet. So, this article aims to evaluate the effectiveness of the flipped classroom technique applied to this subject. Two research questions related to the influence of the flipped model on both, students' final grades and their opinion about its effectiveness were carried out. The experiment was applied to four groups: two groups took the course with the traditional method while the other two attended the flipped classroom model. Students from group A-B had to attend a face-to-face lecture, while learners from group C-D had to watch a pre-recorded lecture before class attendance. As result, students in the traditional model got better average final grades than those of the flipped one; however, students, in general, were more satisfied with the flipped model. The flipped model promoted self-learning and proactivity from students to look for what is unknown to them, which is a quite valuable skill in the field of Civil Engineering.

1 INTRODUCTION

For decades, institutions worldwide have invested large amount of resources, to train people in order to meet the requirements demanded by society. Unskilled people are highly expensive for society, because they can waste resources, cause material damages and even human losses. In most situations, governments must bear these expenses, which with limited budgets in developing countries are difficult to afford. In 2015, the United Nations launched the Sustainable Development Goals (SDGs), which must be fulfilled until 2030. The fourth of these goals are related to global education. It refers to having access to inclusive and quality education to create sustainable development (UN, 2015). In response to this initiative, several institutions in every country have tried to contribute to this objective.

One of these institutions is the Council of Higher Education of Ecuador (CES). The CES is responsible for planning, regulating, and coordinating the Higher Education system of the country; and its relationship between the executive function and society. The Ecuadorian government has a plan called "2017-2021 Sustainable Development Plan", which first goal includes education as a mean to guarantee a dignified life and opportunities for everyone (SENPLADES, 2017). In this developing economy, universities are also concerned about providing quality education.

One of those universities is the Universidad Técnica Particular de Loja (UTPL), located in the south of the country. Several years ago, a trainee program was launched to improve teaching skills of the faculty members. Experts in the fields of pedagogy and related fields guided the trainee program. To approve the courses, students should complete 70% as a minimum attendance value and a minimum academic performance of 70% as well. The compromise was to apply the developed skills later in the subjects they are in charge.

Pavement design is one of the subjects taught in the career of Civil Engineering of the UTPL. This course teaches students how to calculate the structural design of flexible, rigid, and articulated pavement. Traditionally in this subject, students

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received a lecture, and then they carried out problem-solving sessions inside and outside the class. The instructor detected that some students, who got the minimum grade, did not reach the competence in designing the pavement structure. Thus, the instructor considered that the flipped classroom model would be an alternative to overcome this weakness. In this scenario, the objective of this study was to evaluate the effectiveness of the flipped classroom method applied to the subject of pavements. Two research questions where analysed throughout this work First, does the flipped classroom model influence the students' final grades? And, what is the student's opinion about the flipped classroom model? In order to answer these questions four groups of students participated in the experiment: two groups took the course with the traditional method and the other two with the flipped classroom model.

The paper is structured as follows. Section 2 gives an overview of the flipped classroom model, including some studies in Civil Engineering mayor. Section 3 describes materials and methods including details about sample size, course model and structure, and data collection. Section 4 shows the results obtained from the experiment, and finally the principal conclusions are presented.

2 FLIPPED CLASSROOM MODEL

The flipped classroom is an active learning model, where students have greater participation in their learning. In this method, students do not receive a lecture as in the traditional one. Instead, they study some academic material before the face-to-face class. Within the classroom, students participate in more significant academic activities such as problem-solving sessions, discussions or games. With these activities, students develop skills of self-learning to discover what is unknown for them and not just absorb passively what the instructor shows (Le & Do, 2019).

This method has had good results at the university. With this model, students have more active participation in their learning process. It is encouraged their self-learning, and classroom time is optimized (Milman, 2012; Roehl, Reddy, & Shannon, 2013). As a result, pupils develop creative skills to tackle real-world problems, work actively as a team, and learn collaboratively. These skills are valuable in the work field. Currently, given technological advances, students prefer these innovative methods than traditional ones (Bates & Galloway, 2012; Subramanian & Kelly, 2019) since they are more familiar with the use of electronic devices and the use of Internet. Because of these pros, this method has been extensively used worldwide by several areas of knowledge.

Specifically, in Civil Engineering, several studies have been conducted using the flipped classroom technique. For example, in water resources subject, learners improved their conceptual understanding and problem-solving skills (Li & Daher, 2017). Students of the subjects of mechanical engineering, computing, and construction materials admitted that the method had a positive impact on their learning (Gardner, Willey, Vessalas, & Li, 2014). In the subject of Transport Engineering, students were satisfied with the flipped learning, since they had the opportunity to work at their own pace, interact with the instructor and work collaboratively with their classmates (Karabulut-Ilgu, Yao, Tarmo, & Jahren, 2016). Also, in Static subject, the method encouraged their self-learning, and pupils actively assumed their learning (García-Ramírez, 2018). In a mechanics of materials course, learners who received it with the flipped classroom method performed better than the students who received it with the traditional approach (Lee, Hackett, & Estrada, 2015). In a dynamic course, students improved their learning experience and their ability to solve problems (Fredericks et al., 2013). In classical mechanics course, most students were satisfied with the flipped model (Bates & Galloway, 2012). Despite these good academic experiences and results, the flipped model has not applied to the pavements design subject in Civil Engineering.

3 MATERIALS AND METHODS

3.1 Sample Size

Four groups participated in this study to answer both research questions. Group A and B took the course with the traditional model, while Group C and D took it with the flipped model. Group A had 37 students, and Group B had 31. Both were in the April-August 2017 academic period. Group C and group D had 33 and 24 students, respectively. Both groups enrolled in the course in April-August 2018. All groups were attending their fourth year of Civil Engineering at the UTPL. The instructor was the same in all groups.

3.2 Course Model Details

In the traditional model, students received a lecture every week. A random short test was taken by the instructor; at the beginning of the class. This test aimed to know if learners read the topic of the week. During face-to-face class, students participated in a problem-solving session either individually or in teams. Then, they had to resolve other problems as homework. The activities in-class and extra-class had a score of 30% of the final score grade, while the reading controls had a weight of 20% and the midterm value of 50%.

In the flipped model, students had to watch videos of pre-recorded lectures before the face-to-face class. Videos were planed and made for the instructor. Then, videos were uploaded to the YouTube platform and their links were shared through the Virtual Learning Environment (VLE). Videos were available online throughout the whole course, so learners could go back to review them whenever they needed to. In-class, students asked the professor about the unsolved issues related to the videos and the weekly topic. Students took a reading control every week. They also participated in problem-solving sessions. After this class, students solved other problems as extra-class assignments. Both models had 1 hour of a weekly tutoring session. The scores were similar to the traditional model.

3.3 Course Structure

The course was structured based on the 16 weeks, as can be seen in table 1.

The four groups had the same course structure. Table 1 also included the duration of the pre-recorded lecture of the flipped model. In the first class and the last one, and de midterms, there were no any pre-recorded lectures, because of the topic and the activities planned in that week. Videos lasted between 16 to 43 minutes. Previews researchers had considered a duration between 20 min (Enfield, 2013) up to 1 hour (Sohrabi & Iraj, 2016). Pre-recorded lectures were made using digital slide presentations with voiceovers in Microsoft PowerPoint software.

Table 1: Pavements course structure in the traditional and flipped model.

Week	Topic	Duration mm:ss
1	Introduction to pavements	-
2	Traffic study	32:01
3	Soil study for the design of pavements	26:10
4	Soil stabilization	29:08
5	Flexible pavement structural design for highways – Asphalt Institute method	21:47
6	AASHTO flexible pavement structural design for highways	26:23
7	SHELL flexible pavement structural design for highways	19:47
8	Midterm	-
9	PCA rigid pavement structural design for highways	37:04
10	AASHTO rigid pavement structural design for highways	18:00
11	Articulated pavement structural design for highways method	43:13
12	FAA flexible pavement structural design for airports	24:19
13	PCA and FAA rigid pavement structural design for airports	16:08
14	Failures in Pavements	39:36
15	Maintenance & Rehabilitation – Pavement	-
16	Midterm	-
- There was no any pre-recorded lecture.		

3.4 Data Collection

Data collection consisted in collecting the final grades of each group and applying a survey to assess whether students like the new technique. Final grades were calculated based on what students achieved throughout the semester, according with what was described in the section of Course Model Details. A histogram was built with their individual grades, to figure it out the differences among groups. Descriptive statistics for final grade were calculated for every group in order to compare the results. Finally, an ANOVA analysis was performed using 95% level of confidence. This analysis helped to determine whether there was a significant difference among mean scores from both groups.

The survey was optional: 33 students were willing to answer in group A, 25 in group B, 31 in group C, and 23 in group D. The survey had ten questions related to the course and its methodology. In the first two questions, learners rated the course and their self-learning based on their impressions, questions were:

1 How many points would you give to the Pavements course?
2 How much did you do in the learning of the Pavements course?

From questions 3 to 10, they had to answer questions based on a five-point Likert scale selecting from: strongly agree, agree, neither agree nor disagree, disagree, strongly disagree:

3 The topics of the subject were interesting.
4 The number of problems performed in class was enough.
5 The problem-solving carried out in class was representative of each topic.
6 Other activities carried out in class (tests, team work) were enough.
7 The instructor showed knowledge about the subject.
8 The grading of homeworks, lessons, and exams was fair.
9 The learning method was implemented well by the instructor.
10 This method should be employed in other subjects of civil engineering.

A final question was asked about the changes that they would suggest for the next Pavement course.

4 RESULTS

4.1 Final Course Grades

The final average score grades were: 71.97 (group A), 73.84 (group B), 68.21 (group C), and 71.71 (group D). An analysis of variance (ANOVA) was carried out using the statistical software Minitab 14.2 (State College, 2005). This test determined whether the difference between the average values between groups was statistically significant. Those values should not differ in a 95% level of confidence. Results show that groups with the same method did not show any statistical difference: traditional (p-value = 0.270) and flipped (p-value = 0.081). Scores from group A differ significantly from group C (p-value = 0.030), but not from group D (p-value = 0.875). Scores from group B differ significantly from group C (p-value = 0.000), but not from group D (p-value = 0.061). Finally, scores from the traditional model (group A and B) were statistically different from the flipped model (group C and D) (p-value = 0.003). Which means that with the flipped classroom model influences the students' final grades, but in this case, it does negatively. In previous literature, students got higher scores in the flipped classroom than in the traditional class.

To verify if the traditional model has better performance than the flipped one; other elements related to the scores were analysed. First, the maximum score that students can get is 100 points, and they needed 70 to pass the course. The percentages of students who passed the subject were: 62%, 74%, 48%, and 50%, for group A, B, C, and D, respectively. Again, with the traditional model, more students approved the course than in flipped classroom model.

Another element is to observe their score distributions and compared it between groups, as seen in figure 1. Figure 1 shows that most students got their score around the minimum value to pass the subject. Also, the flipped classroom model got the maximum values but also the minimum one. Considering that the previous element did not show a clear trend, students' performance was analysed inside the groups, to compare then between groups.

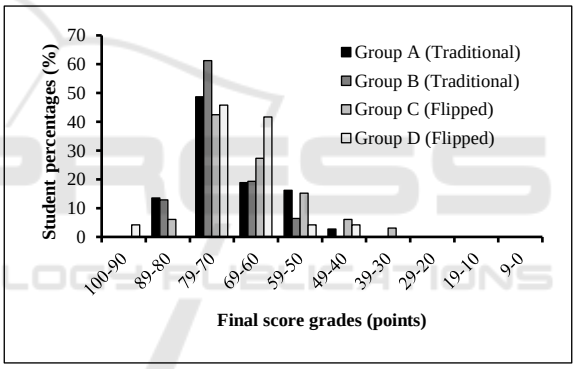

Figure 1: Final score grades and student percentages for all research groups.

This analysis was performed using the score of the first part of the semester (1-8 weeks) and the score in the second one (9-16 weeks). It calculated the differences between those scores. In this case, 31 students from group A got an equal or higher score than the first part, so did 21 students in group B, 18 in group C, and 18 in group D. Those students had made good progress in the second part of the semester. The traditional model "allows" students to get better scores than the flipped classroom; or maybe the traditional model got better results because group A and B have good students, that the flipped classroom model does not have. Also, this explains the percentages of students who passed the subject in traditional groups.

4.2 Survey Answers

The survey had several parts: rating, selecting options, and responding to open questions. First, learners had to rate the applied method and their self-learning from 1 to 10. In every group, the mean value was calculated of both ratings. Table 2 shows those rates for all study groups.

In general, the four groups evaluated the method with high values. Even though traditional method applied to group A, and alternative method was applied to group D delivered higher mean; it was not statistically different from the other groups (p-value>0.005). Group A and B the rating of self-learning statistically differs from group D (p-value = 0.032, p-value = 0.006, respectively), and the rest ratings did not. It could be said that students considered that in the flipped classroom model, they did more for their learning that in the traditional one. It concluded the same previous studies (Le & Do, 2019; Milman, 2012).

Also, the students answered about the implemented method with closed-ended questions.

Table 2: Average ratings provided by students in the traditional and flipped model.

N° of question	Average ratings provided by students (1=lowest value and 10=highest value)			
	Group A	Group B	Group C	Group D
1	9.00	8.68	8.50	8.74
2	7.88	7.28	8.09	8.48

1 How many points would you give to the Pavements course?
2 How much did you do in the learning of the Pavements course?

These closed-ended questions had a five-point Likert scale: strongly agree, agree, neither agree nor disagree, disagree, strongly disagree. Table 3 includes the percentages of the agreement answers (agree and strongly agree). Most students for all groups considered the topics interesting (see Table 3). The number of problems, its representativeness, and the other academic activities were adequate for all four groups. In these questions, Group C had the lowest percentage. Consistently in all groups, learners considered that the instructor knows the subject topics, so, it means that the instructor can be eliminated as a variable that can influence the results.

On the other hand, it shows a more significant difference in questions 8, 9, and 10. In general, students perceived that grading was fairer in traditional method than in the flipped model. The same tendency was shown when asked about the implementation. When the method was better perceived by students, they would recommend using it more often in other subjects, than the traditional method. It seems students did not see the flipped model benefits because they are used to the traditional model, as most of their lecturers apply this technique.

Table 3: Survey five-point Likert scale answers in the traditional and flipped model.

N° of question	Percentages of students that agreed (strongly agree and agree)			
	Group A	Group B	Group C	Group D
3	97.0	100.0	100.0	95.7
4	90.9	96.0	87.5	95.7
5	90.9	96.0	87.5	95.7
6	87.9	88.0	87.5	87.0
7	97.0	96.0	96.9	95.7
8	84.9	80.0	71.9	73.9
9	87.9	88.0	71.9	73.9
10	75.8	84.0	68.8	69.6

3 The topics of the subject were interesting.
4 The number of problems performed in class was enough.
5 The problem-solving carried out in class was representative of each topic.
6 The other activities carried out in class (tests, team work) were enough.
7 The instructor showed knowledge about the subject.
8 The grading of homeworks, lessons, and exams was fair.
9 The learning method was implemented well by the instructor.
10 This method should be employed in other subjects of civil engineering.

Students answered an open question related to the changes they would suggest in the next Pavement course. The answers can be summarized in five items: no modifications, field visits, the instructor solve and explain a problem, asphalt mixtures theory or laboratory, and others. Table 4 shows their percentages for every group. It is interesting that more students from group C-D suggested that it should be no modifications to the course of the pavement compared to groups A-B. This suggests that the flipped approach was according to students expectations. Another investigation agrees on this, and 51% of the pupils considered that the use of the flipped method was excellent (Bates & Galloway, 2012).

Students suggested, especially in the traditional method, that the course should be complemented with field visits to the pavement in the highways

around. They asked this element since the course of the pavement was developed exclusively inside the class. Also, they asked that the instructor should solve and explain an example before students try to solve their own.

Table 4: Percentage of answers that students suggested changes in for the traditional and flipped model.

Item	Percentage of student answers what changes they suggested in the next Pavement course			
	Group A	Group B	Group C	Group D
a	39.39	36.00	65.63	65.22
b	15.15	16.00	3.13	-
c	18.18	20.00	12.50	8.70
d	9.09	8.00	-	-
e	18.18	20.00	18.75	26.09

a No modifications
b complement with field visits to pavement in the highways around
c the instructor should solve and explain the problems first before students solve their own problem example
d teach asphalt mixtures theory or the course should have a laboratory practices
e others.
- There was no person who suggested this item.

In the course, the instructor delivered the problems that learners should solve, and then they analysed other similar solved examples before to try to solve it. During the problem-solving session, the instructor was showing some key details and answers, so students can monitor their progress. Additionally, they asked that the program should include asphalt mixtures theory or the course should have laboratory practices. This requirement was asked students from group A and B; because previous pavements courses included those elements.

Finally, students had several demands, for example, changing the schedule of the weekly tutoring session, improving the internet connection, having larger tables to place the computers, among others.

In general, most of the comments about the flipped model were positive. They saw that the method offers more possibilities that the traditional one. With the inclusion of technology, students felt more confident when using in-class and out the class. Students from group C and D answered whether pre-recorded lectures helped them in their learning process. In group C, 99.68% answer affirmatively; while in group D, all students responded the same. The comment of the only student who did not think the pre-recorded lectures helped him was that videos had the same information than the book, while others, considered it as an advantage, as seen in the previous comments.

5 CONCLUSIONS

The aim of this article was to evaluate the effectiveness of the flipped classroom method in the subject Pavements. After analysing the results, some conclusions can be raised:

The flipped classroom had a negative impact on student's final grades, given by the lower values than those obtained by the traditional model. However, results might not be conclusive, as students in this group (A and B) could have performed better without regards of the learning methods. So, this is an extrinsic aspect one should keep in mind.

Despite the low final scores grades, student's opinion about the flipped classroom model was positive. Most students in the flipped classroom did not want to change the implemented method, which means they were satisfied with the model. Their comments in the open questions widely confirmed this.

The flipped classroom model promotes active self-learning, better than does the traditional model. In spite that students asked the instructor to solve and explain an example problem before the students try to solve their own; students learn by doing it. This skill is a competence that future professionals should learn to get a better result in the field work. Also, pre-recorded lectures help to cover a wide range of learning styles, since students learn in different ways and speed. For all these good aspects, this method, without consideration of the grades, is better than the traditional one. Furthermore, it is congruous with the developing countries educational system, because they are starting to make more efforts to deliver better education.

This study has a number of limitations. First, groups were not homogenous since they performed differently in the second part of the semester. Also, students could forward the pre-recorded lecture, since this is on the learner's control. Furthermore, it performed the study in one university with a small sample size.

Despite these limitations, this study extends the knowledge of application the flipped classroom model in Pavements course. It showed that the model is accepted positively by students. Also, the model promotes self-learning and reinforces the idea that in the class, students have broad learning styles.

The method focuses more on learning activities than on the grading tasks. In short, the method significantly improves the learning experience.

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APPENDIX

Showing up next some comments made by the students regarding the changes in the course of pavements with the flipped classroom model:

- *The subject was well-performed, except in some evaluations details. In general, for me is excellent how it was carried out. Also, its methodology was very educational that archives the learning.*
- *The classes were very educational. I think it is a remarkable learning method to use inside the classroom by reviewing the topics in advance. It can cover the knowledge gaps with the instructor and performing examples applied to our environment.*
- *I think the applied methodology was satisfactory. Videos were very helpful because we could go back to them quickly when doubt came out.*
- *I think the method is good because it requires the student to review the material in a proper*

way. Sometimes it becomes a bit tired and repetitive, but it seems a good way to learn.

- *The videos were extremely helpful because, with previous knowledge, it could do more examples in-class. It used the classroom at 100 percent.*
- *It was an interesting and dynamic course, where you learn a lot, and you learn well. The instructor shows mastery of the subject, besides being understanding and making yourself understood very well. I would give a 10/10 to the method that was being used to teach this course.*
- *The subject is really important. The instructor showed a complete mastery of the subject, knowing how to meet all expectations in the pavement course. But the exams and tests were a bit complex.*
- *My experience was positive because the classes are more dynamic. The use of computer in-class promotes learning and speed to perform the academic tasks.*
- *The method is very satisfactory since the flipped classroom model allows us to delve more into the subjects, before the class explanation.*
- *It is a useful method because it allows us to be more aware of the subject. We need to pay more attention due to the evaluation is continuous.*
- *I would have liked to attend weekly tutoring; however, my schedule did not allow it. It would be nice to have other schedules options.*
- *Despite the broad content of the course, the teaching method was ideal, because more knowledge of the subject was acquired.*

Showing up next some comments made by the students about the pre-recorded lectures:

- *The implementation of videos for teaching seemed a good idea. In my case, it promoted concentration.*
- *Videos are a quick and comfortable way to review the content to any doubt, in addition to self-feeding knowledge before class, and minimize time to take advantage of solving problems in-class.*
- *Pre-recorded lectures help me a lot because I do not enjoy reading. When I watch the video, it is much easier to understand the subject.*
- *Well, we could review them if we had any doubts. Videos explained issues that in the books is very difficult to understand.*
- *They helped me to prepare for the reading controls and my studies. When I had any doubts, I only played the video as many times as necessary until I understood the class.*
- *Videos helped to have a clear idea about the content in the next class, always ahead of what we are going to see. If something in-class was not clear or we could not attend the class; we may go to the videos to review them and resolve those doubts.*
- *They helped to have shorter study times, and the teaching is given faster and in a better way.*
- *They made learning more didactic because the book has too much theory. Learning from video is much better. Videos are complementary material; you can watch them, in the case that you see a new term in the book.*
- *They are more focus on the practical life, taking into account events that can be carried out in situ, that in-class, on many occasions; they are not taken into account.*