



A hybrid online/lectures teaching model for Mechanics of Structures Courses involving new learning spaces

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Abstract

The main objective of this work is to show the implementation of a model that involves the availability of online videos and lectures in a newly designed classroom called the “Innovate Room” at our university. The combination of flipped learning as well as the use of such a learning space make the overall student experience a memorable one when compared to a traditional lecture model in courses that are usually difficult for most students of Architecture and Civil Engineering. The selected courses for this study are Mechanics of Structures courses with students of Architecture and Civil Engineering during their second year. The aspects analyzed in this work include the student’s perception on the use of a new learning space, the use of flipped learning, collaborative work during sessions and the use of experiments and models during those classroom sessions. Results indicate a very positive perception by the students of the groups taught with this model and how this model has positively affected student satisfaction and passing rate since its incorporation. The results of this work can be applied in designing new teaching models that involve the design of new spaces for engineering education, and we think it can improve the engagement of new generations of Engineering students in the twenty-first century.

Introduction

Some courses in any Engineering program always represent a bigger challenge for some students, especially in programs that have several disciplines, such is the case of Civil Engineering and Architecture, as the students always tend to prefer other type of courses in which they show greater motivation. In the case of Architecture and Civil Engineering programs, Structural Mechanics courses are typically considered hard by the majority of students. In this work, we show how some elements of the course can improve student motivation and satisfaction and, overall, the performance of students in the final exam. We analyze several semesters in which the new elements were included and compare them to previous semesters when the courses were taught in a traditional lecture model. It is important to mention that the courses have students from both programs in the same class, avoiding the approach taken by other universities and even some other campuses of our university, in which different groups are formed for Architecture and Civil Engineering students. The elements that are considered as part of a new model include a new learning space, flipped-learning, collaborative work, smaller class-size and some video production by students. The size of the class for each course is limited to 30 students and in total, 280 students have participated in the courses Mechanics of Structures I and Mechanics of Structures II, taught by one of the authors of this work over the last ten years.

Objectives

The main objective of this work is to propose a model that incorporates several elements to a traditionally theoretical course that makes it more attractive to students, especially to Architecture students. According to our records, it is not uncommon that more than thirty percent of students fail the course in their first attempt. The evaluation of the course is usually the sum of:

- a) Marks of two partial exams
- b) Mark of collaborative work and homework
- c) Mark of the final exam

The two partial exams usually account for 50% of the course, collaborative work and homework, 20% and final exam 30%, respectively. The final exam is at the end of the course when the classes period has ended and students are only sitting for exams or delivering final projects in other courses, therefore, the final exam period is extremely stressful for students and if they did not perform well in the partial exams, the need for a good mark at the final exam could make matters worse.

In the last few years our university has worked in a new education model, namely (name removed for blind review) that is student centered and encouraging the use of the latest technologies inside and outside the classroom [1-2]. These technologies include remote distance courses [3-4] and even courses with holographic telepresence from other locations different to the place where the session is taking place [5]. This modality has worked well for certain type of courses in which there is no problem solving on a board since the resolution on the remote screens do not allow the original board to be displayed properly according to feedback provided by our students. In this work we present a hybrid model in which a professor attends the sessions during the semesters and each session can have different contents, such as problem-solving sessions, collaborative activities in small teams or the production of videos by students. Some theoretical topics are watched on videos by the students outside the classroom using a video repository that has been prepared for each of the two courses analyzed in this study.

As for the learning space, a new room, different from the traditional lecture room has been prepared on campus with audio and video capabilities. The learning space has been named the “Innovate Room” and professors are expected to use it during the semester provided it is booked in advance. With respect to the Mechanics of Structures courses, the room was booked for the whole semester for both courses so students experience a new space on each of the sessions of the semesters. The objective of using a different learning space is for the students to have a different experience compared to other courses they have already taken prior to their enrollment in these courses.

Method

The Mechanics of Structures courses have been taught using a traditional lecture model, with some sessions involving problem solving, set of problems as homework and the evaluation was done with two partial exams and a final exam. The professor had to have at least a master’s degree in Structural Mechanics but a doctorate in the field was preferred. The percentage of students failing the course was over thirty percent and the motivation was not optimal according to feed back provided by the professors at end of term. Our university has been working on a new educational model [1-5] that includes a more active role by the student during the sessions.

The participants of this study are the students enrolled in two different courses, Mechanics of Structures I and Mechanics of Structures II. The professor of both courses is the same and new elements were added to the course in an attempt to improve student motivation. The new learning space was used, and Fig. 1 shows the first day of a semester in that room with the professor and the students.



Fig. 1. The Innovate Room. First day of class, fall term 2018.

The learning space as it can be seen in Fig. 1 has four projectors located in three different walls allowing for the projection of up to four different sources. The lighting of the room was also designed to allow video-recording and the fourth wall where there is no projector or whiteboard is a glass wall to the exterior so natural light comes into the space. Most sessions are then recorded and uploaded to the YouTube channel of the professor used as a video repository. Each semester new material is added and currently it has more than five hundred videos of the sessions of both courses. Some of the topics are covered as flipped classes covered by video playlists and students are asked to watch those recorded sessions or lectures from past semesters so they can come to class to solve problems in small teams or with the help of the professor. As it can also be noted in Fig. 1, the chairs allow for mobility within the classroom and small teams of up to four people can be easily assembled.

As for the participants, each semester a group of up to 50 students from two groups of the aforementioned courses take part of this study, which includes now a total of 290 students. The students are given a questionnaire at the end of term, before the final exam. This usually takes place on the last session of the term. It is important to note that for both courses there is an optional group with a traditional teaching model and students can choose at enrollment in which group they want to register. The courses with this hybrid model usually fill up very quickly on the first day of enrollment as it is common among students to enquire about professors and courses before enrollment. During the first day of the semester the professor asks the reason they

chose the group and usually a third of students answer the question mentioning the model and the use of videos in the course of the professor, information that has been passed to them by viva voce from students who have already experienced the model in previous semesters.

First attempts with video for Architecture Students at our university

At our university we have tried other techniques using video to reach other locations transmitting video in real-time, with a professor lecturing from a different city to a special classroom receiving the signal since the early 90's. At that time even satellites were used to transmit the lectures in a program called PACSI (Program to support the campuses of our university system, acronym in Spanish). Then internet video conferencing made things more widely available and programs such as Skype or Zoom allow us to have a different model, in which a professor can have a set of students from many cities, connected to the same session, we call this model the FIT courses (Flexible, interactive and with Technology). However, these models happen in real-time and students have to connect at the time of the class. The professor of the Mechanics of Structures courses noticed about ten years ago that Architecture students were having more problems with courses of Structures because their motivation was not very high and they were missing lectures when they had to deliver a project in courses as Architectural Projects I-V. Students then would come to the tutorials in the office of the professor a few days before the partial exams in an attempt to catch up with the material and each student had different requirements for their reviewing. The professor started then preparing recorded presentations as videos that were uploaded to his YouTube channel. This was well received by students since they could watch the videos even at 3am while they were waiting for renderings to complete in their computers. But the videos were long and tedious and not part of a whole model for the course.

Proposed Hybrid Model

Students of all levels from primary schools to university level use YouTube for their own learning even when their teachers or professors do not recommend it explicitly in class [6-11]. The model that we have developed makes use of YouTube as part of the course for flipped classes as well as for an extensive library of solved problems. The Edu channel now contains more than five hundred videos on Statics and Mechanics of Materials, the topics covered in the courses Mechanics of Structures I and II. As previously mentioned, the channel is not a substitute to the sessions in the classroom but just an element to the course. It has been noted that even if the full course is available as a playlist of videos, students enjoy the hybrid nature of the model as they come to the sessions to work with classmates in small projects or in problem solving sessions.

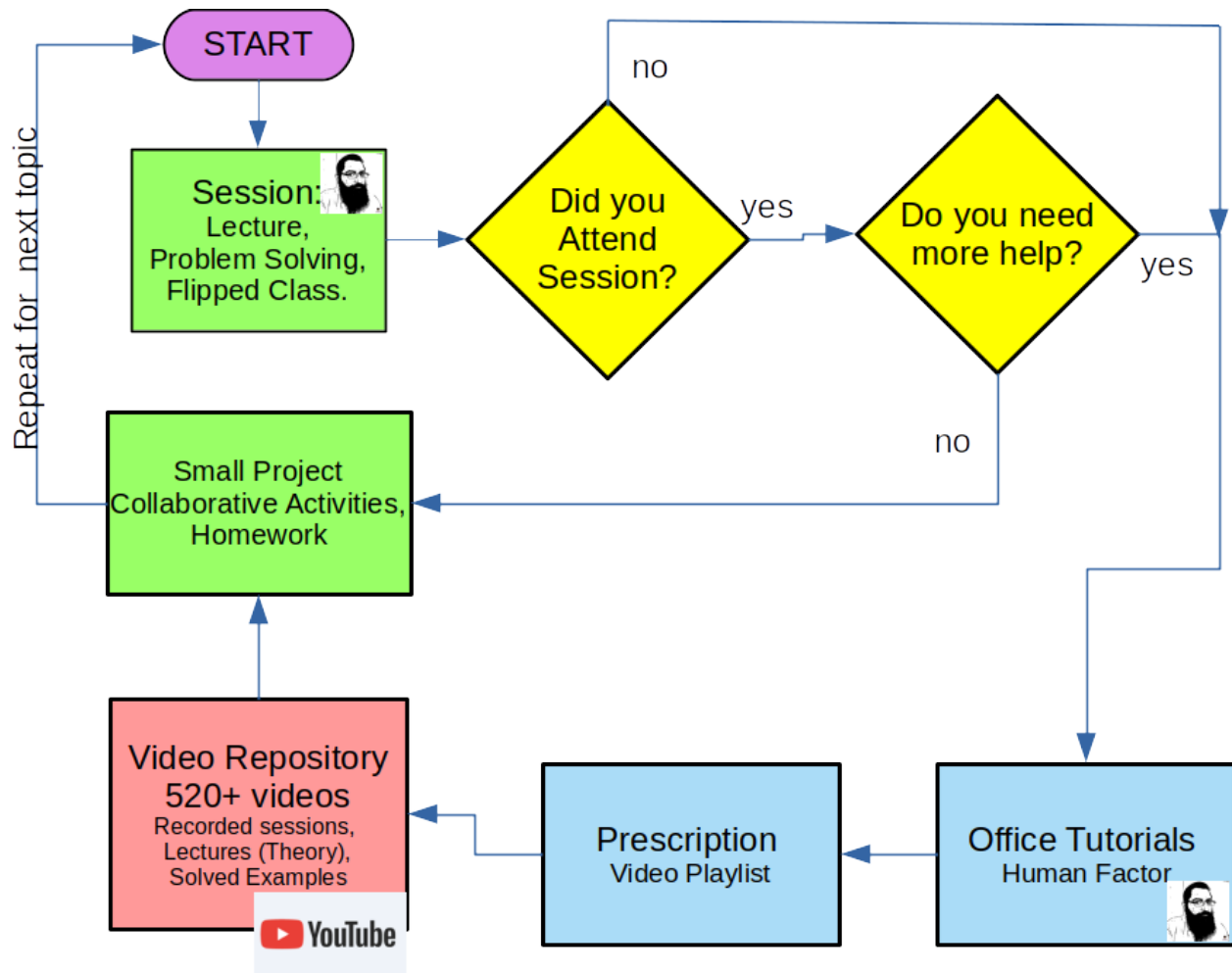


Fig. 2. The Proposed Hybrid Lectures/Flipped-class Model

The steps considered in the model and shown in Fig. 2 can be summarized as:

- i. Session takes place and is recorded. The session could be a short lecture, a small experiment with prototypes or structural models brought to class by the professor. It could be a session for problem solving on the whiteboards. The video is uploaded to YouTube the same day of the session avoiding delays due to editing. No edition is actually performed on the recording and this has given the videos a flavor of the real session.
- ii. If some students missed the session, they can watch it a few hours after it happened since the video is available usually the same night of the day of the session. This is important for students who might have traveled representing the university in a sports team or if there was a field trip for another course. There is usually a group on Facebook for each course and the videos of the sessions are posted on it. Students who missed the session and get in touch with the professor before the next one can be “prescribed” with a video playlist to watch as homework.
- iii. If any student requires more help or she/he is finding complications with the topic, an appointment can be made to visit the professor in his office. The professor then could

solve some questions and “prescribe” more problems to practice, with the aid of the YouTube channel.

- iv. Students work on project or assignment for the topic of the week. This project might involve solving a set of problems in teams and recording videos of their solution.
- v. Repeat steps 1 through 4 until the end of course.

Analysis and results

A questionnaire was applied to each group of students for a total of 290 students in the last six terms, starting in the Spring Term of 2017. The questions had to do with the implementation of the model in the Mechanics of Structures courses. All students have taken other courses at least for a year in our university before enrolling in the Structures courses. Students are mixture of Architecture and Civil Engineering programs. The questions focus on the use of the new learning space for this type of courses, the use of flipped-learning, collaborative work during the sessions, and the use of the video repository in the form of a YouTube Edu channel. Some questions deal with the characteristics of the videos that students prefer and the type of courses they would like to see using this hybrid model.

The analysis shows that students prefer the hybrid model to a traditional model for courses that involve problem solving and some theoretical content as it is the case for the Mechanics of Structures Courses. In this course not only YouTube was used as a social media network, Facebook was used for the informal communication with the groups and during some sessions even Spotify was used for music during collaborative activities. The use of digital social media has already been widely studied for other disciplines, see for instance [6-9]. Another aspect that students really appreciate about the model is its flexibility as they can choose when to watch the material and the time is not fixed when they should get online to have their pre-recorded classes. Furthermore, students can also watch the material or pause it according to their own pace. The use of YouTube has been successfully used for other disciplines such as medicine [10-14].

Fig. 3 shows the results of the question on what elements a twenty-first century learning space should include. The item that got most answers as the most important element is “Good audio and video equipment” for the learning space, with 39% of the selections, followed by the selection of chairs with wheels with 22% and a reduced class-size (no more than 30 students) with 20% of selections. Other elements considered important by students were good acoustics with 12% and air conditioning with 8%. This is important for summer months when temperatures could reach 30° Celsius.

Elements of a XXIst Century Learning Space According to students

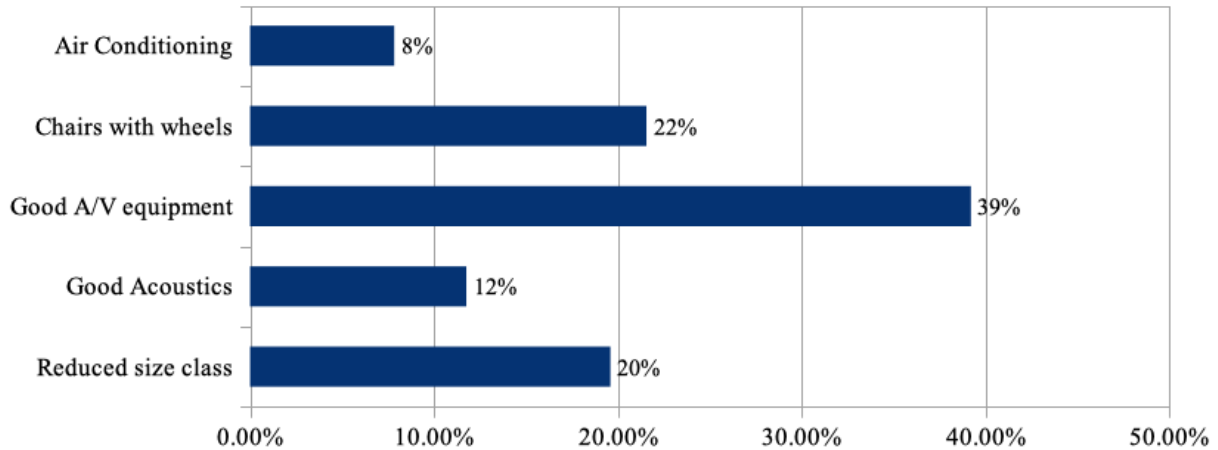


Fig. 3 . Elements of a XXIst Century Learning Space according to students.

Another question regarding the use of models and experiments during the sessions and not only the traditional lecture and some examples was answered as shown in Fig. 4. A majority of students agreed (86.49%) with the statement that the experiments and models should be part of a course as Mechanics of Structures I or II. Only 5.41% of students disagree with the use of models and experiments during the sessions of the course with 8.11% giving no importance to experiments and models.

Students were also asked if, in their opinion, the use of a new learning space in the form of the Innovate Room was helpful for their learning process. Fig. 5 shows the results of the question with a majority of students thinking that this type of spaces is helpful in Structures courses. Over 48% of students consider that the availability of audio and video equipment was very helpful for their learning process in the Innovate Room. Other important section of students considered that it was of great help with all the resources available in this new facility (35.14%), whereas only a minority of students thought it was of minimal help (13.51%) or of no-help at all (2.70%) in their learning process during the semester.

Classrooms should include scale models and experiments

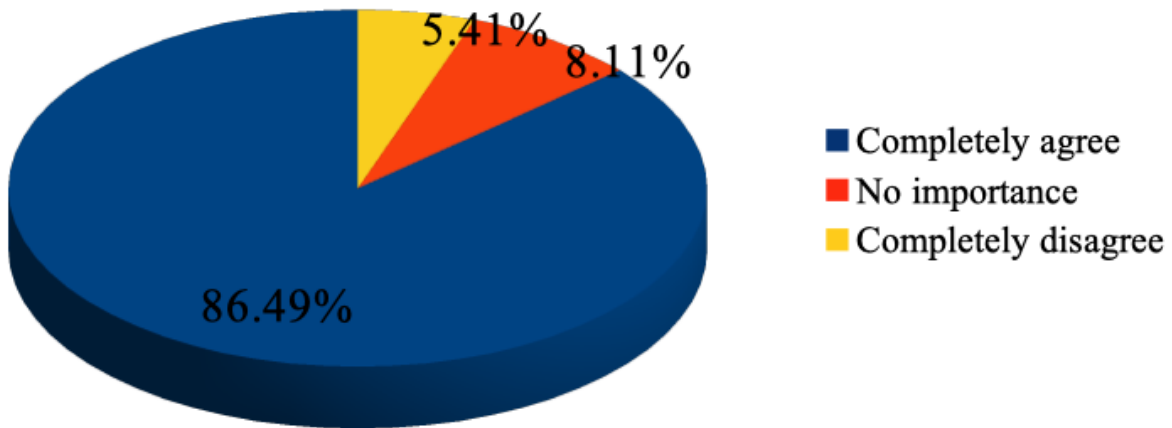


Fig. 4 . Use of experiments and models in a Mechanics of Structures course.

Was the use of Innovate Room of any help?

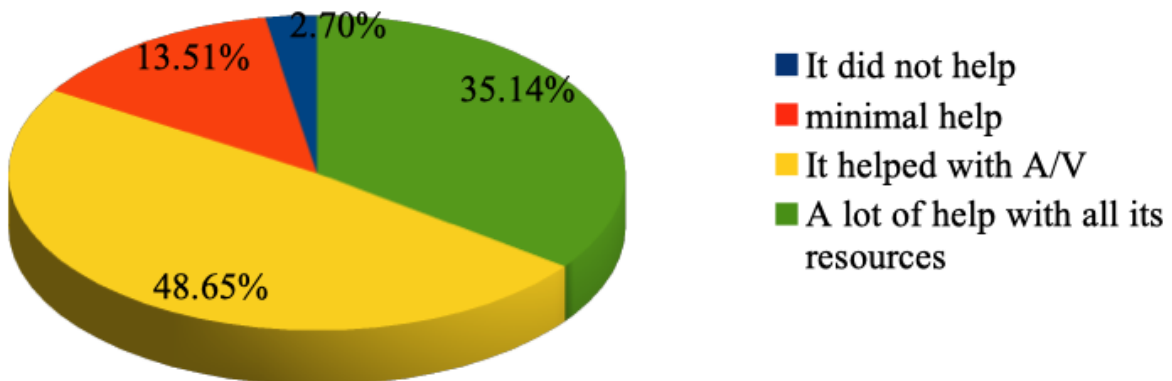


Fig. 5 Use of new learning space in a Mechanics of Structures course.

As it was already mentioned in previous sections, the courses of Mechanics of Structures I and II are taken by Architecture and Civil Engineering Students in the same class. The development of our hybrid model took into account the different levels of motivation and engagement of students from two different programs. The elements of the model can be listed as:

- a) Flipped learning. Some contents of the course are learnt by students in a flipped-class manner, usually by watching a playlist of videos at home and coming to the Innovate Room to solve a collaborative activity with a team.
- b) Videos produced by students. This is a competence of our new educational model that we call communication and digital transformation. Students should be able to present their ideas and projects with a short video. In this type of activities, mixed teams of Architecture and Civil Engineering students work best, as Architecture students tend to be more comfortable in front of a video camera.
- c) Background music during collaborative activities and problem-solving sessions. Spotify is used for this purpose with a playlist of soft music.
- d) Use of the Innovate Room during the whole semester.

Students were asked to name the most important element of the above list and the results are shown in Fig. 6 with a near tie with the use of the Innovate Room and the use of Flipped classes, with 31% and 34% of answers, respectively. An important 23% of students considered video production as the most important element of the model and 11% the use of music.

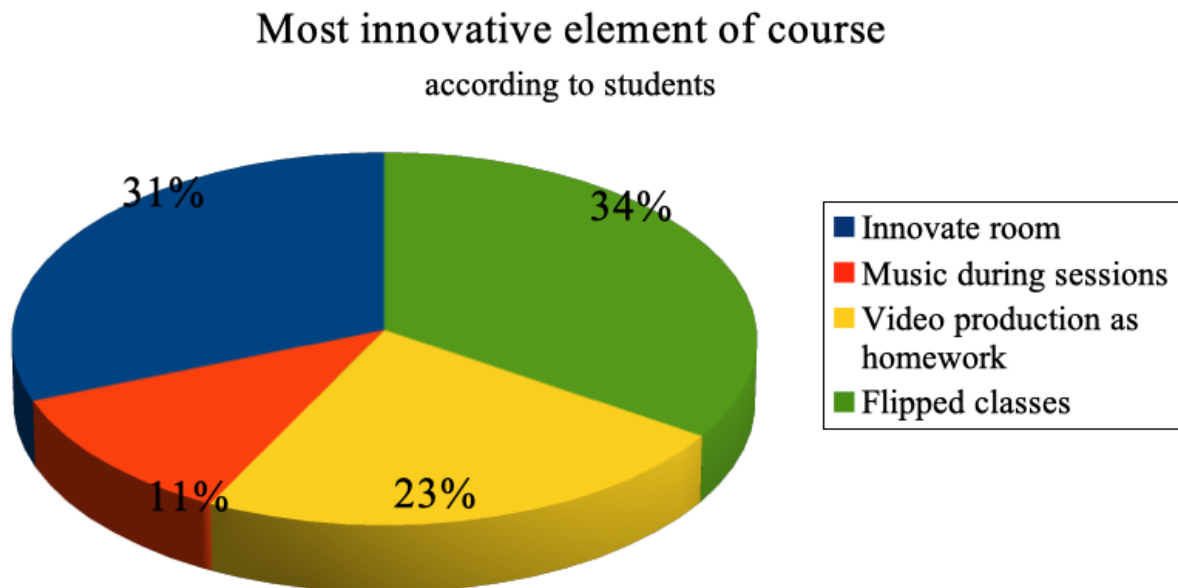


Fig. 6 . Most innovative element of course according to students opinions.

Next question deal with the advantages of using flipped-learning and the use of the video repository. The results are shown in Fig. 7, with the option that got the majority of answers “reviewing with videos is easier than with books” with 39.22%, followed by the flexibility of the model with 15.69%. The availability of more solved examples in video playlists got 17.65% of answers as the main advantage of using videos. Nearly 12% thought that session reposition was the main advantage of the use of the video repository and this coincides with the number of students in sports teams that represent the university in tournaments during the academic year, as they can review the material missed in class by watching the recorded session.

Advantages of using video repositories

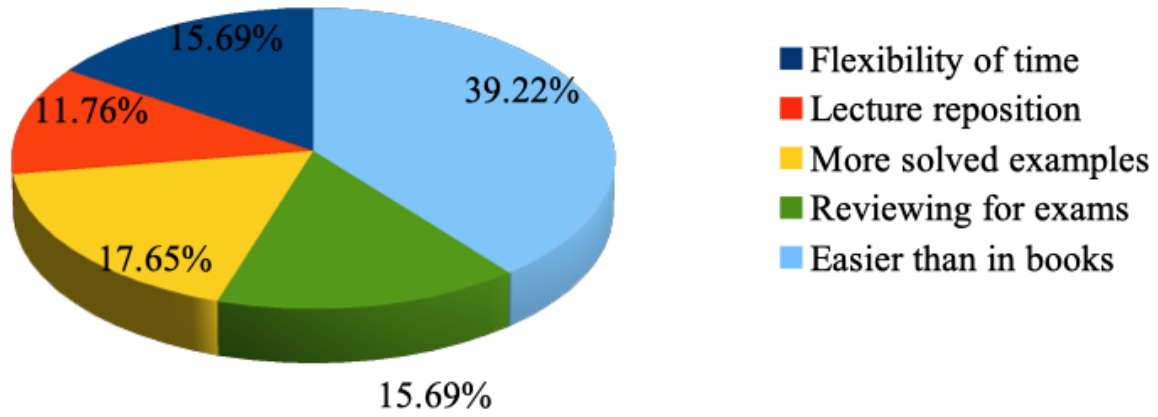


Fig. 7 . Opinions of students regarding the advantages of using flipped-classes and recorded sessions.

Regarding the competence of communication and digital transformation that we want to develop in our students, the answers to the question on whether college students should be able to produce videos and communicate their findings in that way, Fig. 8 shows the results.

Should University students be able to produce videos?

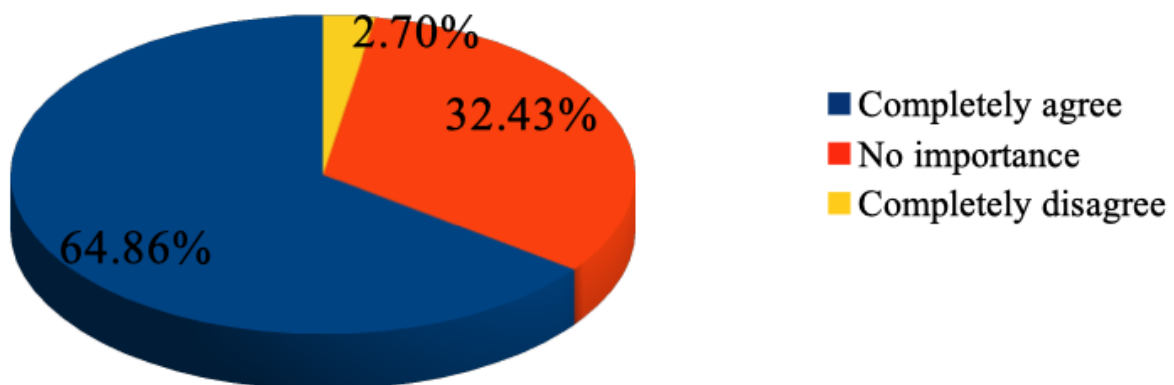


Fig. 8 . Opinions of students regarding the advantages of using flipped-classes and recorded sessions.

On the type of courses that should implement our model, students gave their opinion, classifying the courses as: a) Theoretical courses, b) Maths, Physics, Structures courses, c) All courses or d) none. The results are shown in Fig. 9, where we can see that 62.19% of students consider that Maths, Physics and Structures courses should implement this model, nearly a third (32.43%) think that the model should be implemented in all courses and only 5.41% think that theoretical courses should have this model.

Types of courses that should implement hybrid model

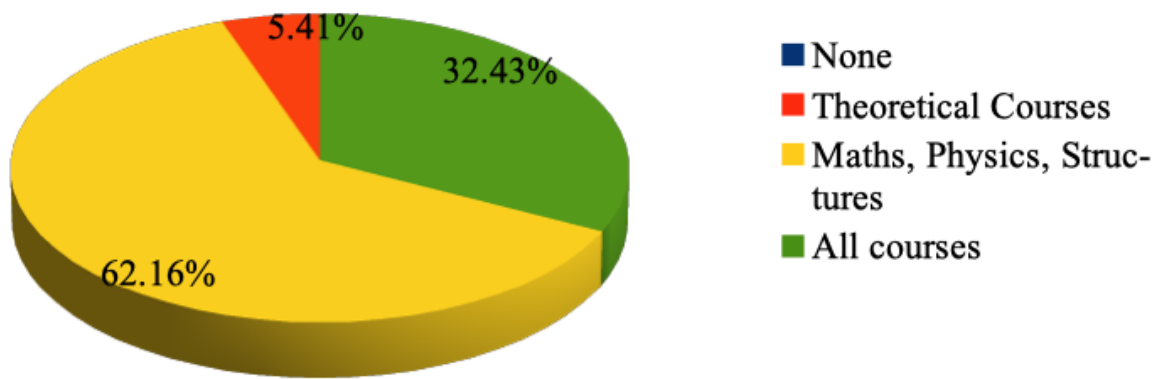


Fig. 9 . Other courses that should implement the model, according to students’ opinions.

One indicator that students are passing positive information to the next generation is how quickly the group gets filled at enrollment. The courses with this model reach their limit population the first hours of enrollment. A question was asked to students to indicate if whether the model and new classroom were important factors at enrollment. Fig. 10 shows the results for the question, with more than half the group (55.56%) indicating that it was an important factor when choosing the group for the course, as there are other options for the same subject but in a traditional teaching model.

In the last few years, more universities in different countries have paid attention to student satisfaction numbers. In the case of our university we have had a survey applied to students for more than three decades, adapting it from time to time. A simple question was added to our questionnaire regarding how satisfied the students were with the course with four possible answers: a) very satisfied, b) satisfied, c) neutral and d) disappointed. Results are shown in Fig. 11, with an 86.84% indicating that they were very satisfied with the course, 7.89% were “satisfied” and 5.26% had a “neutral” opinion with zero answers in the “disappointed” category.

Course selected because of its model & Innovate Room

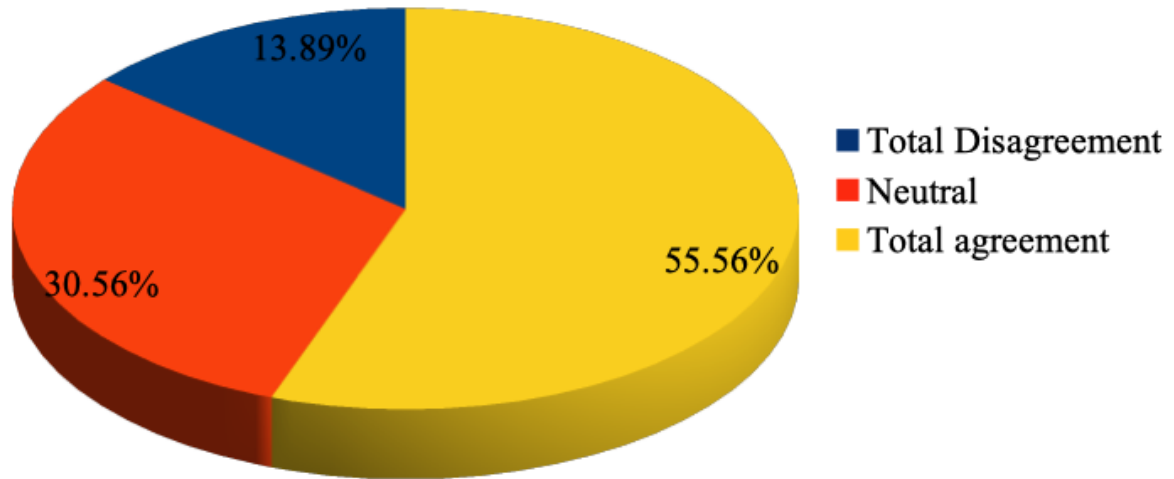


Fig.10 . Students' Opinions on whether the course model and classroom was an important factor when selecting the course.

Students' Satisfaction

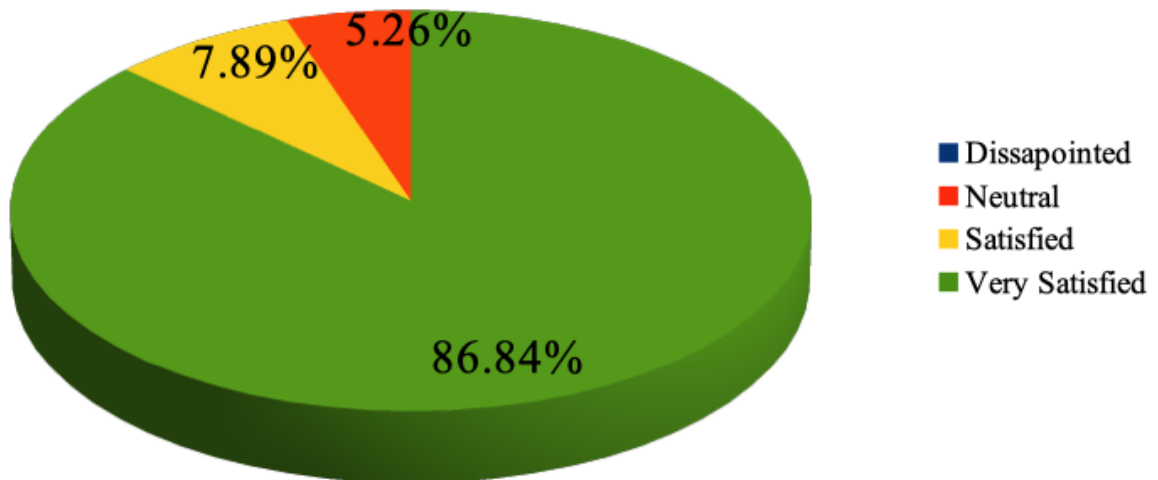


Fig. 11 Students' satisfaction with the course using a hybrid model.

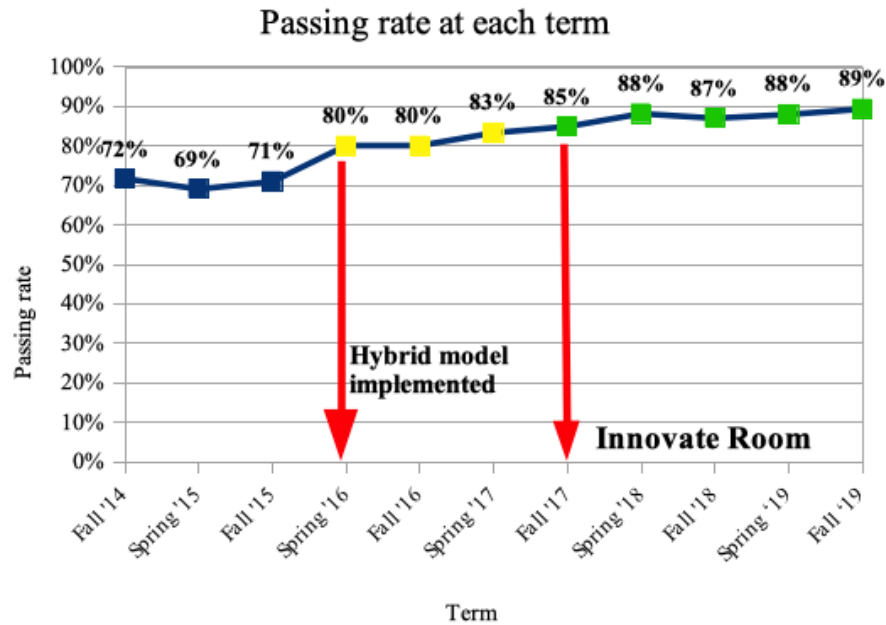


Fig. 12. Passing rate in the Courses Mechanics of Structures I and II since the model started to be introduced compared to courses taught without the proposed hybrid model.

For students perhaps the most important factor is passing the course, especially for Architecture students who typically prefer other courses over the Structural Eng. courses. Fig. 12 shows the behaviour of the passing rate since changes were introduced to the way the courses are taught by one of the authors of this work. In the Spring 2016 term the Hybrid model of Flipped-Learning and traditional lectures was introduced, with a 80% of passing rate. As the model continued to mature and get more videos into the channel, the rate increased a little bit. In the 2017 Fall term the Innovate Room was selected for the course and an increase of 2% was observed, reaching an 85% of passing rate and it has stabilized around 88% for the last term. Comparing this number with 72% observed in the Fall 2014 term, that is an increase of 16% which typically represents around 6 or 7 more students passing the course in the observed groups.

Conclusions

We have presented a hybrid model that incorporates not only flipped learning but other elements to a couple of courses of Mechanics of Structures. The elements incorporated in the teaching model include the use of digital social media such as a YouTube Educational Channel with videos of the sessions recorded by the professor, the use of a new learning space that offers the professor and the students with good audio and video equipment for all sessions, including proper lighting for video production. The motivation of Civil Engineering and Architecture students has improved as the groups get filled the very first day of enrolment. The selected courses for this study are the initial courses in Structural Mechanics that students of both programs have to take, offering the theoretical fundamentals that are needed to understand Structures and materials behavior. Results show that students welcome this kind of initiative and

offer an insight into what sort of measures, in our opinion, colleges and Schools of Engineering should be implementing in order to increase the motivation of students when facing tough and difficult courses in their curricula. This work is an active project that gets improved term after term, taking into account students' opinions. The latest incorporation into the model was the development of digital communication competence, in the manner of video production by students. Some comments received by the professor include mentions to the fact that they appreciate all the efforts in making a somehow tedious and difficult course into an attractive and enjoyable experience. Student satisfaction in the courses where this model has been applied is pretty high, with over 85% of students mentioning that they are very satisfied with the course. The teaching model presented in this work can be applied to other subjects, as the opinion of students suggest that they would like to see more courses with a hybrid model. Future work will include the application of the model to other courses and the use of more experiments during the sessions in the Innovate Room.

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