A hybrid model for Architectural Engineering courses with Digital Transformation Competencies

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Abstract

This paper presents some lessons the Online Terms during the Pandemic left to universities and professors in terms of Digital Transformation Competencies developed by students and professors and the perceptions of students after the return to the campus. We propose a model for online education in the post-pandemic years for Engineering Schools in particular for Structural Engineering courses for Architecture Students and Civil Engineering students. This model is the evolution of models used by the authors in years prior to pandemic and during the pandemic online terms and, they include the positive lessons learned from pandemic terms and the new digital competencies that we consider should be included in all courses, as some of these skills are highly desirable in Engineering graduates.

A total of 298 students answered a survey regarding their perceptions on what their experience was during the online terms and what sort of courses they consider are better suited for online teaching. Some questions in the survey also dealt with the problems faced by students during online terms and the results are included in this work to avoid them in future implementations of online courses. The results and analysis of the survey that students answered give a clear indication that overall, online education is well received by students and that universities should continue to have part of their curriculum in an online format. Especially after several terms online, four semesters in the case of our university, in which professors and students developed digital transformation competencies that can be very useful in successful implementations of the models presented in this paper. We present this model and its results as a tool that can be used by professors and universities worldwide when designing new courses for Architectural Engineering in an online or hybrid format.

Introduction and Objectives

Teaching of Structural Engineering courses to students of majors in the same course is not an easy task, as the motivation level varies from one major to another one. In our university, in the past few years, it was decided to separate students from Architecture Program and from the Civil Engineering program in different groups, but in our opinion this is not the best solution. In this paper we present a model that has worked well in terms prior to pandemic as well as in the terms that had to be taught online due to lock-down that our country experienced during the pandemic years 2020 and 2021 and also for some terms of the return to campus in 2022. The model was adapted and it is now used as a hybrid model that include the best practices and what students recommend as part of their courses.

It is important to mention that in our university, Tecnologico de Monterrey, we have been working in a student-centered teaching model. The model is also a competence-based one, in which each program has major competences that we declare our students will develop during their studies. The name of our model is Tec21 and has proven to be very successful in attracting students to all the programs. The model also includes the design of new learning spaces and the use of the latest technologies in the learning rooms [1-6]. Fig. 1 shows the new layout for teaching Engineering courses in our university.

Fig. 1. New learning spaces with chairs that allowed collaboration (September 2019)

The main objective of this paper is to present some of the activities that have been well accepted by students as well as some of the best practices from online terms, in which professors had to adapt the material and experiments to a new set-up, the digital classroom. It is important to mention that even after the classes resumed in our campuses during the 2022 terms, students keep on demanding courses or at least some sessions of a course in an online format.

We consider that a good model for Architectural Engineering courses should include a mix of activities, including the use of models in the classroom, some videos or documentaries from famous structures or construction processes, some collaborative activities or small projects to be solved in teams of students and also, some online sessions in order to develop some digital transformation competences in our students. Other disciplines within the Architecture and Civil Engineering programs are already going virtual or are taking better advantage of the latest technologies, such as Building Information Modeling (BIM). These courses are more attractive to students of these programs [7-8]. The new trend in universities in our country is to have educational models based on the developing of competences. In our university we are also incorporating this methodology using Challenge-based courses in some Structural Engineering courses [9].

In the following sections, results of a survey applied to nearly 300 students will be shown. The perceptions of students on the preferred activities and the use of new material such as video/documentaries will also be discussed.

Methodology

During the last four years, several innovations were made in the way the Structural Engineering courses for Architecture students and Civil Engineering students were taught in our campus in order to increase the motivation of students. The changes had to be carefully implemented, without affecting the motivation of Civil Engineering students, and maintaining the same level of difficulty in exams and activities. These innovations included the use of a different learning space: we moved from the traditional lecture room to a room that had a different setup with projectors in three of the four walls of the room where the professor could project different material at the same time. This was well received by students as more interaction could be had with the professor of the course and with other students. At the same

time the professor could project tables of design, some formulas or even examples of applications of the current theoretical topic.

We analyze the results of a survey applied to a total of 298 students over several years taking the courses related to Structural Engineering, namely Mechanics of Structures and Structural Systems. It is important to mention that students had the choice of enrolling in other groups of the same subject with different professors and different teaching model. During the Covid19 pandemic, the local and federal governments in our country decided to move all courses in all levels of the educational system to an online format. In the case of the courses of this study, four terms were held online, using zoom as the learning space (see fig. 2). After the return to the campuses was gradually allowed in 2022, universities had to adapt for the new normality. In the case of our university, a hybrid format was used, with special equipment in the classroom that allowed a certain number of students in the classroom and the rest following the session at home. The classrooms were equipped with cameras that would follow up the professor, who had to be masked and using a Lavalier microphone (see fig. 3). Rechargeable batteries and chargers were placed in each classroom. This hybrid modality allowed some students who were not able to attend the campus due to financial problems, to continue their studies from a different city. This was greatly appreciated by families who were struggling with their finances.
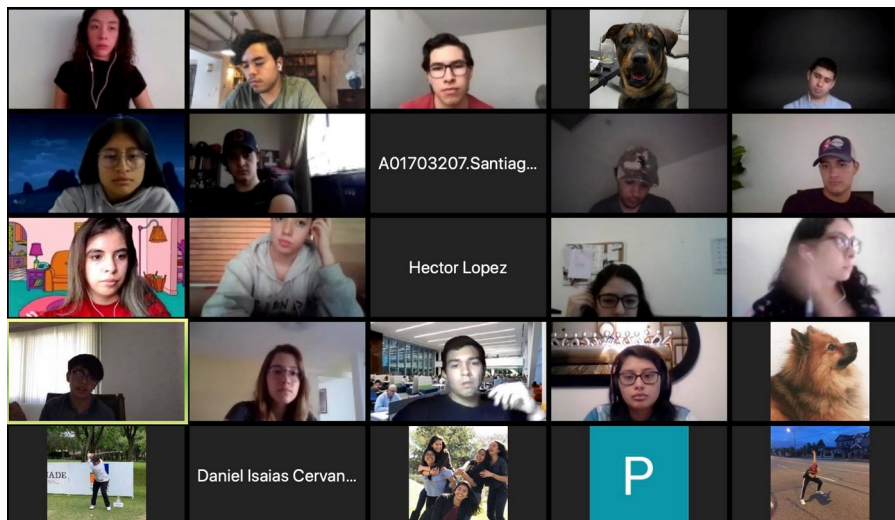

Fig. 2: Online learning space: Zoom Classroom

As it will be shown in the results, the initial resistance to online courses gradually changed and towards the last term online, students started demanding more online courses as they had identified certain advantages of online learning/teaching. The incorporation of a YouTube Channel as a video repository several years ago played an important role during all the terms this teaching model has been used, as students had the choice of over 650 videos to choose from for reviewing. Most of the videos were recorded live on campus in years prior to the pandemic terms. In this way, students can review the topics seen during their semester, with several more solved examples in video as well as previously-recorded lectures of certain difficult topics. As it has been successfully applied in other disciplines, an educational YouTube channel can be a very useful add-on to any course [10-15] as it is the case for Structural Engineering.

Evolution of Model

In the past few years, we have been working on a model that includes several components that make courses such as those of Structural Engineering, more attractive to students and, at

the same time, improve the performance of students in these courses. We started with a model in which the student could review material before his/her next class. Fig. 4 shows the model used in terms before the pandemic affected our world.

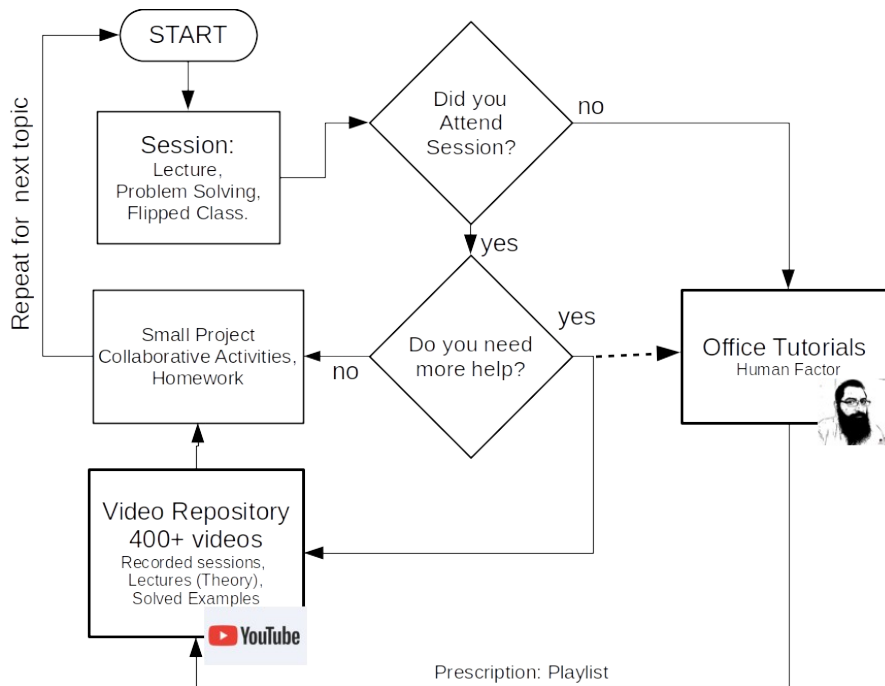Fig.3: New learning spaces for hybrid teaching, post-pandemic terms.

Fig.4: First model used with flipped-learning

Hybrid Model

In 2020 the covid19 pandemic affected the whole world, including teaching at universities. Health and Safety measures varied from one country to another but, in most cases, at least several months were taught online. In the case of our country, years 2020 and 2021 were completely taught online for most schools and universities. It was towards the end of 2021 that a gradual comeback to campuses was allowed. During the pandemic terms, professors and students had to adapt to the new learning space: a Zoom classroom. Our model adapted perfectly and it allowed us to experiment with shorter sessions online, to avoid the Zoom fatigue. Since there were many recorded videos in the YouTube channel from previous terms, a flipped classroom combined with Zoom sessions made the experience not so hard on students and professors. A student with a regular academic load in our university system has to enroll for an equivalent of 18 hours of teaching per week, considering six courses per semester. The course is taught in a semester manner with three hours of class on campus per week and the students are expected to work five hours per week solving homework or collaborative activities. Fig. 5 shows the adapted model for a hybrid experience with some students connecting from home and some others attending a classroom on campus. It is important to note that some sessions can be fully online, with the class not meeting physically any given day. Some sessions are for problem solving activities, leaving some of the theoretical lectures as flipped-classroom activities.

As it can be seen in the flowchart, the session can be held on campus or online and it can be one of the following types of session:

- Lecture
- Collaborative Activity in small teams
- Group Problem-Solving sessions
- Video documentary
- Review of material prior to a mid-term or final exam

If the student did not attend the session, she/he needs to contact the professor for an online or in-person meeting. In this meeting the professor may indicate a playlist of videos from the YouTube channel (from the professor's educational channel). When the student is ready she/he may proceed to solve the homework or small project that may involve the production of a podcast or short video.

All sessions are recorded by the professor using the hardware provided in the classroom or via Zoom and these videos are made available to students within hours after the session ended. No further post-processing is done to the videos as it is important to keep a good work flow of the videos.

One thing that we can take as a positive lesson from pandemic terms, is the fact that more professors and students have developed some digital transformation competencies such as communication in video conferencing, preparation of technical videos, oral communication skills using digital media, and others.
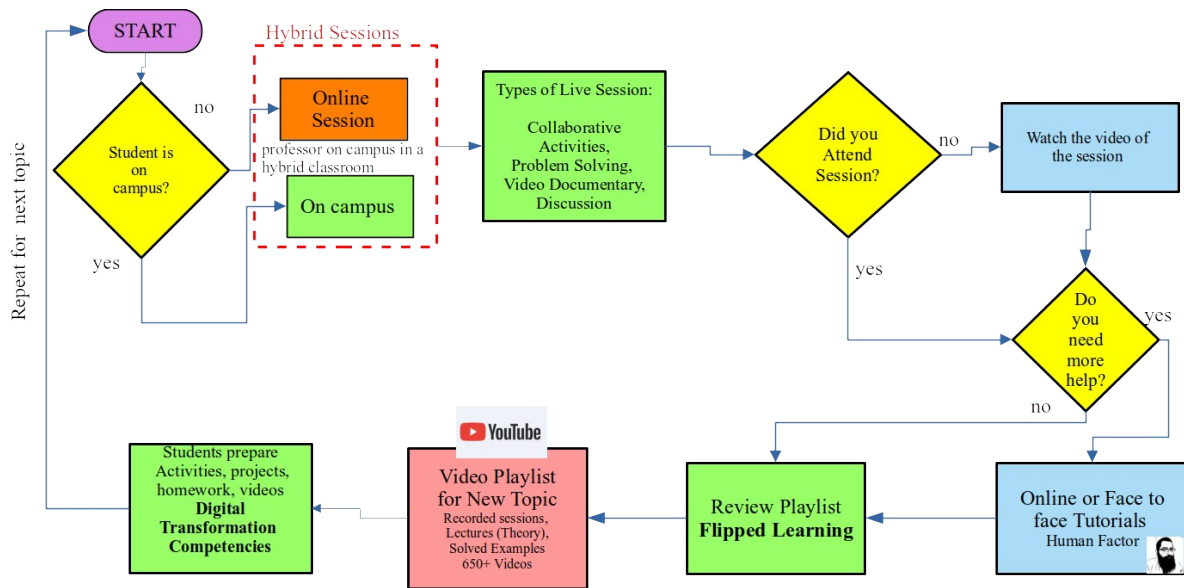
Fig.5: Hybrid model for the new courses with online contents

Results

As it was mentioned in the previous section, students answered a set of questions regarding several aspects of the hybrid model used in the course. The questions covered topics from the competencies that students further developed by solving certain activities to their perceptions on what professor should do in future implementations of the course using a hybrid model. Fig. 6 shows the results to the question on what digital competencies students developed during the course, with 60.70% selecting "Effective oral communication using digital media" as their choice, 32.10% responded with "Effective communication using videos" and 3.6% of students answered with "Effective oral communication using audio podcasts" and the rest, 3.5% of students answered "Effective communication using messenger apps".
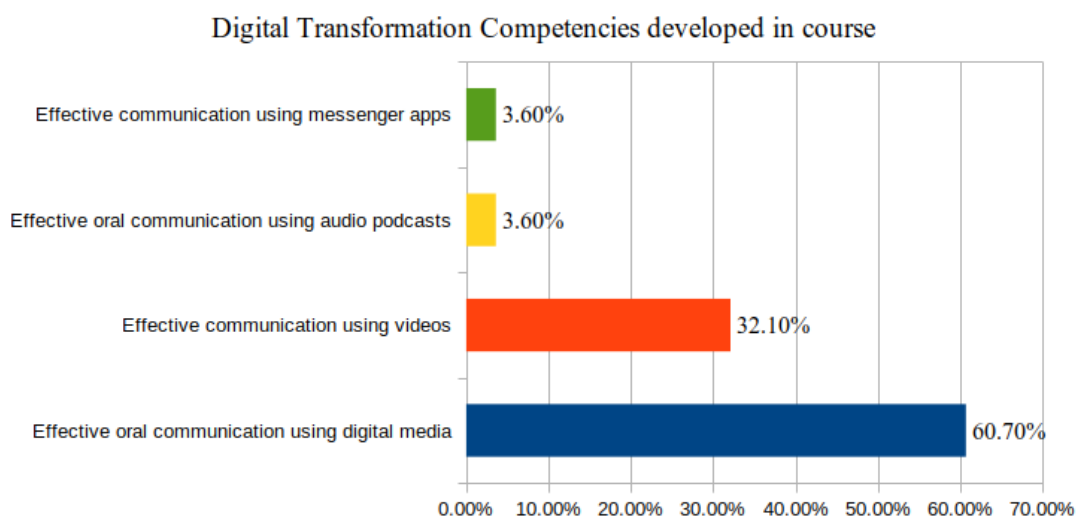

Fig.6: Students' perceptions on digital transformation competencies developed in the course

Fig. 7 shows the perceptions of students about the advantages they see in online education. For instance, 25.10% of students considered that Online classes are modern and flexible, 25% consider that online sessions allow for a better use of technological resources in the Zoom classroom (video sharing, breakout rooms, polls, etc.). 17.9% of the group considered that the experience from online terms was positive and some lessons can be taken from them, 14.5% of students gave importance to environmental issues as the reduced pollution from their vehicles as a main advantage of online education.
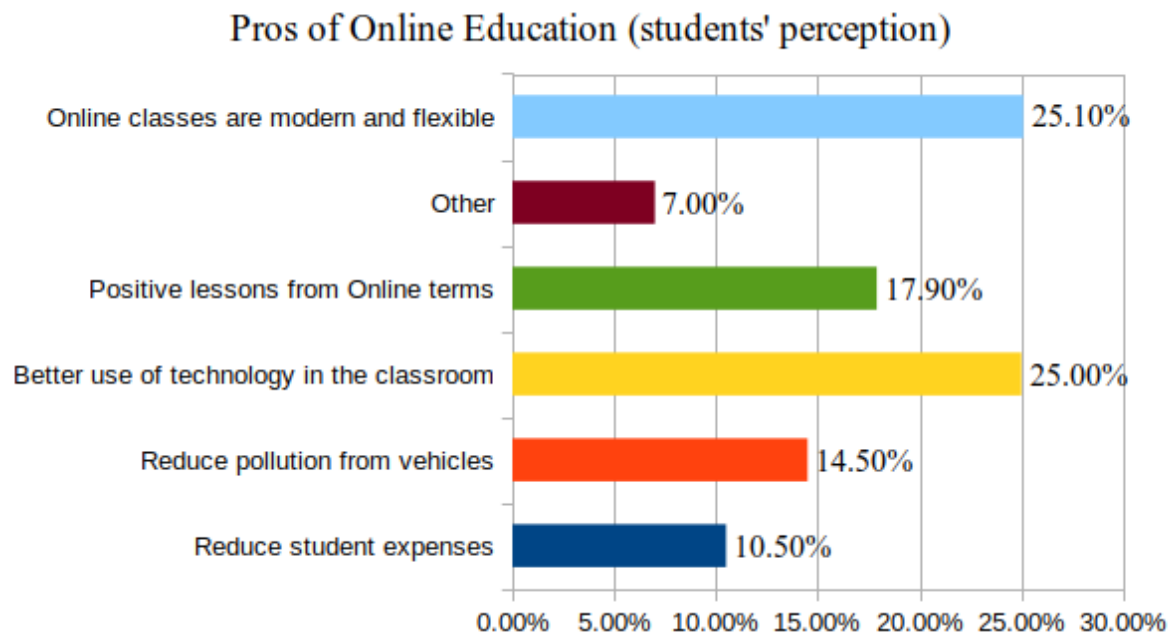

Fig.7: Students' perceptions on the advantages of online sessions

In another question, students were asked if they considered that recording videos of their solutions or the process of solution of some problem-sets helped them develop digital transformation competencies. Fig. 8 shows their answers, with 89.50% expressing that this activity does help in the developing of effective communication skills using digital media, 7% considered that these activities did not help and 3.50% are unsure about it.

Recording videos of homework solutions helped me develop digital transformation competences
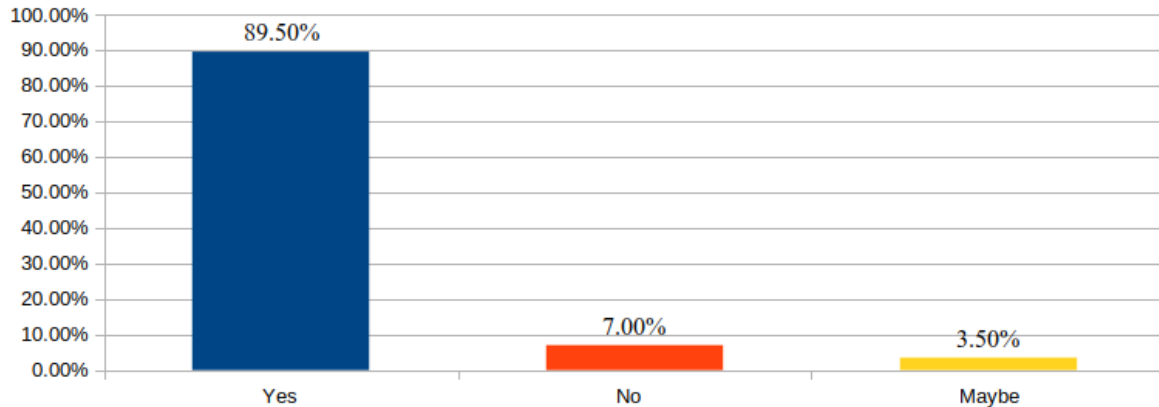
Fig.8: Students' perceptions on developing of digital transformation competencies.

A question was asked to students regarding what they would recommend in their perception, to make a better hybrid experience, thinking of future implementations of the course. Fig. 9 shows these results, with the majority (25.4%) recommending not using the whole session for a lecture, followed by 21.50% asking for more gamification in the classroom, 21.30% of students recommended activities like documentaries or videos related to the topic, 18.10% recommend that professors continue their training in digital media production, 10.80% would like to see more collaborative activities. The rest, 2.90% mentioned other factors.

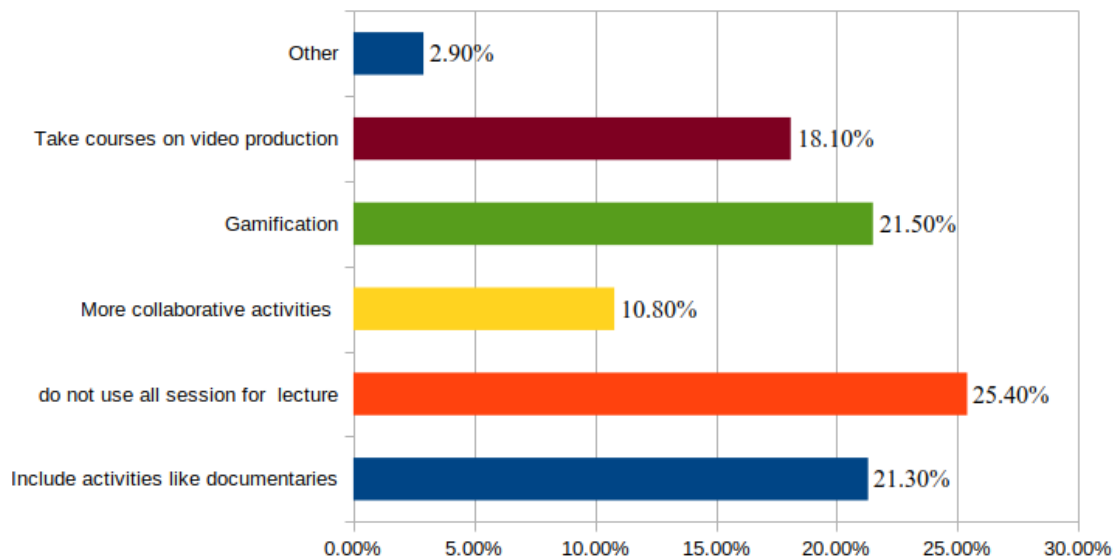**Recommendations to professors for a better hybrid course**

Fig.9: Students' recommendations for a better hybrid course

One of the main objectives of this work was to help students and to increase their motivation in the course. Student satisfaction was higher than in previous versions of the course but something we observed, as motivation increased, their performance naturally improved. Fig. 10 shows a timeline of the passing rate for the course in the last years. As it can be seen, in the first versions of the model, with flipped learning and the use of the YouTube channel,

passing rate increased to 80% (yellow bars). In the first terms shown in the figure, with the course taught in a traditional lecture model, passing rate was around 71% (blue bars). As new innovations were introduced, performance of students increased. These innovations included the use of a new classroom with projectors and more light in the classroom, as seen in Fig. 1 (green bars). Then we had to move online because of the pandemic measures (orange lines) but still performance was high. Then, there is the return to campus when students and professors had to adapt to be in a reduced class and masks were mandatory (lime bars).
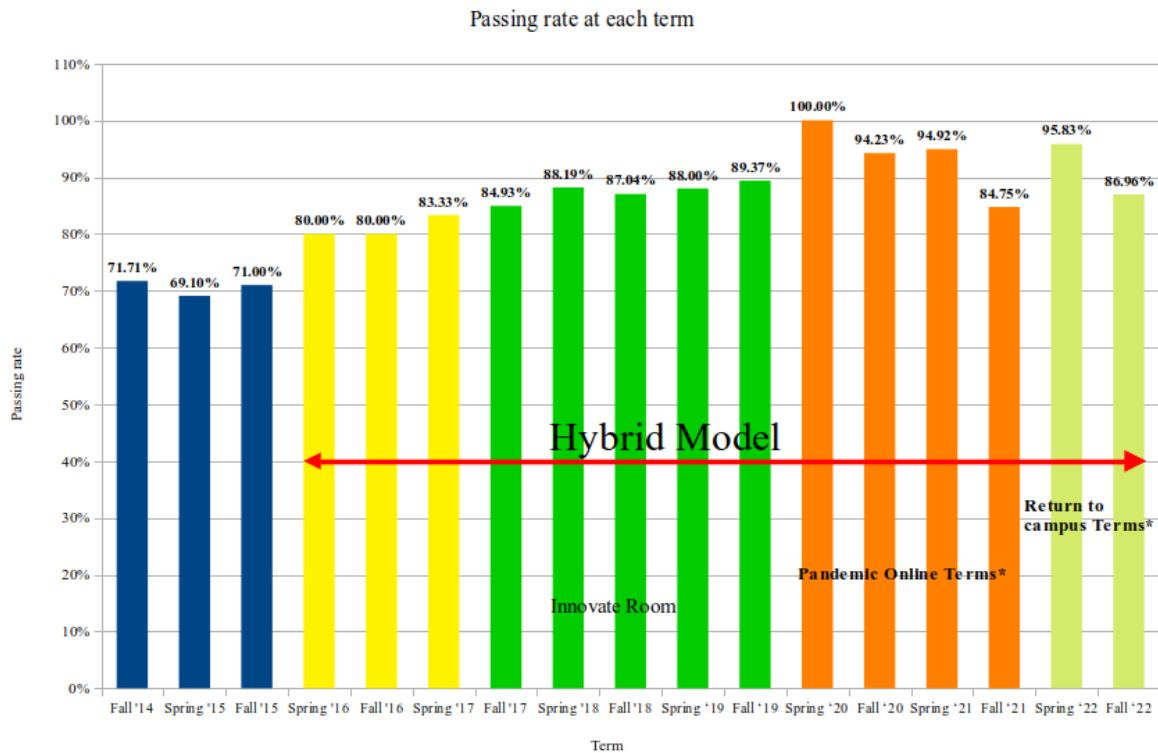

Fig. 10: Students' passing rate for the last several years.

Conclusions

In this paper we have shown the results on the perception of students on the implementation of a hybrid teaching model for courses of Structural Engineering for the Architecture and Civil Engineering programs. Typically, these courses are considered difficult by students and are also difficult to teach, given the different levels of motivation that students might have in a group. By using flipped learning and the use of new video repositories, students get a whole set of tools that can help in their motivation and performance in such courses.
Results shown from a survey answered by students are very positive and after several online terms due to constraints by the health authorities because of the covid19 pandemic, students and professors can take advantage of improved models for online teaching. Several recommendations expressed by students in the survey for future implementations of online courses are also included and presented in this work so that they can be implemented in other subjects.
We consider that online courses offer a set of advantages including the use of videos and documentaries that students can watch asynchronously and that these tools complement the

theoretical aspects of courses like those of Architectural Engineering/Structural Engineering for Architects, helping in the motivation of students as they can see the applications of the topics in real case scenarios.

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