

A Hybrid and Flexible Model for Structural Engineering Courses: Lessons Learnt During the Covid-19 Global Pandemic

Prof. Miguel X. Rodriguez-Paz, Tecnológico de Monterrey

Prof. Rodríguez-Paz got his B.Sc. in Civil Engineering from Tecnológico de Oaxaca in 1993. He studied a M.Sc. in Structural Engineering at Tecnológico de Monterrey and got his Ph.D. from the University of Wales at Swansea in 2003 where he did research on Numerical Methods for Fluid Dynamics as a post-doc Research Officer. In August 2004 he joined Tecnológico de Monterrey at its Puebla Campus. He is a full professor of Applied Mechanics since 2009. His research topics include Engineering Education, Structural Dynamics and Applied Mechanics. He has been a member of the National System of Researchers (SNI) in the Mexican Council of Science and Technology. He has held several positions within the School of Engineering, including Head of School and his current post as head of the department of Sustainable Technologies and Civil Engineering. He enjoys teaching Engineering in a fun way and likes to learn about Flipped Learning and Open Education. Since 2010 he is an Academic/educational Youtuber.

Mr. Jorge A. Gonzalez-Mendivil, Tecnológico de Monterrey

Master in Sciences with a speciality in Quality Systems and Industrial and Systems Engineer by ITESM in Mexico, twenty years of experience in engineering education, several projects in innovation of engineering education such as the use of 3D virtual ambiances as a way of developing competences.

Prof. Israel Zamora-Hernández, Tecnológico de Monterrey

Israel Zamora-Hernández has a B.Sc. in Electronic Engineering from the Autonomous University of Puebla, Mexico. He has a M.Sc. in Digital Systems from Tecnológico de Monterrey. He has been a lecturer in the School of Engineering for over 18 years. His work specializes in attracting new students to STEM programs at University level. He has directed several teams in the Admissions Office at Tecnológico de Monterrey.

Dr. J. Asuncion Zarate-Garcia, Tecnológico de Monterrey

J. Asuncion Zarate-Garcia received a B.S and a M. E. in Mechanical Engineering from Tecnológico de Monterrey and a Ph. D in Mechanical Engineering from Arizona State University.

He is currently Professor of Mechanical Engineering in the Mechatronics Department of the School of Engineering and Sciences of Tecnológico de Monterrey in Puebla, Mexico, where he teaches Heat Transfer, Thermodynamics and Fluid Mechanics. He also serves as the Head of the Mechanical Engineering Department in the School of Engineering and Sciences of Tecnológico de Monterrey in Puebla. His areas of interest are the analysis, design and optimization of thermal systems and the efficient and optimum use of energy in buildings. He has published some articles in the numerical simulation of single phase heated turbulent flow and two-phase turbulent boiling flow.

Prof. Martha Elena Nuñez, Tecnológico de Monterrey

Professor since 2013 at Tecnológico de Monterrey, where currently she is the Dean of the Architecture Department. PhD at Birmingham city University, UK (September 2016 – July 2020). She holds two Master Degrees: Industrial Design and Construction Management and Engineering. Other positions she has occupied at Tec de Monterrey are: National Coordinator of the Architecture, Design and Arts Academies, Academic Director of the Industrial Design Department. Shortlisted at the QS-Stars Reimagine Education Awards, U.S. (2015-2017). She is also a judge for the Reimagine Education Awards (2016 – present). In May 2017 she won the "Inspiring Professor Award" at Tec de Monterrey. She has organized successful Summer Programs in UK, Japan, China and Thailand. She has presented her Research and work at different international forums: ASME, Pittsburgh, U.S. 2018 / The Festival of Teaching at Birmingham City University, 2017 / Hayashi Genjuro Art Gallery, Kurashiki, Japan 2016

Dr. Gibrán Sayeg-Sánchez, Tecnológico de Monterrey

Dr. Gibrán Sayeg-Sánchez is professor – consultant in the Science Department in Tecnológico de Monterrey, Puebla campus. He studied a PhD in Financial Science in EGADE Business School (2016), a MSc in Industrial Engineering in Tecnológico de Monterrey (2011), and a BEng in Industrial and Systems Engineering in Tecnológico de Monterrey (2006). Dr. Sayeg-Sánchez has more than 10 years of experience in teaching statistics, mathematics, and operations research; and more than 12 years of experience in Operational Excellence consulting. His current research interests are focused in educational innovation and educational technologies.

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Abstract

This work presents the latest results on how to successfully apply a hybrid and flexible model for teaching Engineering Courses, particularly Structural Mechanics courses to students from Architecture and Civil Engineering programs during emergency conditions such as those due to the Covid19 Pandemic. This model has been used for the last few years with tremendous success in the performance of the students and their overall satisfaction as it has been shown in [1]. For the pandemic conditions, the synchronous sessions were changed from the classroom on campus to the online classroom with videoconferencing. Some new types of activities were included for online teaching such as video documentaries and also some modifications were made to the standard synchronous sessions, which are discussed in this work.

A total of 200 students have taken the courses that use this model during the spring term, summer term and fall term of 2020. The students come from different cities across Mexico and are located in three different time zones. These students answered a survey that include several aspects of the online experience: problems faced by students when connecting online, type of connections available at their homes, preferred type of sessions, courses that are better suited for online teaching and their personal experience with the course, among others. This paper shows the results of the analysis of the questions answered by the students and some important graphs are included. Some recommendations are also given that future implementations of hybrid and flexible (HyFlex) models can take into account for a better overall experience of both, students and professors in Structural Engineering courses. This model can also be applied for the new normality where some toggle terms are expected, that is, some weeks on campus and some weeks with online teaching as new covid19 cases are detected in each region.

Introduction and Objectives

During the first term of the year 2020, most universities around the world had to move to an online teaching model. In the case of our university, the first term of 2020 had started on campus on February 7th and it was during mid-March that the decision was made to go fully online, based on nationwide cases of Covid19 being confirmed. Our university was the first university making such a move in Mexico and in order to prepare for the online model, a week was given to all professors and instructors to adapt their courses before going fully online on the third week of March 2020. In the case of the courses being currently taught by one of the authors of this work, they were already being taught in a hybrid manner, combining asynchronous offline sessions with synchronous sessions in the classroom. Due to online teaching, students had to face a sudden change in the way they were learning with all their courses now in this modality, which it was not easy and as we will show in the results section, students prefer courses in which there is a combination of asynchronous material with synchronous teaching. The proposed model in this paper for online teaching combines different activities that are used by the professor and a video repository for flipped learning.

At our university, Tecnológico de Monterrey, the educational model has changed in the past few years from a professor centered model to a competence-based model centered around the students. The introduction of this new model, namely Tec21 has included the design of new courses, the design of new learning spaces and the use of the newest technologies for the classroom [1-4]. In any undergraduate program, students find some courses more difficult and more complicated than others and each student might have her/his own selection of favorite courses. In the case of the courses involved in this study, most students consider them as complicated as it includes some Physics and Math concepts, and the passing percentage of students is one of the lowest in our records for Structural Engineering courses in the Architecture and Civil Engineering Programs. One of the authors of this paper has been working in the past few years in ways of motivating the students and improving their performance and, as a positive result of these efforts, increasing the passing percentage of students in these courses. We have found that students have a different level of motivation for Structural Engineering courses, and it is usually the case that Civil Engineering students prefer this type of course compared to Architecture students that prefer their projects courses. The hybrid model used prior to the Pandemic of covid19 had proven to work with students from both programs [1-5]. When the pandemic arrived at the beginning of 2020, the model had to be adapted and it was not a complicated task to adapt it as it already included flipped learning and the use of videos in the way of a YouTube Channel for the courses.

The main objective of this work is to present a series of recommendations that can be applied for future implementations of online teaching models and to present our hybrid and flexible model for teaching Structural Mechanics Courses in an online manner. The recommendations and conclusions take into account the feedback provided by our students during the three terms in which online teaching was implemented due to the Covid19 Global Pandemic.

During the last few years, the main author of this paper has been teaching Structural Engineering courses to Architecture and Civil Engineering Students and has presented a Hybrid Model that works well when on campus instruction was possible. Due to the lock down measures implemented during March 2020 and still in place during the first semester of 2021, teaching on campus is still not possible in Mexico. A good and attractive model is needed to motivate students that usually find these courses more complicated than others so that students can continue their studies during the lock down.

Another objective of this work is to present a model that can be used in the new normality when hybrid teaching is needed for reduced classes on campus and the rest of the class in an online synchronous manner.

In the following sections, some results of a survey applied to 200 students will be shown. The results are about the online experience of our students and the main problems faced during their online semesters.

Methodology

In mid-March 2020, all the Education system in Mexico was moved to an online format. In our university, the move came a couple of weeks before the government announced the measures for

all levels of education. As for March 2021, the whole country continues in an online format. Some of courses analyzed in this study started the semester on campus, in February 2020, and the professor had to migrate them to an online format a month after. The following periods of 2020, summer period and the fall semester were taught fully online.

Prior to the pandemic, the courses selected for this work have been implementing new measures such as the use of a new classroom with reduced number of chairs (maximum of 32 students), with proper lighting for video recording and several media projectors. The hybrid model used for the courses in previous semesters made extensive use of a video repository in the form of a YouTube channel prepared by the professor with material from several semesters. At the beginning of the implementation of these measures the percentage of students failing the courses was over 30% and as it was mentioned before, the motivation in students was not the best and with large variations in the level of motivation each student had. Our new educational model that is centered in the student requires the student to participate actively during the session and the professors must design their material accordingly [1].

As the courses moved online, the use of the new on campus classroom was not possible and the professors had to adapt to the online virtual classroom. Our university decided to use Zoom as the standard video conferencing tool for all courses. Fig. 1 shows the change in classroom from the on-campus classroom to the new digital classroom used during online teaching.

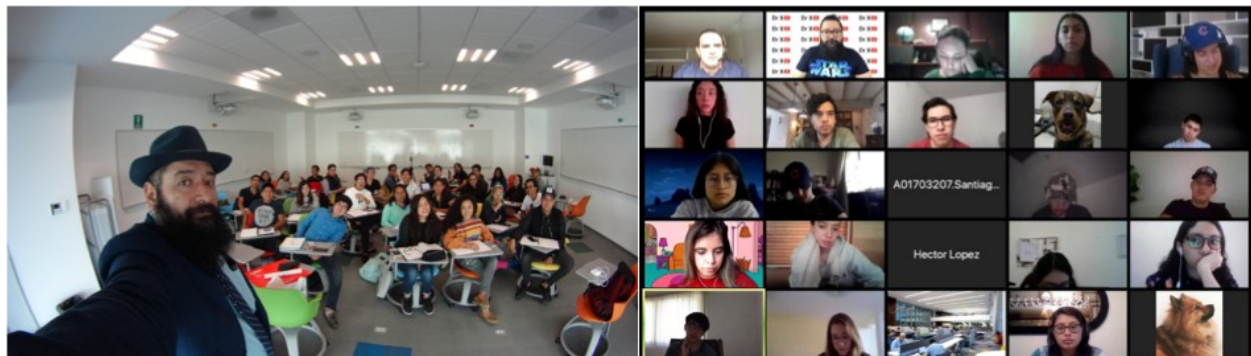


Fig. 1 Left: The classroom on campus in 2019, Right: The digital classroom during Pandemic months of 2020.

The digital classroom at the beginning of the lock down had a novelty effect in students as they were curious about how the learning process would take place online. For some of them it was their first experience online and the same applied to some professors. The online sessions were held at the same time as they were scheduled for on campus teaching, however, it soon became evident that long sessions were not best suited for online teaching, as there are some courses with sessions up to 4 hours in a row for courses like Architectural Projects. In Fig. 2 we can see a typical session on campus where the professor can make use of models that he has available for the course on campus. During the lock down and teaching from home this was not available.



Fig. 2 Models are used in the classroom but could not be used during lockdown

Another change that was introduced during the lock down was the initiative of National Courses, in which students from the 26 campuses of our university could enroll in certain courses. Two of the groups of this study were in that format. Having students from different campuses and different time zones (4 time zones in Mexico) made things a little bit more complicated, as the courses were programmed using the Central Mexican Time and for some people in the Pacific Time, that meant that an 8am course would be 6am in their time zone. It is for reasons like this latter one, that it soon became evident that asynchronous material was needed as an important component of online teaching.

As it can be seen in Fig. 1, when the courses were held on campus prior to the pandemic, the number of students was limited to 30 students per course. During online teaching, that is, the summer period of 2020, the fall semester of 2020 and the spring period of 2021, the maximum number of students was limited to 40 students per course.

Proposed Hybrid and Flexible Model for Engineering Courses

The model that has been applied during the lock down terms includes only online teaching. Fig. 3 shows a modified version of the hybrid model making it now flexible as it might include on campus teaching for a reduced class. If the pandemic measures given by local and federal governments indicate that schools and colleges must go online again, the model adapts in what we call a “New Normality Term”.

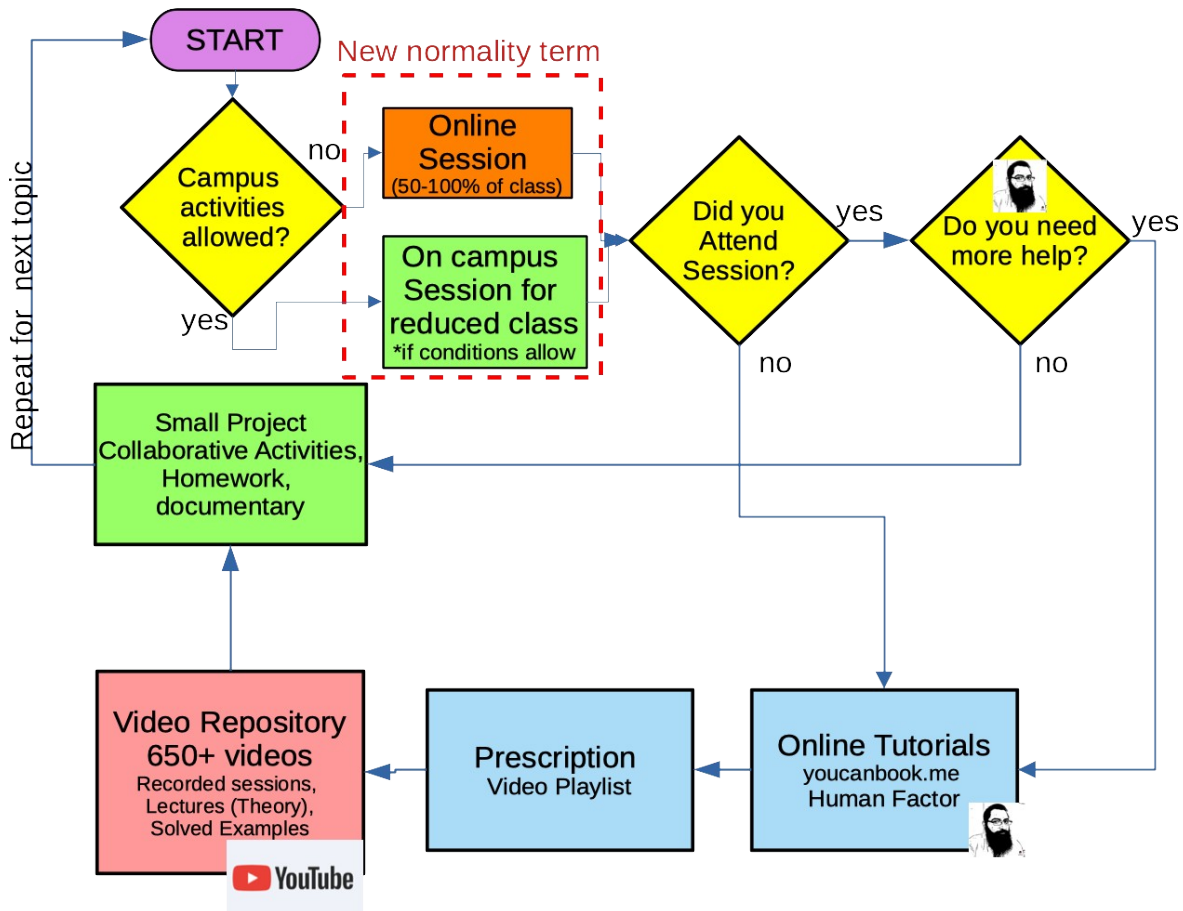


Fig. 3 Hybrid and Flexible Model for the New Normality.

The procedure indicated by the flowchart of the Hybrid and Flexible model include the following steps:

- I First question “are on campus activities allowed?”
 - I.a Yes, then course sessions take place in a special classroom prepared for hybrid teaching, that is, it has a camera that follows the professor at all times and transmits in real time to a number of students that can be connected online from a different location. The session is also recorded on the cloud. The capacity or the number of students is limited so that social distancing is kept during the classroom activities and masks are mandatory.
 - I.b On campus activities are not allowed, so the session is held online using Zoom. In this modality up to 100% of the class is expected to attend the online session.
- II Second question to students “Did you attend the session?”
 - Yes, in this case if the student needs more help, she/he should contact the professor to book for an online tutorial. For this purpose, the website youcanbook.me is used to book an appointment with the professor at the time he has declared as available. If the student thinks he does not need extra help after the session, she/he can continue to homework or project before next session.
 - No, the student did not attend session. An appointment with the professor is indicated in this case.

- III Online tutorials, for those that need to book an appointment with the professor for a personal tutorial, as indicated in the previous step, the professor sees that person in a one-to-one format using zoom. According to the questions the student might bring the professor directs the student to a playlist of videos that she/he has to see to get a better understanding of the current topic.
- IV Solution of homework, collaborative activities, small projects before next session.
- V Repeat steps I-IV throughout the semester

As the lock down measures are gradually lifted in countries where vaccines are available, new work schemes will be needed to return to our campuses. In our university, some guidelines have been given on how the gradual return will take place: reduced number of students per class, keeping a minimum distance between any two students at any time and proper ventilation of classrooms. In some cases, the classrooms can be adapted but in others it gets more complicated for interior classrooms with windows that cannot be open.

As for the faculty members and students, the decision to go back to campus is personal. Our university has given staff the freedom to choose if they prefer to stay at home for personal reasons such as being in a risk group, because of personal health problems or because the staff member lives with a person that is in a risk group. As the vaccines roll-out in Mexico is very slow with less than 3% of population already given a vaccine, we anticipate that the fall semester of 2021 will still have an important component of online teaching.

In the following section we show results on how the model has been received by our students and what have been the difficulties students have faced at home for online teaching, as well as some recommendations given by students on what they perceive as a good implementation of online teaching.

Lessons learned: some results on students' opinions

As it was mentioned before, a survey was applied to our students during the three terms of 2020 that moved to an online format. A total of 200 students answered a survey regarding the implementation of the model and the overall online experience.

Fig. 4 shows the distribution of students between male or female students or undeclared. It is important to mention that this is an Engineering course, but it is part of the curricula of both Architecture and Civil Engineering programs. In Engineering there are 32% of female students and this graph shows that this percentage was also present in our courses. More work is being done to increase the number of female students in the School of Engineering.

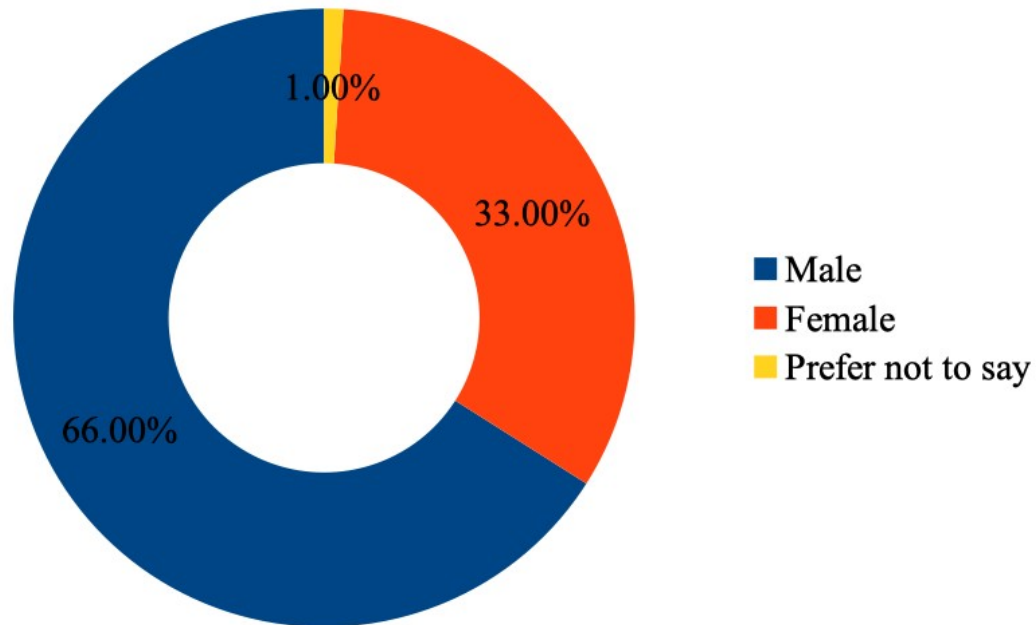


Fig. 4 Distribution of students in the courses of this study.

Fig. 5 shows the distribution of students according to the semester in which they are enrolled at the moment of taking the course. The academic programs in our university last nine semesters for Civil Engineering and ten semesters for Architecture. It is important to mention that sometimes Architecture students leave the courses analyzed in this work to the last semesters compared to Engineering students that need to advance in their curricula since they have more courses on Structural Engineering and these courses are the foundation courses for Structural Engineering. 52.30% of students are in the second third (4th semester, 5th semester or 6th semester) of their program, 21.90% in the first third (1st semester, 2nd semester or 3rd semester) and 25.80% in the last third of their studies (7th semester, 8th semester or 9th semester).

Figure 6 shows the distribution per academic program of the students, with Architecture students being the majority with 57% and Civil Engineering with 43% of the total of students. It is usually the students of our Architecture program who struggle or lack motivation for Structural Engineering courses taught from the Civil Eng. Department. The professors have adapted their material throughout the year to make it more attractive to these students. Fig. 2 shows an example of simple models used during the sessions to show a certain concept and this has been very well accepted by students. Videos of past sessions are available in the YouTube Channel of the professor and have been very useful during the pandemic terms with online teaching.

When the students moved online, most of the students moved to a different city, usually to their family home and one of the first problems they had to face was the internet available there. Since there was no previous experience on what sort of internet connection is recommended for online teaching, sometimes they used whatever was available at their family home which in some cases was just basic internet for web browsing and email apps.

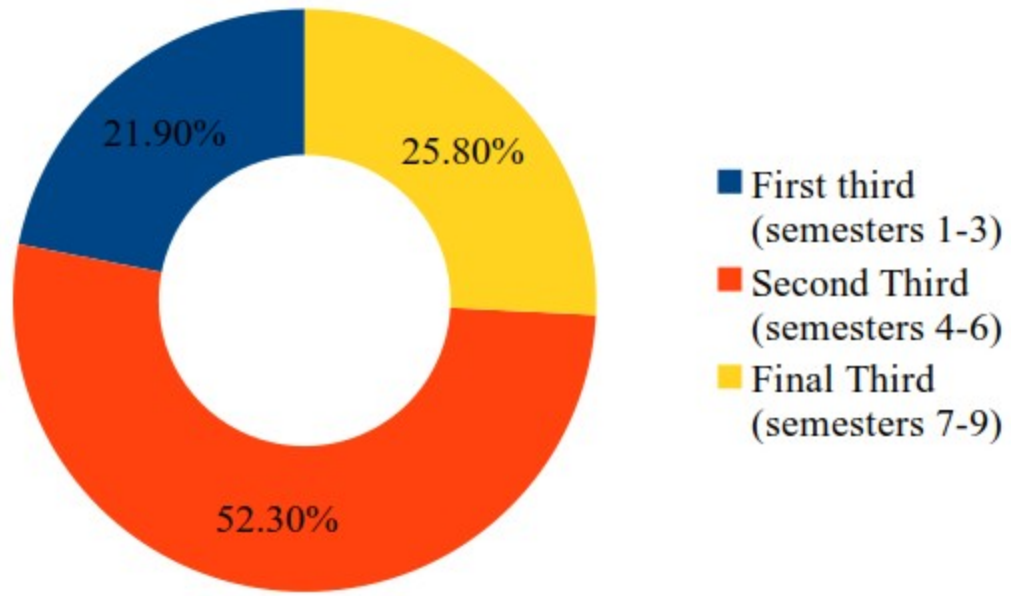


Fig. 5 Distribution of students by their semesters in their programs

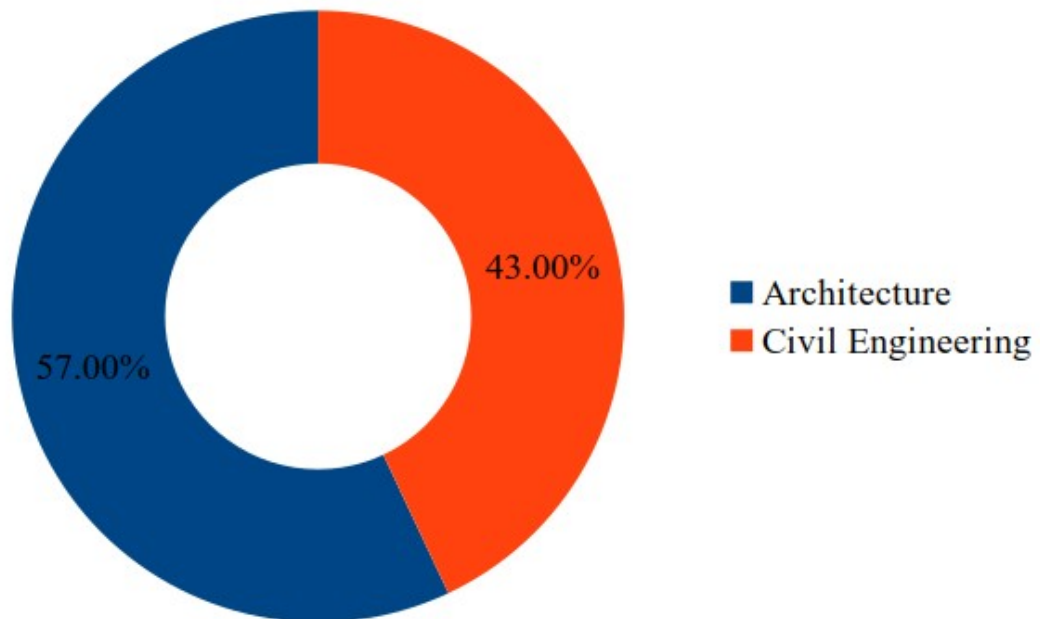


Fig. 6 Distribution of students by academic program

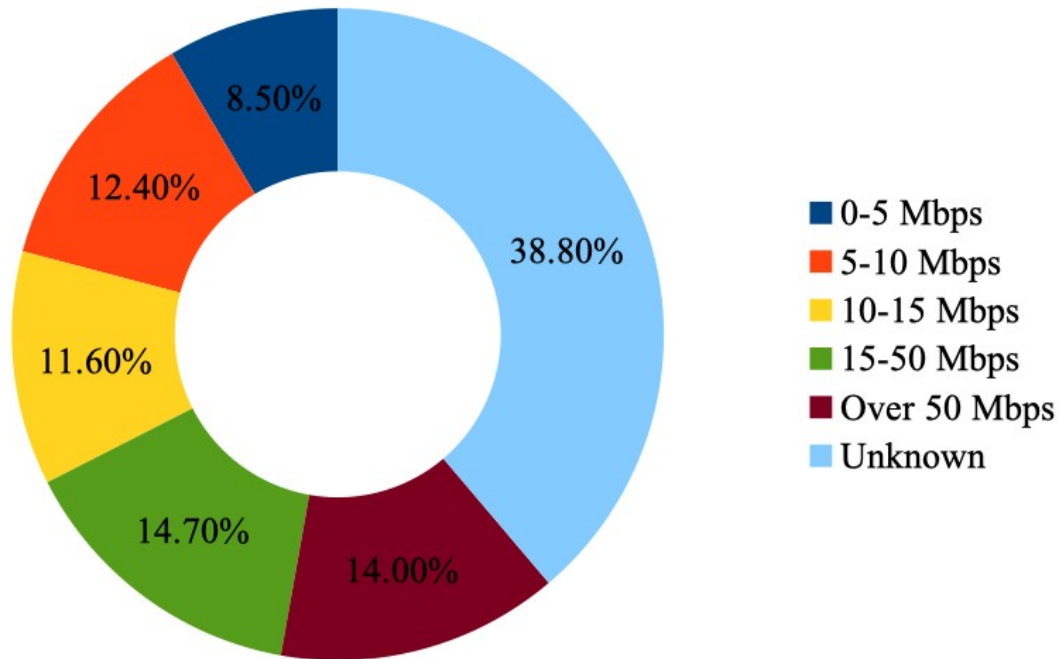


Fig. 7 Internet speeds of the participants.

In some extreme cases, some students moved to locations where broadband was poor. Fig. 7 shows the results on what the students knew about the internet speed at their place of connection. 38.80% did not know their internet connection speed, 14.70% declared to have an internet connection of 15-50 Mbps, 14% with an internet connection over 50 Mbps, 12.40% with an internet connection of 5-10 Mbps, 11.60% had a speed of 10-15 Mbps, and 8.50% with a basic internet speed lower than 5Mbps.

When asked about what they considered to be the main problem of online teaching, 44.10% of students mentioned a lost connection during the sessions. 25.20% mentioned that the main problem of online teaching is the lack of interaction with professors, 15.70% considered that the lack of flexibility in time of online sessions, not being the best time for courses, as shown in Fig. 8. At this point it is important to mention that the timetables were the same for the first semester of 2020 as the beginning of the term that was a normal on campus semester. For the following terms, summer 2020 and fall 2020, the timetables were slightly different, and more options were available to students as some courses were offered from other campuses and students could enroll in them as if they were offered in their local campus. Two of the courses in this study used that format that we call a "National Course" with students from all campuses able to enroll in them, knowing that they would have a class with students from many cities and not their usual friends or classmates from previous semesters.

Main problem faced in online teaching

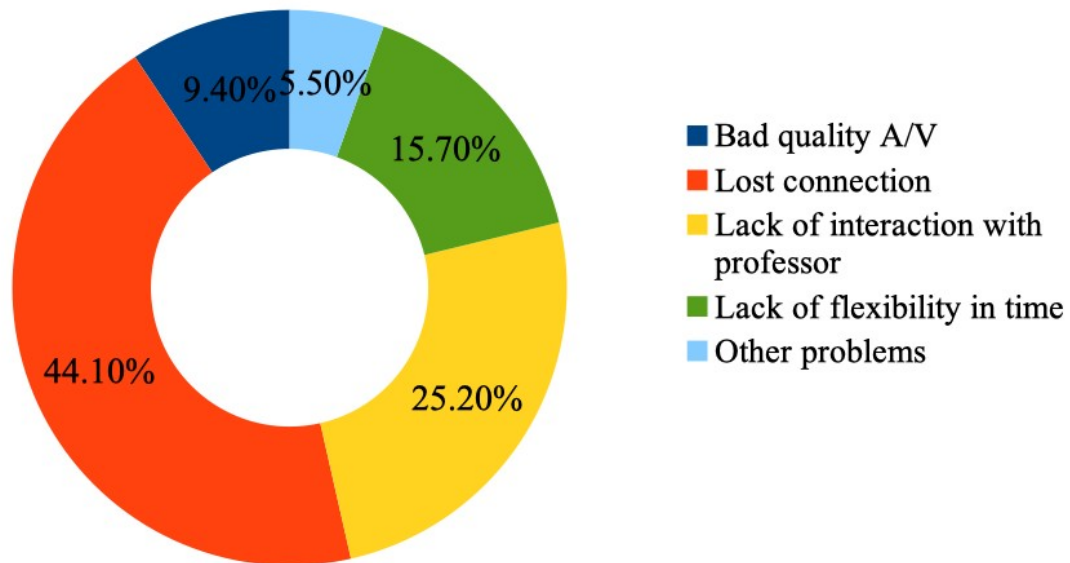


Fig. 8 Main problem faced with online teaching during an online semester.

In the results about the contents of the sessions, a question was asked to students regarding the importance of asynchronous material for online education. Fig. 9 shows the opinion of students about how important is to have asynchronous material such as videos or flipped classes in an online course. 41.67% considered that asynchronous material has a high importance for them, and it should be implemented in more than 75% of courses, 41.67% considered that it has medium importance and perhaps more than 50% of courses should include asynchronous material and only 16.67% thought that asynchronous material has low importance and less than 50% of courses should implement asynchronous material.

When applying our hybrid and flexible model, some sessions were flipped classes, others live lectures or problem-solving sessions. Students were asked about their preferred type of session and Fig. 10 shows the opinion of students. 55.20% of students considered that professors should have a mix of flipped sessions (asynchronous) and live Zoom sessions, 28% preferred the Zoom sessions alone, 16% liked flipped classes the most and 0.8% considered another non-specified type of class as their favorite.

The use of YouTube has already been successfully used for different disciplines [5-14] in situations prior to the Pandemic of Covid19. The authors have used in the past as well as a video repository for this type of courses but now with the pandemic, the YouTube channel has provided an important component for asynchronous material. We consider that any model that is implemented during online teaching should have asynchronous material in the form of flipped classes or more solved examples than those that can be seen in an online session. Students have shown their appreciation of the availability of such material and have expressed their desire to have more courses in this format.

Importance of Asynchronous Material in courses

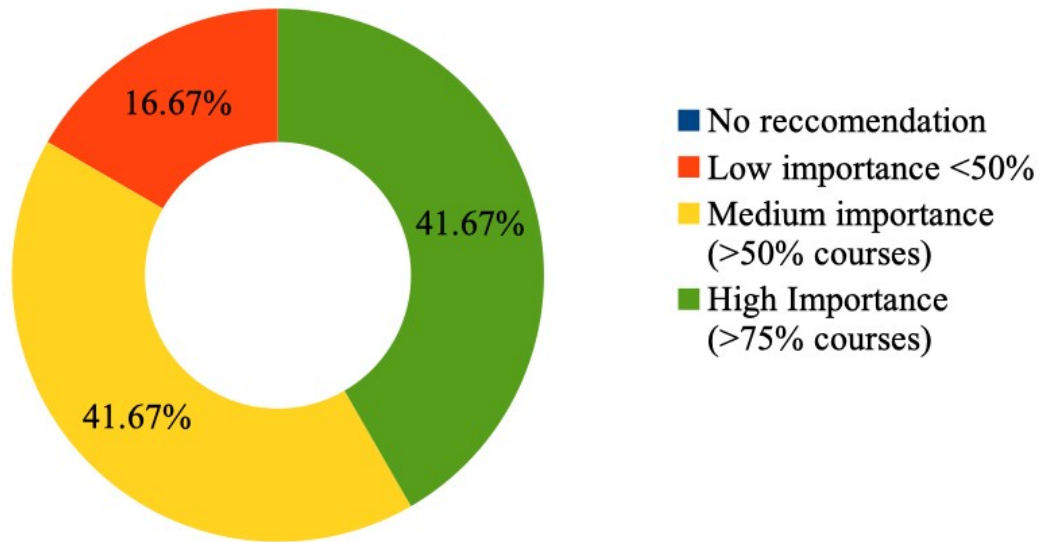


Fig. 9 Importance of having asynchronous material in the courses, according to students.

In Fig. 11 we can see the main factors students mentioned for having a bad experience in some other courses than the ones of this study during online semesters. The two main reasons, with 25% of opinions each are: the professor was not prepared for online teaching and the timetable of the course, followed with 17.90% of opinions mentioning that the professor did not adapt well for online teaching, 14.30% mentioned a lack of empathy from the professor, 7.10% said that they did not have a single bad experience and with 3.60% of opinions for a bad experience was the duration of sessions (too long), too much homework given by professors and some considered that it was a bad experience because it did not allow them to go to campus.

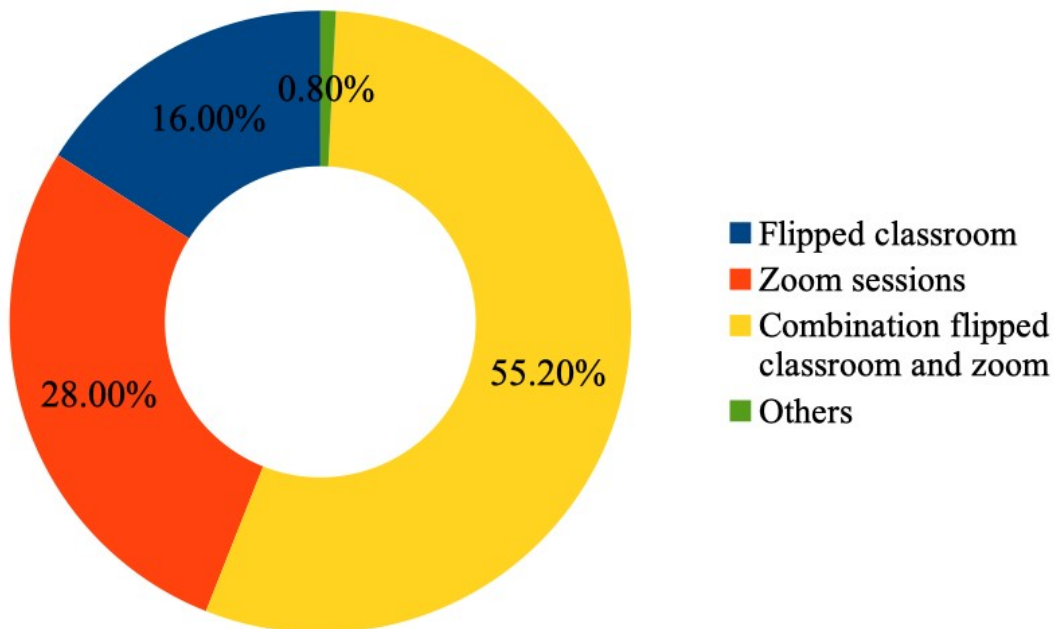


Fig. 10 Type of session preferred by the students

Main factors for bad online experience in other courses

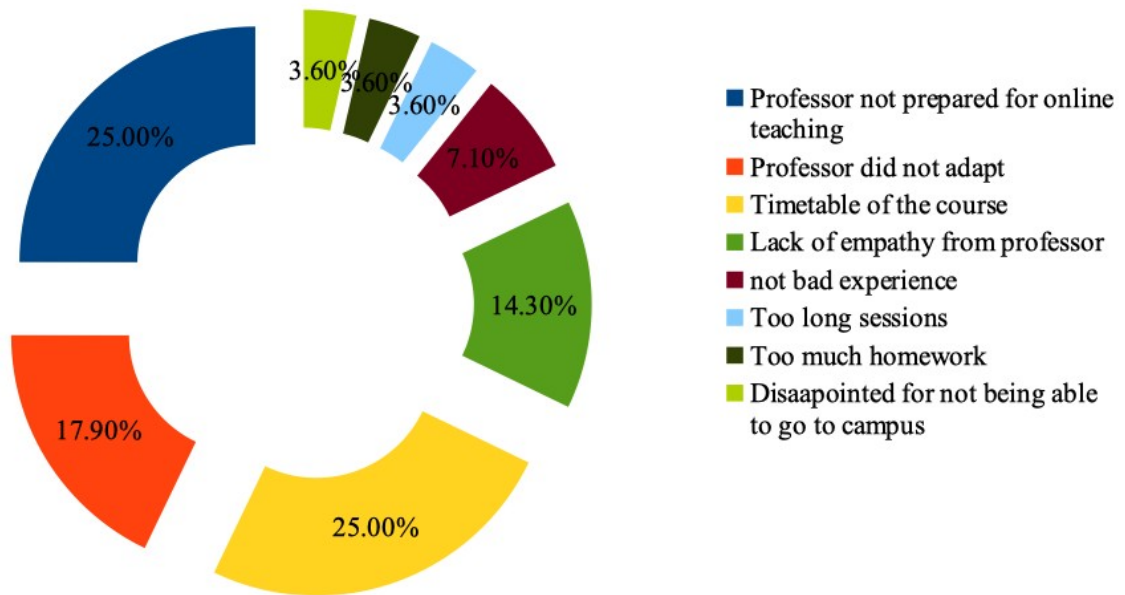


Fig. 11 Main factors causing a bad online experience in other courses

Conclusions

We have presented a Hybrid and Flexible Model that was successfully applied during the 2020 terms and the first term of 2021 in our university for a couple of Structural Mechanics courses. This model can be applied in future terms as humanity starts to go back to the new normality after the Covid19 Pandemic. As the vaccination campaigns are different from one country to another, we expect that still some terms will have a strong component of online teaching during the year 2021 and probably the beginning of 2022 in our country. The results of the survey applied to the students that took the courses analyzed in this paper show that students can perceive when a professor is not well prepared for online teaching. Another important finding is that the duration or length of online sessions is crucial for any successful model. Sometimes professors want to replicate what happens in a lecture room on campus in the virtual classroom and sessions can be tedious for students if the professors do not vary the stimulus to keep students connected. We recommend the use of asynchronous material in the form of per-recorded videos as a way to have more options for all courses taught in an online modality.

Another recommendation that we consider important for future implementations of online teaching is that professors can be taught some basics about video production, in this way, they can appear more fluent in front of a camera. It is also advisable that professors do not replicate the same length of a session as that used on campus, as it is becoming more and more evident that students and professors might experience fatigue from prolonged teaching sessions in an online format.

We expect that online teaching will be an important part of the offer of any School of Engineering and the combination of live sessions with asynchronous material can provide a flexible and hybrid model for students and professors in the new normality.

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