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# THE EFFECTS OF LONG EXPOSURE TO SYNCHRONOUS ONLINE COURSES ON THE COURSE'S ENGAGEMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING STUDENTS DURING THE COVID-19 PANDEMIC

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**Abstract:** After exposure to three semesters of synchronous online courses due to COVID-19 pandemic restrictions, higher education students faced negative effects in terms of motivation. To evaluate the impact of this long exposure to face-to-face online sessions in student's motivation to be present and participate in class, an online survey was applied to Industrial and Systems Engineering students in a private university in Mexico at the end of each semester, beginning with the start of the COVID-19 pandemic and its restrictions preventing face-to-face class sessions. The survey included questions in a Likert scale for quantitative analysis and two open ended questions for qualitative analysis. A Two Sample T-test was conducted to identify significant differences in evaluations after time passed. The evaluations of different aspects, such as students' motivation to participate and be present in class showed a significant reduction between the first two semesters. Some results indicated the professors' ability to adapt the courses. The motivation to attend synchronous online sessions for mixed DFM courses (balancing practice and theory) decreased significantly between the first semester (Spring 2020) and the second semester (Fall 2020). Students' active participation during the mixed-course sessions changed significantly between Spring 2020 and Fall 2020, the latter having less participation. Notably, this demotivation was observed in the synchronous online courses.In qualitative analysis, answers were classified into categories for what student's considered valuable and what not and findings revealed demotivation for other activities that extend students' screen time exposure, such as readings, homework, requiring software and simulators, practices, and online teamwork sessions. This analysis provides recommendations for improving students' engagement, and participation. It considers immediate future scenarios, designing more effective courses for the "new normality" and unforeseen circumstances.

**Keywords**: Higher Education, Educational Innovation, burnout, Education during the pandemic, engagement

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## Introduction

After more than two years since the COVID-19 pandemic's start, some elements in terms of digital education design still require analysis to identify if they can be implemented, improved, or eliminated for similar circumstances, to those provoked by named pandemic. One of those aspects is to investigate the face-to-face, synchronous digital courses that students experienced for several months of confinement and how they affected their motivation and participation.

This idea comes from the fact that the students' attitude changed from the beginning of the confinement as the time passed by. The first weeks after the Covid19 pandemic declaration were very challenging for educational institutions, in the case of Tecnologico de Monterrey it was decided to stop all face to face activities and only one week was given to the academics to adapt their courses into a synchronous online mode. After this adaptation period, classes were delivered by zoom, and the students reacted positively to this change, somehow, they were aware of the teacher's efforts to keep running the semester and not lose the academic year. However, as the pandemic went by, the motivation and behavior of the students changed, until reaching a point where they were reluctant to turn on their cameras, they expressed to feel tired to be many hours in front of the computer and they did not feel enthusiastic to attend the online classes.

During the confinement period, the teachers had to include some activities or interaction moments with their students in order to keep them interested in the online sessions. The activities performed in teams using separate virtual rooms were often used as a strategy to involve students with their classmates and to apply the concepts learned in practical exercises. Other strategies to increase students' motivation were focused on using educational tools or programs that allowed interaction between students and teachers, the use of gamification activities, dedicated media files, and some others.

The main purpose of this research was to analyze which course design elements in an online environment were valued by students and which harmed their motivation and participation. Some findings reveal that new designs must point to inclusion of appropriate elements that allow intensive exposure and deeper interaction between the participants of the Synchronous Online Courses,

## Literature review

The original objective of this study was to identify the most convenient elements to be included in the design of a synchronous online course. Some results might validate the importance of one or more elements, or also, their lack of relevance. However, the context of this analysis was the Covid-19 pandemic confinement, which obligated 100% of the courses to be offered in a synchronous online format. It is essential to identify if some of the results were influenced by this prolonged exposure to the pandemic over three semesters and if they are a consequence of the burnout syndrome, which is defined as a chronic stress that is not correctly managed. During the pandemic, changes in education due to the sudden shift to an online format, could have increased the stress levels in students and the way they performed their academic activities (Mheidly, 2020). Furthermore, online learning led to the development of new roles by the faculty or the students, affecting how courses were designed and the participants' interactions (Coppola et al., 2002).

As the pandemic contingency prolonged schools' physical closures, the research group investigated if the exposure to computer screens for long periods and several months of confinement affected the students' motivation to attend and participate in their digital online courses. Goppert & Pfost (2021) noted some positive changes in university study conditions for students in the summer term of 2020 (after the first wave of the COVID19 pandemic). Some of the positive changes were that students did not have to get up early to get to college, and the recorded lessons gave students more flexibility in managing their time. However, after one and a half years of online courses, conditions might have changed and as the perception of what is valued or not. For example, Bedenlier (2020) mentions that students did not feel comfortable having their webcams on in long synchronous online courses and shut-off cameras tend to generate disconnection and demotivation even among teachers, who end up talking only to a screen where students' emotions and reactions are not displayed. Also, as Lin & Gao (2020) argued, social disconnection affects students' motivation to learn, so in pandemic confinement this was a critical issue to consider.

There are some aspects that professors could do in their classes to promote the student's participation as Fabriz, Mendzheritskaya, and Stehle (2021) conclude, teachers need to make more effort to provide opportunities for students to interact with the learning content and with their professors and peers. Also, Baltá-Salvador, Olmedo-Torre, et al. (2021) mentioned that courses should be revised and adapt them to virtual learning and Malik and Javed (2021) considered that course workload also must be evaluated.

Finally, in a more local context, authors analyzed if there were significant differences in the motivation to participate in face-to-face online sessions between the semesters when the Digital Flexible Model (DFM) was fully implemented. Also, the authors analyzed what elements were valuable to include for students and which should be eliminated or used with moderation in DFM courses. It is noteworthy that this particular model provides flexibility, classes through web conferencing, leverage of technology, and active learning (Tecnologico de Monterrey, n.d).

**Research Objectives**

Since the COVID-19 emergency began, academia was one of the most affected sectors. Schools closed for almost two years, and classes migrated from traditional face-to-face classroom sessions to online sessions where faces appear on screens. This study aims to identify what characteristics of online sessions are appreciated by Industrial Engineering students in a private university in northwestern Mexico after three semesters of taking online synchronous classes in this modality. The information obtained intends to shed light on the best practices in future courses using this modality.

***The specific objectives are:***

Identify any significant differences in students' motivation to be present and participate in a class between the first semester of face-to-face online sessions and the following two semesters.

Identify the characteristics of face-to-face online sessions still valued by students after the online sessions were extended to several semesters.

Propose how to implement the Digital Flexible Model (DFM) proposed by Tecnológico de Monterrey to motivate students to participate in the distance online sessions.

## Methodology

The survey used as the instrument to collect data was designed from a previous research whose objective was to identify the characteristics to be included in DFM courses to motivate and engage students (Resendez-Maqueda, Sandoval-Correa, Forte-Celaya & Swain-Oropeza, 2021). The web survey was applied during the following two semesters, and its results were used to identify differences between motivation levels during the three academic semesters as it was stated in objective 1. After the first semester, two open-ended questions were added in order to obtain information about what elements were considered valuables by students within this course modality, as declared in objective 2.

As all the courses were taught in the DFM modality during the three semesters of this research, there was no control group to compare motivation and participation between face-to-face courses and synchronous online courses. So, we conducted posttest-only, non-experimental design research in the expanded period. The mixed analysis, quantitative methodology used a Likert-scale questionnaire with the qualitative analysis of the open-ended questions to answer the research questions. The web survey measured perception and collected students' opinions; thus, it can be considered social research. We used a non-probabilistic sample convenient for the authors (Trochim, Donnelly, & Arora, 2016). The Industrial and Systems Engineering students were asked to answer 31 questions using a Likert scale, with 5 being the highest score and two open-ended questions. Some of the students might have answered the survey in other courses, and not all of them necessarily answered the survey during the three semesters, as some could have graduated. The analysis at this point did not consider tracking individual students; we obtained the mean of the evaluations of the questionnaire. Also, we considered the course classification and its nature (Resendez-Maqueda, Sandoval-Correa, Forte-Celaya & Swain-Oropeza, 2021), primarily the mixed courses as they were the ones that could be evaluated during three periods.

Since surveys used as the instruments used to collect data were previously studied, validity is assumed. Talking about the test, internal consistency of the questionnaire was evaluated with Cronbach's alpha test. Taherdoost (2016) and Taber (2018) suggest that items of the questionnaire are considered to represent a measure of good internal consistency or reliability if the total of Cronbach’s alpha value was more than 0.7. Table 1 showed the results of Cronbach's alpha test for the data collected. As we can notice, in all cases Cronbach's alpha is greater than 0.7 then could be considered a reliable instrument.

*Table 1: Cronbach’s test*

| Semester | Test | Numerical | Mixed |
|---|---|---|---|
| FJ2020 | Cronbach´s alpha | 0.89 | 0.81 |
| AD2020 | Cronbach´s alpha | 0.91 | 0.91 |
| FJ2021 | Cronbach´s alpha | 0.90 | 0.89 |

The qualitative analysis included the process of listing, sorting, and classifying different opinions. For the question, "What elements do you value the most in a synchronous digital course?" answers were grouped into four main categories or clusters. The names for these categories were a) Participative Activities (class teamwork, breakout rooms, exercises during class, Kahoot, Socrative, etc.); b) Resources Availability (recorded classes, available class material, presentations, etc.); c) Available

Extra Time (no time invested in transport or moving to a different classroom); and d) Academic Commitment (interactions with faculty, faculty follow up, conduction of the class by teachers, etc.).

Similarly, for the question, "What elements should not be present in a synchronous digital course?" The categories or clusters defined were a) Workload (too much time in front of a computer, too much homework etc.), b) Traditional Course Conception (too much information delivered by faculty during each class, sessions without participative activities, etc.), c) Duration (2 or 3 hours of class) and, d) External Entities Interaction (laboratory courses, professional practices with enterprises)

***Data collection***

The web survey was applied at the end of the February-June 2020 (FJ2020), August-December 2020 (AD2020), and February-June 2021 (FJ2021) semesters to Industrial and Systems Engineering (ISE) students. Professors helped researchers apply the survey, asking the students to respond through a request sent via e-mail by the program director. The questionnaire was sent to the students enrolled in each semester's courses. The survey allowed the students to submit answers for different courses. The institutional e-mails were collected automatically, and the submissions were checked to avoid duplicity of answers for one course. The questions evaluated the students' perceptions about elements in their DFM courses, and their opinions about what they appreciated or considered should not be included in this modality. Table 2 indicates the number of respondents.

*Table 2: Number of respondents in each academic semester*

| Semester | Number of Students | Percentage of ISE Population in the semester |
|---|---|---|
| FJ2020 | 89 | 87% |
| AD2020 | 56 | 60% |
| FJ2021 | 33 | 45% |

***Analysis***

For the August-December 2020 and February-June 2021 surveys, we added two open questions to perform qualitative analysis, "What elements do you value the most in a synchronous digital course?" and "What elements should not be present in a synchronous digital course?" To consider the survey results and students' opinions, we decided to perform a qualitative analysis of each open-question response and classify these answers, comparing the percentage of comments in each category for each semester. We focused on a single course for this analysis to have a more reliable comparison point; this course was repeated in AD2020 and FJ2021 with the same professor.

In the statistical analysis, we obtained first the descriptive statistics regardless of course classification and then considered the classification together with course nature. To identify a significant difference between the mean evaluation of the relevant questions for this research in the different semesters (as part of the descriptive statistics) regardless of course classification and nature, we conducted a two-sample t-Test. Table 3 shows the sample in each semester for the questions. Table 4 illustrates the sample of answers considering the course classification.

*Table 3: Question sample in each semester*

| Semester | Total number of answers regardless course classification |
|---|---|
| FJ2020 | 143 |
| AD2020 | 125 |
| FJ2021 | 50 |

*Table 4: Questions sample in each semester considering the course classification*

| Semester | Number of answers for Mixed Courses | Number of answers for Numerical Courses | Number of answers for Theoretical Courses |
|---|---|---|---|
| FJ2020 | 31 | 73 | 39 |
| AD2020 | 94 | 31 | 0 |
| FJ2021 | 50 | 0 | 0 |

The relevant questions for this research were: Q1. I feel motivated to be present in the class session; Q3. I feel motivated to participate and interact in the class session; Q5. My class participation has been more active under the Flexible Digital Model (DFM); Q6. During your class, you often participated voluntarily; Q8. Were there moments/activities in your class that allowed you to interact with your teacher, ask questions, and receive answers? Q10. Were there moments/activities where technology allowed you to express your opinion, discuss, and have a voice in your class? Q11. Activities through technological platforms (Kahoot, Stormboard, Socrative, Padlet, etc.) motivated you to participate more; Q12. Anonymous activities through technological platforms (Menti, Poll Everywhere) motivated you to participate more; Q14. In your class, existed times when technology allowed you to take part and contribute to activities with other classmates? Q15. I actively participated (solving exercises, discussing with colleagues, solving team activities, etc.); and Q29. Do you consider that the teacher correctly adapted the pace and contents of the class considering the group's performance?

For each question, we compared first the semester AD2020 ($\mu_1$) and FJ2020 ($\mu_2$); then AD2020 ($\mu_1$) with FJ2021($\mu 3$). It was considered $\mu x$: population mean of Px considering the semester. We used a 95% confidence level to test the following hypotheses:

1. The average evaluation for each question regardless of the nature of the course doesn't change between the semester AD2020 and the semester FJ2020. (Null hypothesis $H_0$: $\mu_1 - \mu_2 = 0$; Alternative hypothesis $H_1$: $\mu_1 - \mu_2 \neq 0$)

2. The average evaluation for each question regardless of the nature of the course doesn't change between the semester AD2020 and the semester FJ2021 (Null hypothesis $H_0$: $\mu_1 - \mu 3 = 0$; Alternative hypothesis $H_1$: $\mu_1 - \mu 3 \neq 0$)

3. The average evaluation for each question in mixed courses doesn't change between the semester AD2020 and the semester FJ2020. (Null hypothesis $H_0$: $\mu_1 - \mu_2 = 0$; Alternative hypothesis $H_1$: $\mu_1 - \mu_2 \neq 0$)

4. The average evaluation for each question in mixed courses doesn't change between the semester AD2020 and the semester FJ2021 (Null hypothesis $H_0$: $\mu_1 - \mu 3 = 0$; Alternative hypothesis $H_1$: $\mu_1 - \mu 3 \neq 0$)

The results helped identify if the mean evaluation of the students' opinions differed statistically between the semesters and determined if motivation to be present in class is affected as time passed.

Regarding the course classification, only the mixed courses (offering a balance between theory and practice) received answers for all three semesters, so the analysis considering the classification was only conducted for this type of course, following the method described above.

**Results**

The results for qualitative analysis can be seen in Table 5, which shows the percentage of the recurrence of what is more valued by students in a DFM course. In the second semester of the COVID-19 emergency the most valuable aspects for the students were the participative activities included in the courses. Although in the third semester of DFM courses, this category was the most mentioned by students, it decreased in percentage of opinions but increased the opinions about resource availability and the interaction of faculty with students (Academic Commitment).

*Table 5: Percentage of opinions about the students' most valued elements in a DFM course*

| Semester | Participative Activities | Resources Availability | Available extra time | Academic Commitment |
|---|---|---|---|---|
| AD2020 | 67% | 11% | 6% | 17% |
| FJ2021 | 53% | 20% | 6.7% | 20% |

Also, students were asked about what elements shouldn't be present in a DFM course and the results for this question are shown in Table 6. In both semesters, what students didn't like were courses with a traditional design, such as a lecture, increasing significantly in the semester FJ2021. It can also be noticed that high workload and duration of the session had less frequency in FJ2021 if compared with AD2020.

*Table 6: Percentage of students' opinions about the elements that should not be present in a DFM course*

| Semester | High Workload | Traditional course design | Duration | Interaction of external entities |
|---|---|---|---|---|
| AD2020 | 31% | 38% | 25% | 6% |
| FJ2021 | 23% | 54% | 15% | 8% |

For quantitative analysis, descriptive statistics were obtained to see how well the students evaluated each question and the variance between answers.

The results presented in Table7 are regardless of course classification and reflect similar evaluations in the different questions and semesters. It can be noticed that the questions with lower evaluations are Q5, Q6, Q12, and Q29, which refer to motivation to participate actively and voluntarily.

*Table 7: Descriptive Statistics for each question in each semester, regardless of the course classification*

| Variable | Semester | N | N* | Mean | SE Mean | StDev | Variance |
|---|---|---|---|---|---|---|---|
| Q1 | AD2020 | 125 | 0 | 4.3520 | 0.0874 | 0.9776 | 0.9557 |
| | FJ2020 | 143 | 0 | 4.189 | 0.105 | 1.256 | 1.577 |
| | FJ2021 | 50 | 0 | 4.320 | 0.155 | 1.096 | 1.202 |
| Q3 | AD2020 | 125 | 0 | 4.1520 | 0.0991 | 1.1076 | 1.2267 |
| | FJ2020 | 143 | 0 | 4.1538 | 0.0979 | 1.1707 | 1.3705 |
| | FJ2021 | 50 | 0 | 4.220 | 0.160 | 1.130 | 1.277 |
| Q5 | AD2020 | 125 | 0 | 3.304 | 0.121 | 1.351 | 1.826 |
| | FJ2020 | 143 | 0 | 3.385 | 0.118 | 1.409 | 1.985 |
| | FJ2021 | 50 | 0 | 3.560 | 0.200 | 1.417 | 2.007 |
| Q6 | AD2020 | 125 | 0 | 3.520 | 0.116 | 1.299 | 1.687 |
| | FJ2020 | 143 | 0 | 3.909 | 0.102 | 1.221 | 1.492 |
| | FJ2021 | 50 | 0 | 3.740 | 0.176 | 1.242 | 1.543 |
| Q8 | AD2020 | 125 | 0 | 4.7200 | 0.0586 | 0.6550 | 0.4290 |
| | FJ2020 | 143 | 0 | 4.6224 | 0.0664 | 0.7944 | 0.6310 |
| | FJ2021 | 50 | 0 | 4.6800 | 0.0878 | 0.6207 | 0.3853 |
| Q10 | AD2020 | 125 | 0 | 4.5760 | 0.0684 | 0.7648 | 0.5849 |
| | FJ2020 | 143 | 0 | 4.4336 | 0.0863 | 1.0316 | 1.0642 |
| | FJ2021 | 50 | 0 | 4.6600 | 0.0974 | 0.6884 | 0.4739 |
| Q11 | AD2020 | 125 | 0 | 4.216 | 0.101 | 1.133 | 1.284 |
| | FJ2020 | 143 | 0 | 4.2238 | 0.0985 | 1.1774 | 1.3862 |
| | FJ2021 | 50 | 0 | 4.300 | 0.174 | 1.233 | 1.520 |
| Q12 | AD2020 | 125 | 0 | 3.824 | 0.108 | 1.212 | 1.469 |
| | FJ2020 | 143 | 0 | 3.916 | 0.102 | 1.225 | 1.500 |
| | FJ2021 | 50 | 0 | 3.980 | 0.175 | 1.237 | 1.530 |
| Q14 | AD2020 | 125 | 0 | 4.6720 | 0.0689 | 0.7702 | 0.5932 |
| | FJ2020 | 143 | 0 | 4.3077 | 0.0900 | 1.0762 | 1.1582 |
| | FJ2021 | 50 | 0 | 4.600 | 0.118 | 0.833 | 0.694 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Q15 | AD2020 | 125 | 0 | 4.5360 | 0.0750 | 0.8380 | 0.7023 |
| | FJ2020 | 143 | 0 | 4.2448 | 0.0916 | 1.0956 | 1.2002 |
| | FJ2021 | 50 | 0 | 4.6800 | 0.0923 | 0.6528 | 0.4261 |
| Q29 | AD2020 | 125 | 0 | 3.936 | 0.132 | 1.474 | 2.173 |
| | FJ2020 | 143 | 0 | 3.916 | 0.129 | 1.541 | 2.373 |
| | FJ2021 | 50 | 0 | 4.140 | 0.183 | 1.294 | 1.674 |

The two-sample t-test was run to compare the first and second semesters of synchronous online sessions, identify any statistically significant differences, and, if so, whether the evaluation decreased as one semester passed, the results are shown in Table 8.

*Table 8: Results of Two T-Test for each question.*

| **Question** | **AD2020 vs FJ2020** | **AD2020 vs FJ2021** |
|---|---|---|
| **Q1** | 95% CI for Difference<br>(-0.106,0.432), P-Value 0.233<br>Non- significant difference identified | 95% CI for Difference<br>(-0.302,0.366), P-Value 0.850<br>Non- significant difference identified |
| **Q3** | 95% CI for Difference<br>(-0.277,0.273), P-Value 0.989<br>Non- significant difference identified | 95% CI for Difference<br>(-0.436,0.300), P-Value 0.716<br>Non- significant difference identified |
| **Q5** | 95% CI for Difference<br>(-0.414,0.253), P-Value 0.634<br>Non- significant difference identified | 95% CI for Difference<br>(-0.709,0.197), P-Value 0.266<br>Non- significant difference identified |
| **Q6** | 95% CI for Difference<br>(-0.692,0.086), P-Value 0.012<br>Significant difference identified | 95% CI for Difference<br>(-0.644, 0.204), P-Value 0.307<br>Non- significant difference identified |
| **Q8** | 95% CI for Difference<br>(-0.0790,0.2743), P-Value 0.278<br>Non- significant difference identified | 95% CI for Difference<br>(-0.173,0.253), P-Value 0.712<br>Non- significant difference identified |
| **Q10** | 95% CI for Difference<br>(-0.079,0.363), P-Value 0.206<br>Non- significant difference identified | 95% CI for Difference<br>(-0.330,0162), P-Value 0.501<br>Non- significant difference identified |
| **Q11** | 95% CI for Difference<br>(-0.287,0.271), P-Value 0.956<br>Non- significant difference identified | 95% CI for Difference<br>(-0.0468,0.300), P-Value 0.666<br>Non- significant difference identified |
| **Q12** | 95% CI for Difference<br>(-0.559,0.247), P-Value 0.445<br>Non- significant difference identified | 95% CI for Difference<br>(-0.386,0.202), P-Value 0.538<br>Non- significant difference identified |
| **Q14** | 95% CI for Difference<br>(0.141,0.587), P-Value 0.001<br>Significant difference identified | 95% CI for Difference<br>(-0.188,0.332), P-Value 0.586<br>Non- significant difference identified |

| | | |
|---|---|---|
| **Q15** | 95% CI for Difference<br>(0.058,0.524), P-Value 0.015<br>Significant difference identified | 95% CI for Difference<br>(-0.405,0.117), P-Value 0.278<br>Non-significant difference identified |
| **Q29** | 95% CI for Difference<br>(-0.344,0.384), P-Value 0.914<br>Non- significant difference identified | 95% CI for Difference<br>(-0.675,0.267), P-Value 0.394<br>Non- significant difference identified |

It is remarkable that, for Q6, which referred to voluntary participation, a significant difference between the semesters FJ2020 and AD2020 existed, with a lower evaluation of voluntary participation in AD2020 compared to FJ2020; but no significant difference was found between AD2020 and FJ2021.

Although voluntary participation decreased after one semester passed, students recognized that they had opportunities to collaborate, this is the case of Q14. The question evaluated if during class sessions existed moments when, through technology, students could contribute to activities with other classmates and a significant difference between the semesters was identified. AD2020 got a high mean evaluation, compared with FJ2020. This can be explained by the fact that professors took several courses during FJ2020 to improve the way DFM courses were delivered and encouraged them to include more activities that include the use of different technologies to collaborate.

The same behavior happened in Q15. I actively participated (solving exercises, discussing with colleagues, solving team activities, etc.). A significant difference was found between the first and second semester. In this case, the lower evaluation was for the FJ2020 semester versus AD2020.

The other questions or semesters presented no statistically significant differences to report.

Considering the course nature and that mixed courses were evaluated during three periods, we calculated descriptive statistics for mixed courses to assess the students' opinions. Table 9 shows that some evaluations varied more between semesters than the general statistics, considering course classification. Also, the questions with lower evaluations were Q5, Q6, Q12, and Q29.

*Table 9. Descriptive Statistics for each question and semester in mixed courses*

| Variable | Semester | N | N* | Mean | SE Mean | StDev | Variance |
|---|---|---|---|---|---|---|---|
| Q1 | AD2020 | 94 | 0 | 4.277 | 0.101 | 0.977 | 0.955 |
| | FJ2020 | 31 | 0 | 4.839 | 0.105 | 0.583 | 0.340 |
| | FJ2021 | 50 | 0 | 4.320 | 0.155 | 1.096 | 1.202 |
| Q3 | AD2020 | 94 | 0 | 4.074 | 0.112 | 1.090 | 1.188 |
| | FJ2020 | 31 | 0 | 4.710 | 0.106 | 0.588 | 0.346 |
| | FJ2021 | 50 | 0 | 4.220 | 0.160 | 1.130 | 1.277 |
| Q5 | AD2020 | 94 | 0 | 3.181 | 0.131 | 1.270 | 1.612 |
| | FJ2020 | 31 | 0 | 3.968 | 0.220 | 1.224 | 1.499 |
| | FJ2021 | 50 | 0 | 3.560 | 0.200 | 1.417 | 2.007 |
| Q6 | AD2020 | 94 | 0 | 3.362 | 0.126 | 1.217 | 1.481 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | FJ2020 | 31 | 0 | 4.419 | 0.172 | 0.958 | 0.918 |
| | FJ2021 | 50 | 0 | 3.740 | 0.176 | 1.242 | 1.543 |
| Q8 | AD2020 | 94 | 0 | 4.7128 | 0.0687 | 0.6660 | 0.4435 |
| | FJ2020 | 31 | 0 | 4.9677 | 0.0323 | 0.1796 | 0.0323 |
| | FJ2021 | 50 | 0 | 4.6800 | 0.0878 | 0.6207 | 0.3853 |
| Q10 | AD2020 | 94 | 0 | 4.5319 | 0.0810 | 0.7857 | 0.6173 |
| | FJ2020 | 31 | 0 | 4.8710 | 0.0768 | 0.4275 | 0.1828 |
| | FJ2021 | 50 | 0 | 4.6600 | 0.0974 | 0.6884 | 0.4739 |
| Q11 | AD2020 | 94 | 0 | 4.255 | 0.112 | 1.087 | 1.181 |
| | FJ2020 | 31 | 0 | 4.613 | 0.144 | 0.803 | 0.645 |
| | FJ2021 | 50 | 0 | 4.300 | 0.174 | 1.233 | 1.520 |
| Q12 | AD2020 | 94 | 0 | 3.819 | 0.121 | 1.173 | 1.376 |
| | FJ2020 | 31 | 0 | 4.323 | 0.170 | 0.945 | 0.892 |
| | FJ2021 | 50 | 0 | 3.980 | 0.175 | 1.237 | 1.530 |
| Q14 | AD2020 | 94 | 0 | 4.7021 | 0.0738 | 0.7159 | 0.5125 |
| | FJ2020 | 31 | 0 | 4.452 | 0.185 | 1.028 | 1.056 |
| | FJ2021 | 50 | 0 | 4.600 | 0.118 | 0.833 | 0.694 |
| Q15 | AD2020 | 94 | 0 | 4.5319 | 0.0852 | 0.8257 | 0.6818 |
| | FJ2020 | 31 | 0 | 4.742 | 0.113 | 0.631 | 0.398 |
| | FJ2021 | 50 | 0 | 4.6800 | 0.0923 | 0.6528 | 0.4261 |
| Q29 | AD2020 | 94 | 0 | 3.872 | 0.151 | 1.468 | 2.156 |
| | FJ2020 | 31 | 0 | 4.000 | 0.301 | 1.673 | 2.800 |
| | FJ2021 | 50 | 0 | 4.140 | 0.183 | 1.294 | 1.674 |

Also, a two-sample t-test was run to identify if the evaluation for the semesters differed and which semesters differed, in Table 10 it is resumed the results of the test for each question in mixed courses.

*Table 10: Results of Two sample T-Test for each question in mixed courses*

| Question | AD2020 vs FJ2020 | AD2020 vs FJ2021 |
|---|---|---|
| Q1 | 95% CI for Difference<br>(-0.851, -0.273), P-Value 0.000<br>Significant difference identified | 95% CI for Difference<br>(-0.396,0.309), P-Value 0.808<br>Non- significant difference identified |
| Q3 | 95% CI for Difference<br>(-0.941, -0.329), P-Value 0.000<br>Significant difference identified | 95% CI for Difference<br>(-0.436,0.300), P-Value 0.716<br>Non- significant difference identified |

| | | |
|---|---|---|
| Q5 | 95% CI for Difference<br>(-1.303, -0.271), P-Value 0.003<br>Significant difference identified | 95% CI for Difference<br>(-0.837, 0.078), P-Value 0.104<br>Non-significant difference identified |
| Q6 | 95% CI for Difference<br>(-1.483, -0.632), P-Value 0.000<br>Significant difference identified | 95% CI for Difference<br>(-1.533, -0.582), P-Value 0.000<br>Significant difference identified |
| Q8 | 95% CI for Difference<br>(-0.4052, -0.1047), P-Value 0.001<br>Significant difference identified | 95% CI for Difference<br>(-0.192,0.258), P-Value 0.774<br>Non- significant difference identified |
| Q10 | 95% CI for Difference<br>(-0.561, -0.117), P-Value 0.003<br>Significant difference identified | 95% CI for Difference<br>(-0.389, 0.133), P-Value 0.333<br>Non- significant difference identified |
| Q11 | 95% CI for Difference<br>(-0.778, 0.063), P-Value 0.095<br>Non- significant difference identified | 95% CI for Difference<br>(-0.439,0.350), P-Value 0.823<br>Non- significant difference identified |
| Q12 | 95% CI for Difference<br>(-0.963, -0.044), P-Value 0.032<br>Significant difference identified | 95% CI for Difference<br>(-0.574, 0.253), P-Value 0.443<br>Non- significant difference identified |
| Q14 | 95% CI for Difference<br>(-0.079,0.580), P-Value 0.135<br>Non-significant difference identified | 95% CI for Difference<br>(-0.160, 0.365), P-Value 0.443<br>Non- significant difference identified |
| Q15 | 95% CI for Difference<br>(-0.531,0.111), P-Value 0.198<br>Non-significant difference identified | 95% CI for Difference<br>(-0.415, 0.118), P-Value 0.274<br>Non-significant difference identified |
| Q29 | 95% CI for Difference<br>(-0.751,0.496), P-Value 0.686<br>Non- significant difference identified | 95% CI for Difference<br>(-0.675,0.267), P-Value 0.394<br>Non- significant difference identified |

The result for Q1, which refers to motivation to be present in the class session, presented a significant difference: Semester AD2020 had a lower mean compared to FJ2020. For Q3, which asked about motivation to participate and interact in class, AD2020 had a significantly lower evaluation when compared to FJ2020. Also, Q5 presented the same behavior: in FJ2020, the mean was significantly higher than in AD2020.

For Q6, as with the analysis regardless of course classification, we identified a significant difference between the voluntary participation in first and second semester, being higher in FJ2020. Q8 about finding moments to interact with the professor also significantly decreased in the second semester.

Findings about technology allowing students to participate and have a voice in activities (Q10), revealed a significant difference in the evaluation of semester AD2020 compared with FJ2020 which was higher. Also, Q12 about the anonymous activities through technological platforms presented a considerable decrease in the evaluation comparing the first and second semester.

No statistically significant differences were found for the other questions and comparisons between semesters.

**Discussion**

Most of the aspects evaluated on the Likert scale had means higher than 3, implying that their inclusion in the course design was pertinent; however, the evaluations tended to have lower means after the first semester. Is that lower evaluation, the effect of prolonged exposure to synchronous online courses? Or is it simply a failure of the academicians deploying the model?

Prolonged exposure to online courses was not the only element affecting student motivation. In their study, Lin & Gao (2020) concluded that the lack of social interactions during class and isolation affected motivation to learn. It could be associated with decreased voluntary participation and motivation to attend class.

The course had to be adapted to a synchronous online format in our institution. Our findings showed a significant difference between the first semester and the second when referring to students' perceived opportunities to participate and interact in class using technology to solve exercises. In contrast, Baltá-Salvador, Olmedo-Torre, et al. (2021) did not find a significant difference between two semesters in the adaptation of the course and concluded that it is crucial to evaluate how the courses should be adapted to virtual learning to make a real impact on the students. Along the same line, Malik and Javed (2021) mentioned that assessments should include whether the courses are taught and designed to reduce students' academic workload and stress.

The results of our qualitative analysis suggest that some elements must be included in the design of online courses. Although these elements were found during the Covid-19 lockdown, they could be considered post-pandemic. Baltá-Salvador, Olmedo-Torre, et al. (2021) did a study that identified some common elements to those in our study. The main elements considered more valuable by students include online courses with participative activities (exercises during class), resource availability (recorded classes), and academic commitment (faculty follow up and communication), among others.

**Limitations**

The study was conducted with a limited group of Industrial and Systems Engineering students in a private college in Northwestern Mexico. The analysis did not consider tracking the opinions of individual students in a period. Results may differ for different populations considering other program backgrounds or locations. Further studies should be conducted to track the opinions of individuals to identify other behaviors.

When the results show a lower evaluation, for example, in motivational aspects, we should validate whether it is the effect of prolonged exposure to synchronous online courses (caused by the Covid-19 pandemic, in this case) or due to any other discoverable aspects.

## Conclusions

The percentage difference in the qualitative analysis of the students' opinions about the valuable activities to motivate participation in one of the mixed courses is noteworthy (67% in AD2020 and only 53% in FJ2021). Also, the qualitative analysis found that in AD2020, 38% of the comments about what should not be included in a DFM course mentioned the traditional course design of lecture classes, compared to 54% in FJ2021. Students asked for activities designed to collaborate with peers and promote their active participation.

From quantitative analysis, when not considering the course nature, it was identified that in the second semester, voluntary participation decreased, despite the active participation in solving exercises and the times that students identified that they had the opportunity to contribute to activities through technology, which was higher in AD2020. This could indicate the first signs of burnout syndrome, it can be suggested to include more asynchronous activities that don't require to be in front of the screen.

To reach the finest detail in the evaluation results and information availability, we deployed a more detailed approach, particularly for mixed courses (offering a balance of theory and practice). It was found that motivation to be present in the DFM course did not change between semesters when analyzing the results and not considering the course classification. However, when looking at the mixed courses, the motivation decreased significantly. The statistically significant differences in questions about motivation to be present in class and participation occurred between the first and second semesters, but not between the second and the third. Also, mixed courses presented significant differences within the mean evaluation of key moments identified by students that allowed them to interact and participate in class between the first and second semesters. The second semester and third semesters did not show a statistically significant difference.

As shown in the results, the significant differences were found only between the first semester and second semester, suggesting that in the first semester there was some enthusiasm for the change and a new form of delivering the courses, taking advantage of what Goppert & Pfost (2021) illustrated and in the second semester this wasn’t enough, and burnout was coming up.

The questions about the students' motivation decreased and those referring to the course design (for example, moments to participate and the activities designed by the professor that allow students to participate). This opens an opportunity to investigate the effect of a Flexible and Digital Model extended to the professors' behavior.

The significance and implications of the study to education is related to the proper understanding of the relevance of an appropriate amount of time of students' exposure to Synchronous Online Courses. The original objective of this research, pointed to the adequacy of inclusion of important elements to design an effective Synchronous Online Course, however the over exposure to this type of courses, that students lived due to COVID 19 pandemic, added an extra challenge in the conception. New challenges must point to design and inclusion of appropriate elements for an intensive exposure to Synchronous Online Courses, such as the situation described and pushed by the named pandemic.

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