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Effect of the COVID-19 Pandemic on the Sense of Belonging in Higher Education for STEM Students in the United States and Mexico

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Abstract: The COVID-19 pandemic generated worldwide negative effects on college students' stress levels and motivation to learn. This research focuses on the lack of development of a sense of belonging in engineering students due to online classes during the pandemic and possible differences experiencing online classes between students from different contexts and cultures. Data were collected from 88 Mexican and 139 U.S. engineering students during the Spring 2021 semester using ten survey items asking students' perceptions of the effects of taking online courses during the COVID-19 pandemic on their sense of belonging in their major. Quantitative and qualitative analyses were conducted, aiming to determine the effects of taking online classes on students' sense of belonging in engineering. Findings stressed the poor sense of belonging that engineering students may have after taking online classes during the COVID-19 pandemic when they missed opportunities to develop meaningful relationships with their peers and professors due to the lack of good communication. Consequently, students had uncertainties about successful learning during the pandemic in both Mexico and the U.S. Thus, activities such as accessible office hours, study groups, and meetings with mentors and tutors should be promoted to help students recover from the lack of a sense of belonging in the engineering major generated during online classes due to the COVID-19 pandemic.

Keywords: post-pandemic; coronavirus; higher education; engineering students; remote classes; online classes; distance education; information technologies; students' perceptions; educational innovation

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1. Introduction

1.1. Background on the Effects of the COVID-19 Pandemic on Higher Education

Recent research has documented the effects of the COVID-19 pandemic on college students' mental health [1,2], stress levels, and motivation to learn [3]. These studies pinpoint the negative effects stemming from students' experiences in online courses during the pandemic. Prior work has also identified important links between college students' motivation to learn and their sense of belonging within their major and their institution [4]. Current theories about students' sense of belonging indicate that feelings of being connected, accepted, and validated at their universities and within their courses are crucial for their success and persistence in their majors [4–6]. Students' sense of belonging is also affected by institutional and cultural contexts, as well as access to infrastructures such as

reliable internet connections or a comfortable study space, which can vary widely based on geographic location [3].

Different factors could influence students' sense of belonging in their academic community, such as their relationship with their peers [7], instructors, and teaching assistants [8]. These relationships can help students create bonds and support social integration into college [9]. Having good relationships with their peers may also help students feel accepted as a part of their major and develop a stronger sense of belonging within that community [10]. Sense of belonging at the course level has been shown to be a key factor for engineering students in developing their sense of belonging in their major [11], providing evidence of the important role that professors play in facilitating student learning and engagement [12].

The effects of the COVID-19 pandemic on education, particularly the effect of remote classes [13] and how students' emotions and learning experiences could be affected by hybrid courses [14], have also been studied. Likewise, cases are shown where laboratory courses went virtual [15,16] or where gamification was promoted to develop a more welcoming learning environment [17,18]. Another challenge during the online courses during the COVID-19 pandemic was testing, creating difficulties in completing qualitative and quantitative student performance assessments when they were taking supervised exams via digital platforms [19].

1.2. Sense of Belonging

The term belonging is usually used as a self-explanatory concept by social science researchers. The broad range of fields using the term, such as cultural theorists [20], sociologists [21], and education researchers [4], could generate misunderstandings in the current literature due to different interpretations of feelings of belonging. For example, belonging could be used as a synonym for national or ethnic identity [22,23] or an attachment to a particular place, group, or culture [24]. As a result of a lack of a clear, accepted definition of belonging, it is considered a multidimensional term, encompassing citizenship, nationhood, gender, ethnicity, identity, and emotional dimensions [21,25,26]. Additionally, a sense of belonging could be crucial for the social cohesion, loyalty, commitment, political order, and solidarity of people living in a community [27].

For this research, the definition of belonging is oriented more to the personal feelings of familiarity, comfort, security, and emotional attachment in any particular place or community [26]. This definition aims to separate a sense of belonging within a specific social context from the notion of national identity or citizenship that is more related to the geographical location of the individuals. We focus here on students' sense of belonging in their academic environment and how school-related experiences and activities could affect it.

Prior research has found a positive relationship between students' sense of belonging at the course level and their academic motivation [28], as well as between students' sense of belonging and their performance at the course level [7]. The literature suggests that characteristics of the learning environment, such as academic, pedagogical, and social interactions, could foster students' sense of belonging in their courses [29], and interactions between students and their professors could have a positive effect on students' sense of belonging in their college courses [30]. It is, therefore, important to consider how interactions are fostered and supported in academic contexts, as these variables characterize the learning environment that affects students' comfort and emotional security in their courses [31].

The literature suggests that a positive relationship between professors and students can generate a caring environment in which students feel like an essential part of their college community [9], giving them more confidence to communicate their ideas with their professors [32]. Connection with professors and peers may help students feel "at home" when they are on their campus, which ultimately increases their sense of belonging in their majors. Therefore, developing pedagogical strategies that prioritize a welcoming learning environment can facilitate students' management of both the academic and social aspects

of their academic community [9]. Although the sense of belonging in a particular course is not enough to foster students' sense of belonging in their majors [4], a sense of belonging at the course level has been shown to be a key factor for students in developing their sense of belonging in their major [11], which ultimately affects students' persistence and efforts to complete their major [33].

Foundational work on the effects that a low sense of belonging may have on engineering students reveals that these students tend to switch out of science, engineering, technology, and mathematics (STEM) majors [34,35]. Research on the effects of the COVID-19 pandemic on college students has demonstrated decreased motivation [3] and accountability [2], which can ultimately have negative effects on their sense of belonging in their major. Additionally, feeling disconnected from their major and college community could make it more difficult to concentrate, which has been shown to adversely affect students' learning [2]. Hence, there is a need to understand the impact that the transition to online and hybrid learning during the COVID-19 pandemic could have on students' sense of belonging and learning, particularly for students from different countries and cultures.

1.3. Purpose

This research was conducted to address the gap in the literature about how online classes affected students' sense of belonging and learning during the COVID-19 pandemic. Most colleges offered online courses during the COVID-19 pandemic, and these courses were perceived in different ways by students. Developing a better understanding of how online courses affected students' sense of belonging in their major could be of paramount importance to improve the college learning environment once students get back to face-to-face classes. Understanding how students' sense of belonging was affected in learning environments in different countries and cultures could provide insight into the global effects of the transition to online classes due to the COVID-19 pandemic. Therefore, this research addressed the following research questions:

RQ1: In what ways did a transition to online and hybrid courses during the COVID-19 pandemic affect undergraduate engineering students' sense of belonging in their major?

RQ2: How did engineering students' sense of belonging affect their perceptions of learning during the online courses due to the COVID-19 pandemic?

RQ3: In what ways do these effects differ for students in Mexico and the U.S. based on differences in demographics and culture?

2. Materials and Methods

2.1. Participants and Context

Participants in this study were selected from two larger studies focused on exploring the interactions between undergraduate engineering students' motivation, engineering identity, and sense of belonging. These participants were enrolled in engineering majors at two study sites: one private university in the north of Mexico, and one land grant institution in the southeastern U.S. All participants were taking online engineering-related courses during the COVID-19 pandemic, providing the opportunity for research teams to examine the potential effects of taking online courses on a students' sense of belonging.

The participants at both study sites were enrolled in online sophomore (third/fourth semester), junior (fifth/sixth semester), and senior (seventh semester or beyond) undergraduate engineering courses. U.S. participants were all sophomores (third/fourth semester). Participants at the Mexican university were biomedical engineering (BME) majors and were enrolled in courses such as biomedical engineering design, design of digital bioinstrumentation systems, and cardiovascular engineering. Participants at the U.S. university were from nine different engineering majors (Electrical and Computer, Materials Science, Chemical, Environmental, Industrial, Biomedical, Biosystems, Mechanical, and Civil) and were enrolled in undergraduate level courses required for their majors. For example,

civil engineering majors were enrolled in geomatics, mechanics of materials, and senior capstone design.

2.2. Data Collection

Data for this study were collected using ten items from a larger survey about student motivation, engineering identity, and sense of belonging. The survey has been used to explore these factors for mid-year engineering students, with strong evidence of validity and reliability of data collected with the survey of this population [36]. The selected items (listed in Table 1) pertained to students' perceptions of the effects of taking online courses during the COVID-19 pandemic on their sense of belonging in their major. The voluntary survey was distributed online during the Spring semester of 2021. Out of the 302 students in the BME program at the Mexican university, a total of 88 students completed the survey (29% response rate), with 43 identifying as female (49%), 42 identifying as male (47%), and 3 participants who preferred not to answer this question. These numbers reflect the overall gender representation in engineering majors at the Mexican university. From the U.S. university, out of 803 sophomore students invited to complete the survey, 139 responded (17% response rate). Of these, 53 identified as female (38%), 84 identified as male (61%), and 2 preferred not to answer the question about their gender. These numbers reflect an overrepresentation of females at the U.S. university; based on institutional data reported for the Spring 2021 semester across all engineering majors surveyed, 24.8% of students identified as female and 75.2% of students identified as male. For the open-ended survey responses at the U.S. university, we selected the responses of sophomore Biomedical engineering (BME) majors (n = 21; 13 identified as female (62%), 7 as male (33%), and 1 participant who preferred not to answer this question). This subsample of only BME students from the U.S. university allowed for more direct alignment and comparison with the BME participants at the Mexican university.

Table 1. Survey questions related to COVID-19's effect on students' learning experiences.

Survey Question	Response Type
Q1. How has this transition affected your sense of belonging in engineering?	Open-Ended Response
Q2. In what ways are you connecting with each group?—Peers/colleagues, instructors, teaching assistants/mentors, and other engineering groups	Open-Ended Response
Q3. In what ways are you lacking in connection at this time?	Open-Ended Response
Q4. How has this transition affected your learning?	Open-Ended Response
Q5. To what extent has transitioned to online learning affected your sense of belonging in engineering?	Likert-Type Scale
Q6. To what extent are you connecting to your peers/colleagues?	Likert-Type Scale
Q7. To what extent are you connecting to your instructors?	Likert-Type Scale
Q8. To what extent are you connecting to your teaching assistants/mentors?	Likert-Type Scale
Q9. To what extent are you connecting to other engineering groups?	Likert-Type Scale
Q10. To what extent has transitioned to online classes affected your learning?	Likert-Type Scale

The ten COVID-19-related items included four open-ended questions and six Likert-type questions on a scale from zero (no effect/never) to six (major effect/a great deal). These questions (refer to Table 1) were developed based on prior findings of factors affecting students' sense of belonging in engineering (positive learning experiences, interactions with others outside the classroom, and personal connections) [8]. Over half of the questions were focused on students' connections with others because this factor was the most likely to be affected by online learning formats. Other questions were asked about how the transition to online classes affected students' sense of belonging and learning. The survey was presented to participants in English at both universities as the BME students at the Mexican university were required to speak English as a second language. There were slight wording changes between survey items for the two study sites to account for linguistic and cultural differences [37]. The word "colleagues" was used instead of "peers",

"mentors" was used instead of "teaching assistants", and "professors" was used instead of "instructors" on the survey distributed at the Mexican university. All study protocols, for example, informed consent and de-identifying data, were conducted in accordance with the Institutional Review Board at the U.S. university and the principal research office (academic vice chancellor office and the dean's office of the school of engineering and sciences) guidelines at the Mexican university.

2.3. Data Analysis

2.3.1. Quantitative Analysis

A logistic binomial regression model [38] was used to determine which variables significantly affected participants' sense of belonging in their major during the online classes. Aiming to conduct this logistic binomial regression, the data were classified into two different groups according to the participants' level of sense of belonging in engineering depending on their response to the Q5 question ("To what extent has the transition to online learning affected your sense of belonging in engineering?"). Participants reporting a sense of belonging less than or equal to three were classified in the low group, and participants reporting a sense of belonging greater or equal to four were classified in the high group. These two groups (low and high sense of belonging) were used as a binomial dependent variable [39] for running the logistic binomial regression. Six independent variables were considered for the model: X1) connecting to peers/colleagues, X2) connecting to instructors, X3) connecting to teaching assistants/mentors, X4) connecting to other engineering groups, X5) online classes affecting learning, and X6) gender. These six independent variables were considered as possible influential factors in the participants' sense of belonging level according to the previously established theory [7,29,30]. Using these variables, regression models were created for each of the two study sites.

Additionally, odds ratios for all the independent variables of the regression model were calculated manually, using the estimated coefficient "B" as the "x" variable in the equation f(x) = e^x. Odds ratio values larger than one establish a positive relationship between the dependent variable (sense of belonging in engineering) and that particular independent variable, making it more likely that participants report a high sense of belonging if this odds ratio increases. Conversely, odds ratio values less than one establish that that particular independent variable has a negative effect on students' sense of belonging in engineering [40].

A Student's *t*-test [41] was conducted to analyze possible differences between the effect participants perceived on their learning within the low and high level of sense of belonging groups. Effect sizes for these *t*-test results were calculated by taking the difference between the mean of the effect of online classes on students' learning for each group (low and high level of sense of belonging) and dividing it by the standard deviation of the high sense of belonging group (the group with the highest number of participants, $n = 38$). To further analyze the possible correlation between a sense of belonging in engineering and the effects of the transition to online classes affecting learning during the pandemic, both, a linear binomial regression [38,39] and a Pearson correlation test [42] were used to determine if there was a correlation between these two variables. All inferential statistics and models were created using the statistics software R [43].

2.3.2. Qualitative Analysis

Responses to the four open-ended questions (questions Q1–Q4 in Table 1) were analyzed using open coding to enable codes to emerge as close as possible to the words and ideas of the participants [44]. This coding approach draws from constructivist grounded theory [45] to develop findings that accurately reflect the participants' experiences. All responses to these four questions were coded line by line, then the emerging codes for participants were compared side by side to find codes that could be combined into units of meaning [46] for each question. The code book for the final coding pass was developed by the two team members at the Mexican university and was then used by four researchers

(the original two coders and two from the U.S. university) who conducted the qualitative coding of all responses. The researchers collaboratively resolved questions about the interpretation and application of codes. Sharing the codebook and verifying the meaning of each code provided a robust co-construction of the data interpretation between researchers, which established the communicative validity of the analysis [47].

The framework of belonging in academic contexts was used as a lens to guide the coding process and facilitate better analysis of the units of meaning. This framework helped the research team interpret the codes and guided the discussion of the qualitative results to thoroughly answer the research questions. This qualitative data analysis allowed the researchers to ensure procedural validity of the analysis [47], in that all units of meaning appropriately reflected participants' responses and feelings about their sense of belonging in their major and how the online classes affected their learning during the COVID-19 pandemic. Representative comments from the participants were selected to support and fully explain the findings. Most of the participants answered the open-ended questions in English (the second language for participants at the Mexican university), and these comments were quoted without modifications. Responses provided in Spanish were translated into English by the researchers at the Mexican university for the purposes of reporting the findings.

3. Results

3.1. Quantitative Analysis

Participants' responses to the six Likert-type questions are presented in Tables 2 and 3 to facilitate the comparison and analysis of the descriptive statistics.

The binomial regression models were generated with a binomial dependent variable of a low and high sense of belonging in engineering and six independent variables (X1: connecting with peers/colleagues; X2: connecting with instructors; X3: connecting with teaching assistants/mentors; X4: connecting with other engineering groups; X5: transition to online courses affecting learning; and X6: gender) for both study sites. The regression based on responses of participants at the Mexican university was presented as follows: "$\hat{Y} = -0.610 - 0.177X1 - 0.214X2 + 0.286X3 - 0.133X4 + 0.394X5 - 0.529X6$"; while the regression based on responses from participants at the U.S. university was: "$\hat{Y} = -0.593 - 0.051X1 + 0.140X2 + 0.037X3 - 0.229X4 + 0.285X5 - 0.257X6$".

Table 2. The number of responses for each level of the scale (0 no effect/never to 6 major effect/a great deal), and the means of all responses to the Likert-type questions for participants at the Mexican university.

0	1	2	3	4	5	6	Mean
Q5. To what extent has transitioning to online learning affected your sense of belonging in your major?							
5	17	5	12	13	24	12	3.48
Q6. To what extent are you connecting to with your colleagues *?							
2	5	4	19	12	24	22	4.20
Q7. To what extent are you connecting to your professors?							
4	12	16	17	18	17	4	3.13
Q8. To what extent are you connecting to your teaching mentors *?							
16	20	14	20	7	9	2	2.19
Q9. To what extent are you connecting to other engineering groups?							
20	18	16	9	10	7	8	2.27
Q10. To what extent has transitioning to online classes affected your learning?							
2	7	4	13	23	16	23	4.13

* = Note: The words "colleagues" and "mentors" were used on the survey distributed at the Mexican university instead of "peers" and "teaching assistants" (which were used on the survey distributed at the U.S. institution) for linguistic purposes.

Table 3. The number of responses for each level of the scale (0 no effect/never to 6 major effect/a great deal), and the means of all responses to the Likert-type questions for participants at the U.S. university.

0	1	2	3	4	5	6	Mean
Q5. To what extent has transitioning to online learning affected your sense of belonging in your major?							
13	18	9	30	20	25	21	3.36
Q6. To what extent are you connecting to your peers *?							
4	18	20	34	23	23	11	3.25
Q7. To what extent are you connecting to your professors?							
8	44	32	18	14	10	7	2.33
Q8. To what extent are you connecting to your teaching assistants *?							
13	35	25	19	12	11	6	2.32
Q9. To what extent are you connecting to other engineering groups?							
37	23	13	19	8	3	6	1.73
Q10. To what extent has transitioning to online classes affected your learning?							
2	9	13	19	28	29	35	4.14

* = Note: The words "colleagues" and "mentors" were used on the survey distributed at the Mexican university instead of "peers" and "teaching assistants" (which were used on the survey distributed at the U.S. institution) for linguistic purposes.

The graphs of the linear binomial regressions shown in Figure 1 suggest a positive correlation between the effects that online courses had on the participants' sense of belonging and their learning; and the results of the Pearson correlation test showed a highly significant positive correlation between these two factors as well, with *p*-values below 0.01 at both sites with correlation coefficients of 0.323 for the Mexican university participants and 0.386 for the U.S. university participants.

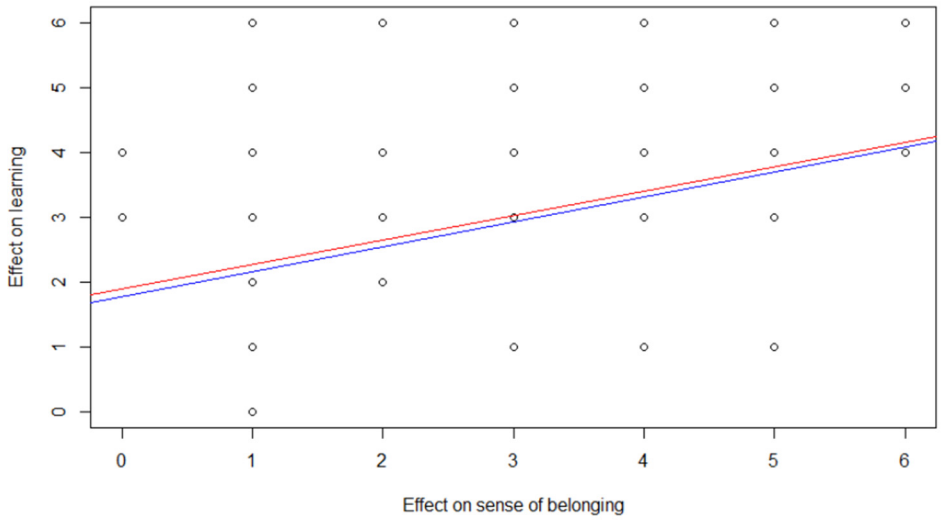

Figure 1. The linear binomial regression of the relationship of the effects that online courses had on participants' sense of belonging and their learning for the Mexican university participants (blue) and 0.386 for the U.S. university participants (red).

The results of the logistic binomial regression are presented in Tables 4 and 5 for participants at the Mexican and U.S. universities, respectively. These results show that, of all the independent variables in the model, only the students' perceptions of the effects of the transition to online classes on their learning were a significant predictor of participants' sense of belonging being low or high.

Table 4. The logistic binomial regression results showing predictors of a sense of belonging in engineering for participants at the Mexican university.

Independent Variables	B	SE	*p*-Value	Odds Ratio
Connection with colleagues	−0.177	0.192	NS	0.837
Connection with professors	−0.214	0.231	NS	0.807
Connection with mentors	0.286	0.215	NS	1.331
Connection with other BME groups	−0.133	0.161	NS	0.875
Online classes affecting learning	0.394	0.152	0.009 **	1.482
Gender	0.529	0.488	NS	1.697

B = estimated coefficient; SE = standard error; NS = not significant; ** = highly significant.

Table 5. The logistic binomial regression results showing predictors of a sense of belonging in engineering for participants at the U.S. university.

Independent Variables	B	SE	*p*-Value	Odds Ratio
Connection with colleagues	−0.051	0.152	NS	0.950
Connection with professors	0.140	0.167	NS	1.150
Connection with mentors	0.037	0.145	NS	1.038
Connection with other BME groups	−0.229	0.155	NS	0.795
Online courses affecting learning	0.285	0.150	NS	1.330
Gender	−0.258	0.226	NS	0.773

B = estimated coefficient; SE = standard error; NS = Not Significant.

The results of the *t*-test comparing the extent to which students' learning was affected during the transition to online courses (Q4, see Table 1) based on students' sense of belonging in engineering (low or high) are shown in Table 6.

Table 6. The comparison of students' mean of their perceptions of how much their learning was affected by the transition to online classes for the high and low sense of belonging groups.

Study Site	High Sense of Belonging in Engineering	Low Sense of Belonging in Engineering	*p*-Value	Effect Sizes
Mexico	3.641	4.53	0.0127	0.871
U.S.	3.7	4.615	0.0008	0.818

The *t*-test results and effect sizes (see Table 6), which indicate the extent to which a significant difference is likely to indicate a true difference between means [48], show that students' perceptions that their learning was affected by the transition to online classes were significantly different between students with a high and low sense of belonging.

3.2. Qualitative Analysis

The coding of responses to the four open-ended questions, presented in Tables 7–9, show the nature of the challenges students faced due to the transition to online classes during the pandemic. These tables also include the frequency with which each code appeared in students' responses at the two study sites. Note that the sum of the percentages in each table is larger than 100% because some of the participant responses were co-coded with more than one code.

Table 7. Codes that emerged from responses to Q1, "How has this transition affected your sense of belonging in engineering?" for participants at the two study sites.

Codes	Mexican University (*n* = 88)	U.S. University * (*n* = 18)
1-Difficulty with peer relationships	43%	86%
2-Lack of practice time	30%	0%
3-No effect due to coping mechanisms	17%	15%
4-Questioning sense of belonging in engineering	25%	0%
5-Difficulty with teacher-student relationship	19%	0%
6-Leveling learning opportunities	24%	0%

* Not all U.S. participants responded to all open-ended survey questions; therefore, there is a difference in the number of participants for each question in Tables 7–9.

Table 8. Codes that emerged from responses to Q3, "In what ways are you lacking in connection at this time?" for participants at the two study sites.

Codes	Mexican University (*n* = 88)	U.S. University * (*n* = 19)
1-Difficulty with personal interactions with peers and professors	66%	68%
2-Difficulty with the development of new academic and friendly connections	39%	21%
3-Decreasing motivation to speak and express opinions	40%	5%
4-Facilitating academic performance	20%	5%

* Not all U.S. participants responded to all open-ended survey questions; therefore, there is a difference in the number of participants for each question in Tables 7–9.

Table 9. Codes that emerged from responses to Q4, "How has this transition affected your learning?" for participants at the two study sites.

Codes	Mexican University (*n* = 88)	U.S. University * (*n* = 21)
1-Promoting self-learning activities	7%	24%
2-Distractions affecting focus on classes	26%	38%
3-Feeling discouraged and tired due to online classes	26%	32%
4-Missing practice opportunities	27%	0%
5-Lacking peer discussions and significant learning opportunities	18%	14%

* Not all U.S. participants responded to all open-ended survey questions; therefore, there is a difference in the number of participants for each question in Tables 7–9.

The results presented in Table 7 show that students experienced difficulties developing new peer relationships while taking online classes during the pandemic. Students noted the difference between how they are used to interacting with peers and online interactions, for example in this quote from a participant at the Mexican university: "This transition has affected due to the lack of interaction with my peers, which is not the same as online interaction". Students also noted the challenge of developing relationships: "Since I had no biomedical courses before COVID-19, I haven't really met most of my engineering colleagues" (a participant from the Mexican university). Students from the U.S. shared similar responses, such as: "I cannot physically see the struggles and successes that my fellow BMEs are going through. It is more difficult to lean on one another when we are doing remote learning". Participants at the Mexican university reported that missing time

in laboratories to put into practice what they learned limited the extent to which they feel part of the BME community, as shown in these quotes from participants: "The physical separation from everything that I was hoping to do, especially laboratory practices, have definitely had a toll on that feeling" and "I don't like online classes because this career is very practical". In contrast, students from the U.S. university did not report such effects, with responses like, "The BME department has done an excellent job reaching out and making me feel connected". Another result from Table 7 is that participants from the Mexican university mentioned that the online courses leveled some learning opportunities, giving a certain type of students the confidence to participate in class and seek help if they struggled to understand any topic. These comments about leveling the learning opportunities were not mentioned by the U.S. university participants, suggesting that Mexican students were the only ones that perceived that the online environment helped them to overcome feelings of anxiety to express their ideas in front of all their peers with comments such as: "Ironically I feel I have spoken to more classmates since I add them in WhatsApp, and since I am shy, online is easier".

Participant responses to Q2 ("In what ways are you connecting with each group?") showed a clear difference between how participants connect with their peers, professors, and other BME groups. Connection with their peers and BME groups was often through the use of social media platforms (Facebook, Twitter, etc.) and texting applications such as WhatsApp. They reported using email and meetings in video conference platforms (such as Zoom) to connect with their professors and mentors.

When asked about their challenges in connecting with different groups, most students at both study sites reported difficulties developing meaningful personal interactions with their peers and professors (refer to Table 8). Example quotes from participants at the Mexican university include, "There is a lack of trust or comfort between our classmates because we really don't know each other", and "Almost no time is dedicated to communicating, also it feels awkward most of the time". Similar responses came from participants at the U.S. university: "The fact that we can't come together as a community to physically help one another through things like study groups, review sessions, and just learning together". Developing new academic and professional connections was also challenging despite having enough technology to communicate with other BME groups and professors. For example: "I don't generally feel much of an incentive to enter into other BME groups despite me knowing that I'd benefit from doing so" or "I think there needs to be more dialogue between professors and students about how the pandemic is affecting our personal/academic lives". Note that fewer participants at the U.S. university identified a decrease in motivation to express their opinions than those at the Mexican university.

One of the biggest issues identified by participants at both study sites as affecting their learning was the distractions that they experienced at home. This issue was reflected in comments such as, "I think that since you are at home there are many things that can interrupt you, even when you have a personal space and a settled time", (Mexican university participant) and "It is a lot harder to focus, and it is stressful to make sure your Wi-Fi and technology are always working" (U.S. university participant). Similar to participants' thoughts about how their sense of belonging was affected by the transition to online classes, participants at the Mexican university felt that they were lacking practice to better understand what they were doing in their engineering course with comments such as: "I'm not learning any technical topics relating to the application of engineering" or "I believe that having to take practical classes online has definitely affected the amount of knowledge I got". Students also mentioned that they were feeling discouraged or tired due to their online classes, with responses such as: "I have learned almost nothing and struggle to have any motivation to learn new topics" (U.S. university participant).

4. Discussion

4.1. Insights on Student Experiences in the Context of the University in Mexico

In response to RQ1 (In what ways did a transition to online and hybrid courses during the COVID-19 pandemic affect undergraduate engineering students' sense of belonging in their major?), quantitative results showed that most students felt that the transition to online classes affected their sense of belonging in their major, with a mean of 3.5 out of 6. This widespread affectation coincides with the study done by Skliarova et al. [49], where college-level students stated that they preferred face-to-face classes instead of remote classes due to the difficulty of the transition due to COVID-19. As shown in Table 2, the most common response to the question about the extent to which transitioning to online classes affected their sense of belonging in BME was 5 out of 6, with 24 students reporting that their sense of belonging in engineering was significantly affected by the transition to online courses during the pandemic (refer to Table 2). These results support other findings that transitioning to online classes negatively affected students' feelings about their major and the way they perceive their academic community [8]. This may be related to the significant correlation between the effects that online courses had on participants' sense of belonging and their learning due to the COVID-19 pandemic as shown in Figure 1. This correlation supports other studies showing that students who feel less connected with their academic environment and community are more likely to struggle to learn new topics about their major, affecting their sense of belonging and ability development [7]. Engineering educators should be aware that some of their post-pandemic students may be struggling to keep track of their course material due to their poor development of a sense of belonging and a lack of identification with their academic community [29,30]. This could ultimately negatively affect their learning abilities and interest in making an extra effort to perform better in their college courses [33].

These findings are supported by the logistic binomial regression results as shown in Table 4. The only significant predictor for a high negative effect on participants' sense of belonging in engineering was the variable "online classes affecting learning". This correlation was highly significant, and the odds ratio showed that an incremental increase in the perception that online courses affected students' learning made them 1.48 times more likely to feel a lower sense of belonging in their major. The qualitative analysis of the question "how has this transition affected your sense of belonging in engineering?" provided more insight into why engineering students felt that online courses affected their connection with their academic community. The most common response to this question, as shown in Table 7, was that online classes created challenges in forming and maintaining peer relationships. This finding suggests that friendly and cooperative relationships with other students are an essential part of developing a sense of belonging in engineering and missing these connections can be an important factor in a lack of connection with a student's major [9,10,50]. These findings may be especially related to this cohort of students, many of whom have never met their peers in person at the time of this study. Another notable factor in the lack of a sense of belonging in engineering was the lack of practice time in laboratories and theory demonstration in class, with 30% of the engineering students reporting these feelings (refer to Table 7). These findings make it clear that students consider laboratory practice and hands-on activities to be important parts of their engineering training. Lacking this practice makes students believe they are missing basic knowledge about their major and feel like they do not belong to the engineering community. This issue could be partly due to the fact that this generation of students belongs to an educational system that prioritizes teaching based on acquiring competencies, as is reported according to the research trends in education innovation in the world [51].

The analysis of the responses to questions about how well they were connecting with others (Q6–Q9 in Table 1) showed that participants' connection with their peers was the least affected during online classes compared to connections with other groups. Findings of the qualitative analysis of the question "In what ways are you connecting with each group?—Peers, Instructors, TAs, Other engineering groups" suggest that engineering

students found a way to keep in touch with their peers, primarily via WhatsApp groups. However, the qualitative analysis of responses about what participants were lacking in connection, as shown in Table 8, reveals that this connection between peers was not necessarily effective, with 66% of participants reporting difficulties in developing personal relationships with their peers and professors. Moreover, most students felt that they were in communication with strangers, making learning and discussions of different ideas less likely to happen. Although challenges in communication due to technology were not an issue among participants, the goal of connecting with their peers was only to complete a specific task or assignment. Relationship development and learning can be affected by this lack of meaningful connection [10,32]. Concerning the aforementioned effect, using information and communications technology (ICT) to form links between people has been shown to have a positive effect on promoting and engaging a remote network of participation for teaching and learning through the citizen science approach [52].

Similarly, students' interactions with possible role models were affected due to the transition to online classes, with relatively low mean scores for connection with professors, mentors, and other engineering groups as shown in Table 2. According to the responses to the question "In what ways are you connecting with each group?—Peers, Instructors, Mentors, Other engineering groups", students mentioned email and social media as an easy way to communicate with their professors, mentors, and other engineering groups. The issue was that this way of communication created a disconnection between them and these important groups of their academic community, generating doubts about their sense of belonging in the engineering community [12,30]. The qualitative analysis of the question "In what ways are you lacking in connection at this time?" showed that a majority of engineering students experienced difficulties in effectively connecting with their friends and professors, as shown in Table 8, with many participants mentioning that these difficulties negatively affected their motivation to speak and express their opinions in class.

For engineering educators to maximize student learning and their relationships with their students, they need to address the lack of connection students perceive in online classes [13]. This issue could be addressed by designing activities that promote more confidence and open new ways of connecting between students and professors, mentors, and other professional engineering groups, aiming to compensate for possible experiences of ineffective connection during the COVID-19 pandemic [3]. These could include the use of online discussion boards, small breakout groups in online meetings, or having students create brief presentations of the course content asynchronously (i.e., outside of class time).

In response to the RQ2 (How did engineering students' sense of belonging affect their perceptions of learning during the online courses due to the COVID-19 pandemic?), students perceived that their learning was affected during the transition to online classes during the pandemic, as shown in Table 2 and Figure 1. These results highlight the importance of developing strategies to help engineering students improve their prior knowledge post-pandemic. These new strategies would need to help students to develop a stronger sense of community and better relationships with their peers, professors, and mentors as well. This way, both engineering students' sense of belonging and learning could be improved in parallel [5,6], as the findings of this research suggest a strong correlation between these two factors.

The analysis of participants' responses to the question on how the transition to online classes affected their learning (refer to Table 9) revealed the detrimental effect of distractions students experience in their homes, with 26% of participants reporting such challenges affecting their ability to stay focused on their academic activities. These findings suggest professors should be prepared for students having difficulties focusing for long periods of time during online classes. This could be exacerbated by reports that students usually multitask during online courses [14]. Another important issue that students perceived as negatively affecting their learning was the lack of practice time in labs and hands-on

activities. Students feeling less prepared due to the lack of opportunities to put into practice what they have learned in their online classes could have long-lasting effects [15,16].

4.2. Insights on Student Experiences in the Context of the University in the Southeastern U.S.

Further analysis of RQ1 (In what ways did a transition to online and hybrid courses during the COVID-19 pandemic affect undergraduate engineering students' sense of belonging in their major?) helped determine that the majority of participants at the university in the U.S. stated that the transition to online learning has had a relatively high impact on their sense of belonging in engineering. In a similar study, students reported a consistently negative impact of the transition to online and hybrid learning on their sense of belonging in engineering [8]. The correlation shown in Figure 1 highlights the implications of this negative impact; for an incremental increase in the student-identified effect on their learning, the impact on their sense of belonging in engineering is amplified based on an odds ratio greater than one.

Although students provided neutral responses to the Likert-type question about the extent to which they connected with peers, many participants' open-ended responses indicated that connection was lacking for them during the pandemic. There is an observed interrelatedness between students' diminished connection with peers, for any amount of diminished connection with peers, and a small decrease in the sense of belongingness. Although statistical significance was not observed in the U.S. data for this relationship, it is still noteworthy as it tells us that the amount in which students interact with colleagues may have bearing on their sense of belonging, but not to an amplified degree.

Interrelatedness between students' lack of connection with professors and their sense of belonging showed that for an observed drop in connection with professors, there was an amplified observable deterioration in the sense of belonging. This demonstrates that there are opportunities for increased connection between instructors, teaching assistants, and students so capitalizing on this opportunity would likely yield an overall higher sense of belonging in engineering.

The relatively low response to the question about connecting with other engineering groups is an indication that students are not branching out and forming new relationships with others outside the structure of their courses. Perhaps a contributor to this low response value was the ambiguity of the term "other groups".

Freeman et al.'s study of the sense of belonging in first-year college students supports the idea that a sense of belonging relates to student learning [4]. Some students reported relying on technology, such as social media platforms, to connect with other students and groups. Upper-level students reported feeling more connected to engineering groups than FYE students. This difference may be because they have had time to build connections and join clubs, study groups, professional organizations, etc. The online transition having less effect on upper-level students' learning may be because there are more project-based courses in senior courses, such as capstone, compared to FYE and sophomore courses, which tend to be more lecture-based.

4.3. Mexican and U.S. Students

In response to the RQ3 (In what ways do these effects differ for students in Mexico and the U.S. based on differences in demographics and culture?), participants at both study sites perceived their sense of belonging in engineering as being affected by the transition to online learning in a similar way, which suggests that the negative effects experienced by engineering students during the COVID-19 pandemic transcend geographic locations. This is important because economically advantaged countries, such as the U.S., might be considered as being better prepared to offer online courses than developing countries, such as Mexico, due to their advanced infrastructure and telecommunication technology [3]. Our study shows that any technological advantages, whether real or perceived, did not help U.S. students feel more connected with their academic community than their Mexican counterparts. Students from both countries experienced issues adapting to online classes

during the pandemic and most of them struggled to develop a sense of belonging in their major. Insight into how participants connected with their peers and professors during online classes (Tables 2 and 3) supports the idea that the U.S. infrastructure may have provided an advantage, as Mexican participants reported more issues connecting with their peers than the U.S. participants. It is interesting to note that these connection issues did not generate a difference between the participants' sense of belonging in engineering at the two study sites.

Our quantitative analyses showed that learning and a sense of belonging are significantly correlated in both the Mexican and U.S. contexts. This correlation needs to be further investigated to determine possible causality aiming to understand the role of online classes in this correlation and to examine if the correlation exists for other populations in different contexts. Regardless of whether courses are delivered online, knowing more about students' sense of belonging could help engineering educators develop strategies to make students feel welcome and comfortable in their academic community, which ultimately could help them to improve their learning experiences [7,27,28]. This may be particularly relevant in the Mexican context since participants' perceptions that online courses affected their learning was the only significant predictor of a lack of sense of belonging in engineering.

The finding that participants classified as having a low sense of belonging in their major reported a significantly higher negative effect on their learning than those classified as having a high level of sense of belonging was similar for participants in both study sites. This provides further support for the idea that promoting a more welcoming environment in classes and better ways of connecting with other students and professors could help develop a stronger sense of belonging [26], which ultimately could improve students' learning experiences and interest in engineering majors [29].

The biggest issue participants identified with the online classes was the lack of face-to-face communication, which affected students' relationships with their peers and was reflected in a low sense of belonging in engineering. The majority of participants in both study sites reported that online classes affected their sense of belonging and that they experienced difficulties developing meaningful relationships with their peers. These findings pinpoint the importance that having a positive relationship with their peers has on engineering students' sense of belonging [30]. Since U.S. students' relationships with their peers were affected in a significant way, U.S. professors and educators need to pay special attention to this issue and try to promote more face-to-face activities that could help their students to feel like they are in a community where they can talk about their life and academic experiences and learn from each other [25]. Lacking meaningful connection affected the way that engineering students interacted with their academic community, and even if the students had the opportunity to establish a telecommunication window with their professors and peers, the main goal of communicating ideas, doubts, or personal feelings was not achieved as it was in face-to-face communication [8].

One of the most important goals of all academic activities is students' learning, and according to these research findings, engineering students' learning was negatively affected by the transition to online courses due to the COVID-19 pandemic. The U.S. students' response to Q10 was the highest mean of all the six Likert-type questions, and it was the second highest for the Mexican students. Figure 2 shows how students' sense of belonging in engineering was affected due to the remote classes during the COVID-19 pandemic. A series of problems related to communication limitations and telecommunications and information technologies infrastructure deficiencies deteriorated students' learning experiences; consequently, this issue affected the sense of belonging in the students toward engineering majors.

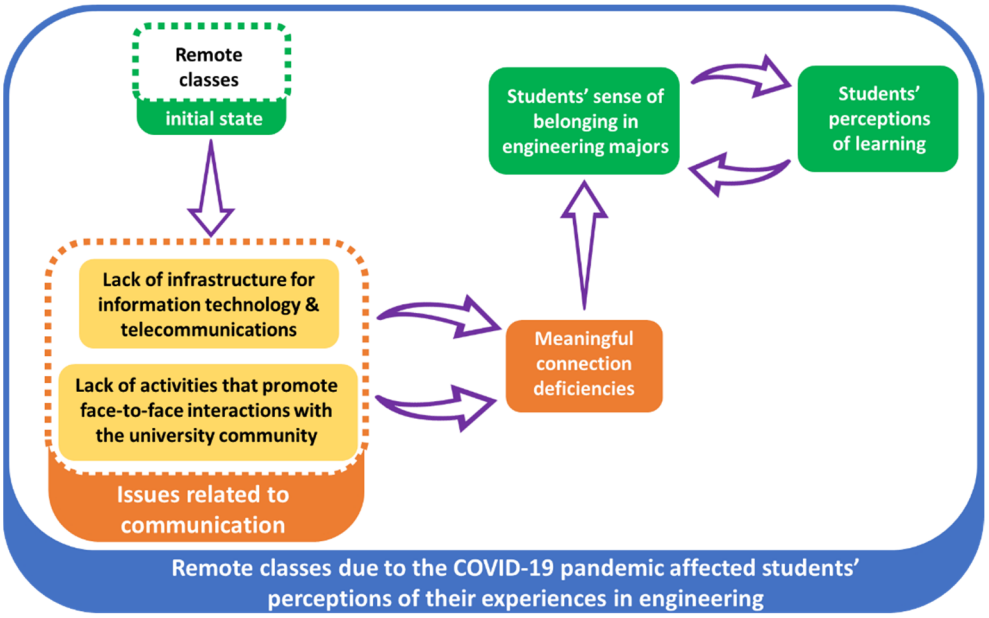

Figure 2. Online courses' effect on engineering students' sense of belonging and learning.

Further analysis of the qualitative responses helped us to better understand the reasons why engineering students felt that online courses affected their learning, and what kind of factors were similar or different between students in Mexico and the U.S. Both Mexican and U.S. participants reported that having to spend many hours in front of a screen was tiring, and that made them feel discouraged to get involved in class activities, making learning new topics a challenging task [9]. Similarly, students were easily distracted by their home environment and lack a special place to concentrate on their classes. This issue affected their ability to focus on their class material and ultimately hindered students' learning. It is important to note that the U.S. participants reported struggling with this issue more than the Mexican participants, and further research needs to be conducted to analyze the reasons for this lack of focus when the environment is not what it used to be in regular classes for the U.S. students. Knowing more about the reasons why students are easily distracted when they are alone in their homes, instead of in their classroom where they could be distracted by any of their peers, could be of paramount importance if universities want to establish online courses in the future.

The online classes had a different effect on Mexican and U.S. participants' learning and academic behavior, creating a greater interest in self-regulated learning activities for the U.S. participants and motivating them to search for knowledge by their own means. This positive effect of online courses needs to be promoted by U.S. professors, even when they return to face-to-face classes [13]. On the other hand, Mexican participants were less motivated to look for self-regulated learning opportunities, and Mexican professors need to develop teaching strategies where students have to take more responsibility for their learning in case their connection with their peers and professors is jeopardized again. Another difference between the Mexican and U.S. participants was that the Mexican participants reported that missing practice opportunities in their engineering courses was the main reason for their difficulties learning during the online classes, while none of the U.S. participants mentioned this lack of practice opportunities as an issue affecting their learning experiences. This finding suggests that U.S. universities may be well prepared to conduct online practices and labs, making students feel like they are getting that practice experience, while this could be a limitation for Mexican universities [3]. As practice is important to engineering students, Mexican universities need to work harder to improve online practice opportunities and labs if they are interested in online courses in the future.

4.4. Limitations and Future Works

This research compared two populations from different countries and cultures, creating a challenge in selecting the right students to compare their experiences during online classes due to the COVID-19 pandemic. This issue generated a mismatch between the two study populations in terms of student levels, with U.S. participants taking courses in their sophomore year, while Mexican participants were taking courses in their sophomore, junior, and senior years. Students' experiences and sense of belonging development could be different between students in their second year and students in upper-level courses, and more information about these possible differences needs to be analyzed in future research. An additional limitation in terms of context is that the data collected for this study were from students at single institutions for each country, which could generate possible differences from students in other contexts and majors. A limitation of the data collection is that, although the validity and reliability of data collected through close-ended survey questions were established in previous studies [36], students' interpretations of open-ended survey questions related to COVID were not verified; these questions were developed based on the emerging literature, not on how students themselves described their experiences. This could be addressed in future studies by interviewing students about how they interpreted open-ended survey questions.

4.5. Future Work

Future research about students' sense of belonging during online classes should include an analysis of telecommunications technology availability and how these variables could ameliorate the lack of meaningful communication and connection development. In addition, it would be interesting to incorporate other populations in different universities and majors with the aim of creating a deeper understanding of students' sense of belonging development during online classes. Likewise, it is pertinent to consider conducting more studies from a longitudinal perspective in order to observe the long-term effects on engineering professionals that graduated after experiencing online classes during the COVID-19 pandemic.

5. Conclusions

Engineering educators need to be aware of the importance of generating a positive learning environment in their classes and academic activities with the aim of developing their students' sense of belonging in engineering. Helping students to identify with and feel connected to their peers, professors, mentors, and other engineering groups could help them feel motivated to be involved in more engineering-related activities that could help them perform better in their classes and successfully complete their assignments. The findings of this research stressed the poor sense of belonging that engineering students may have after taking online classes during the COVID-19 pandemic when they missed opportunities to develop meaningful relationships with their peers and professors due to the lack of good connection with these key pieces of the engineering academic community. These findings were very similar in the Mexican and U.S. universities, showing that telecommunication infrastructure is not enough to recreate a learning environment where students can feel connected and develop a sense of belonging with their academic community. Additionally, regarding the lack of connecting opportunities with the academic community, Mexican participants reported a poor sense of belonging development because they felt that they lost important opportunities to practice what they learned after missing lab practices and hands-on activities. This issue was not reported by U.S. participants, suggesting that good telecommunications infrastructure and well-equipped labs could be excellent tools if engineering programs want to go fully online in the future.

Most of these issues affecting engineering students during classes delivered online disappeared when students returned to campus, but the lack of the development of students' sense of belonging and possible misunderstandings generated by the two years of online courses should be addressed by engineering educators. Activities such as more ac-

cessible office hours, study groups, and meetings with mentors and tutors should be highly promoted to help students recover from any academic and motivational struggles that may have been generated during the online classes due to the COVID-19 pandemic. Failing to develop a well-connected environment that aims to foster engineering students' sense of belonging could have a negative effect on their learning and performance since this study found a significant correlation between students' sense of belonging and their learning.

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