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Evaluating Students' Attitudes Towards Synchronous Remote Course Delivery: An Analysis of Engineering Programs during the COVID-19 Pandemic in the US and EU

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Abstract

The COVID-19 pandemic necessitated an expedited adaptation of engineering higher education programs to remote teaching and learning. However, little is understood about attitudes towards such remote teaching initiatives, including its perceived advantages and disadvantages and its effect on the ability to acquire knowledge and succeed academically, ability to adapt to changing or complex circumstances, and quality of student-to-student interactions, among other things. Many engineering students continue to work while receiving their degrees, revealing emerging student needs related to remote learning, such as by reducing or eliminating commute time to campus and its associated environmental impact and financial costs. Using a survey design, a study was conducted to evaluate students' experiences with and perceptions of the remote-synchronous course delivery method during the COVID-19 pandemic across multiple programs, including engineering and architecture, at two universities, one in the US and one in the EU. This paper provides an assessment of a selection of these experiences and perceptions by program type, program level, and institution. A non-parametric statistical analysis is conducted with ordinal variables using SPSS-based data analysis. At the institutional level, some variation in learning experiences for MSU Denver and University of Pécs students is found. While the results suggest no significant differences in students' level of motivation or the perception of remote labs as being successfully conducted between the MSU Denver and the University of Pécs, the students at University of Pécs did generally place greater importance of student-to-student interactions for positive learning outcomes than MSU Denver students. At the program level, aggregating both institutions, no significant differences between undergraduate and graduate students' experiences were found for any of the measured outcomes. The findings provide evidence-based recommendations for departments considering different course delivery methods. The results suggest that student perception can be improved by increasing the effectiveness of remote laboratories and by providing opportunities for student-to-student interactions in the remote learning environment. These recommendations seek to increase the resilience of engineering education by enhancing its preparedness for natural disasters, pandemics, energy crises, wars, or other unexpected circumstances.

Keywords: engineering education, remote learning, survey

1. Introduction

The COVID-19 pandemic necessitated an expedited adaptation of engineering higher education programs to alternatives to the in-person classroom, usually by adopting some form of online teaching and learning. There are three main types of online-learning environments: synchronous, asynchronous, and hybrid. In the synchronous online environment, instructional activities are facilitated online at regularly scheduled times through live videoconference-based meeting technology. There are no location-specific requirements, however it requires real-time access to the respective technology and internet. In contrast, in the asynchronous online environment, no real-time internet access is required since there are no scheduled meeting times. The hybrid

environment is a blend of the synchronous or asynchronous online environment and the in-person classroom environment. There are location-specific requirements and access to internet and the respective videoconferencing technology is required.

Synchronous remote teaching and learning appears to resemble the in-person classroom environment most closely. A synchronous remote classroom using videoconferencing software and corresponding hardware technology makes it possible for faculty and students to interact and collaborate in real-time on learning and engage with the class [1], [2], [3]. However, little is understood about student attitudes towards such remote teaching initiatives. Recent research seeks to better understand the perceived advantages and disadvantages of remote teaching and learning and its effect on the ability to acquire knowledge and succeed academically, ability to adapt to changing or complex circumstances, and quality of student-to-student interactions, among other things [4], [5], [6], [7].

This paper contributes to this effort by evaluating certain experiences with the remote-synchronous course delivery method from the student perspective across multiple programs at two universities, one in the US and one in the EU.

2. Description

A study using a survey design was conducted to evaluate student experiences with and perceptions of the remote-synchronous course delivery method during the COVID-19 pandemic across programs in engineering (civil, computer, electrical, environmental, and sustainable systems), architecture, and construction project management, at two universities, MSU Denver and University of Pécs. The composition of the responding students by major is shown in Figure 1.

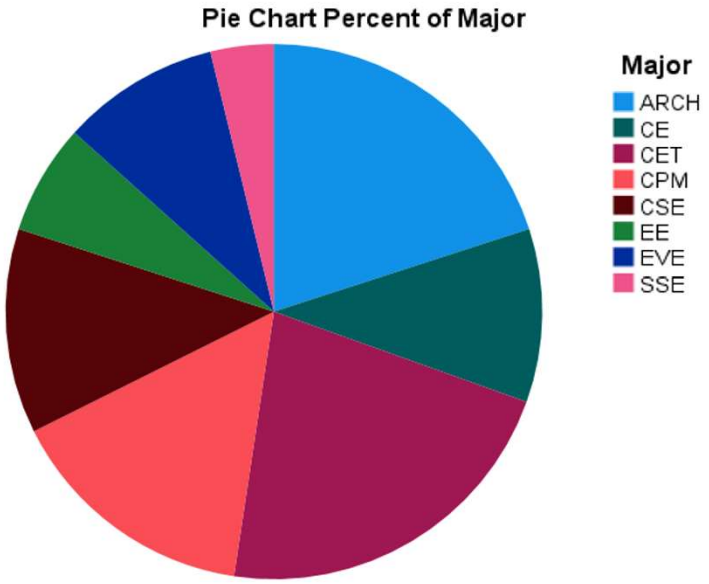


Figure 1. Respondents by major

In this paper, the outcomes pertaining to three of the study's survey questions are presented and evaluated. The three questions were selected to offer insight into the perception and experiences of students with respect to motivation, laboratory classes, and student-to-student interactions in learning, respectively.

3. Methods

A non-parametric statistical analysis is performed with ordinal variables using SPSS data analysis by IBM [8]. To draw conclusions on the distributions of the independent samples, hypothesis testing by the Mann-Whitney U test method is used. The independent categorical variables are groups such as the institution, program type, and program level, as shown in Figure 2, while the dependent ordinal variables are samples consisting of the responses to each of the three questions, with responses based on a five-point Likert scale, as summarized in Table 1.

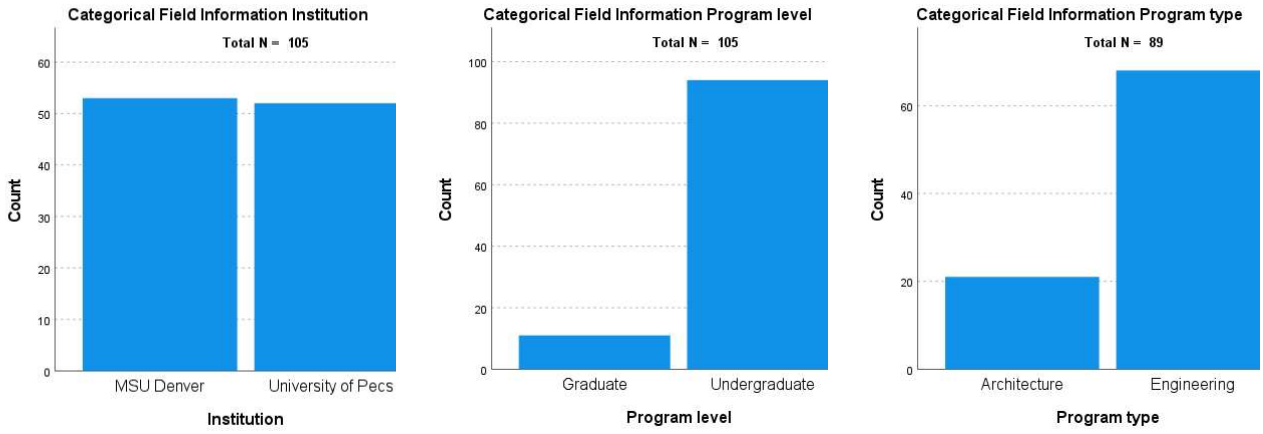


Figure 2. Independent variables: categorical field information

Table 1. Dependent variables

Question summary	Response scale
• Extent motivation is affected • Extent remote labs are successfully conducted • Extent knowledge-sharing among student is important	1- Not at all 2- Slightly 3- Moderately 4- Strongly (very) 5- Extremely

4. Survey results

A summary of the collected data is presented in bar-chart format showing comparatively (as percentages) the distribution of the responses to each question grouped by each independent category. Figure 3 compares the distribution of MSU Denver and University of Pécs engineering students' responses to each question. Figure 4 compares the distribution of architecture and engineering students' responses to each question. Figure 5 compares the distribution of graduate and undergraduate students' responses to each question. Finally, Figure 6 compares the distribution of construction project management and engineering students' responses on the importance of knowledge-sharing among students.

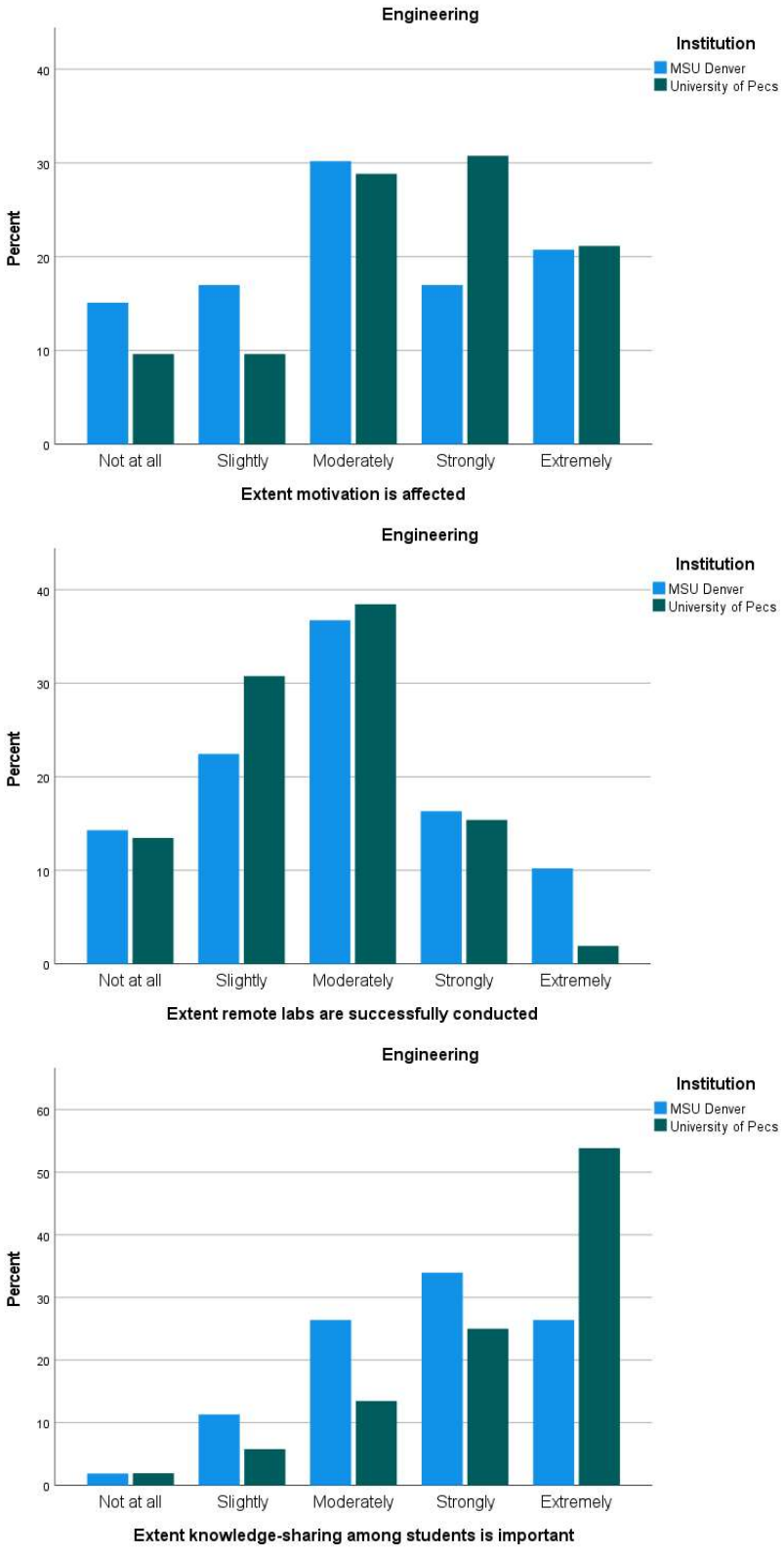


Figure 3. Distributions of engineering student responses by institution

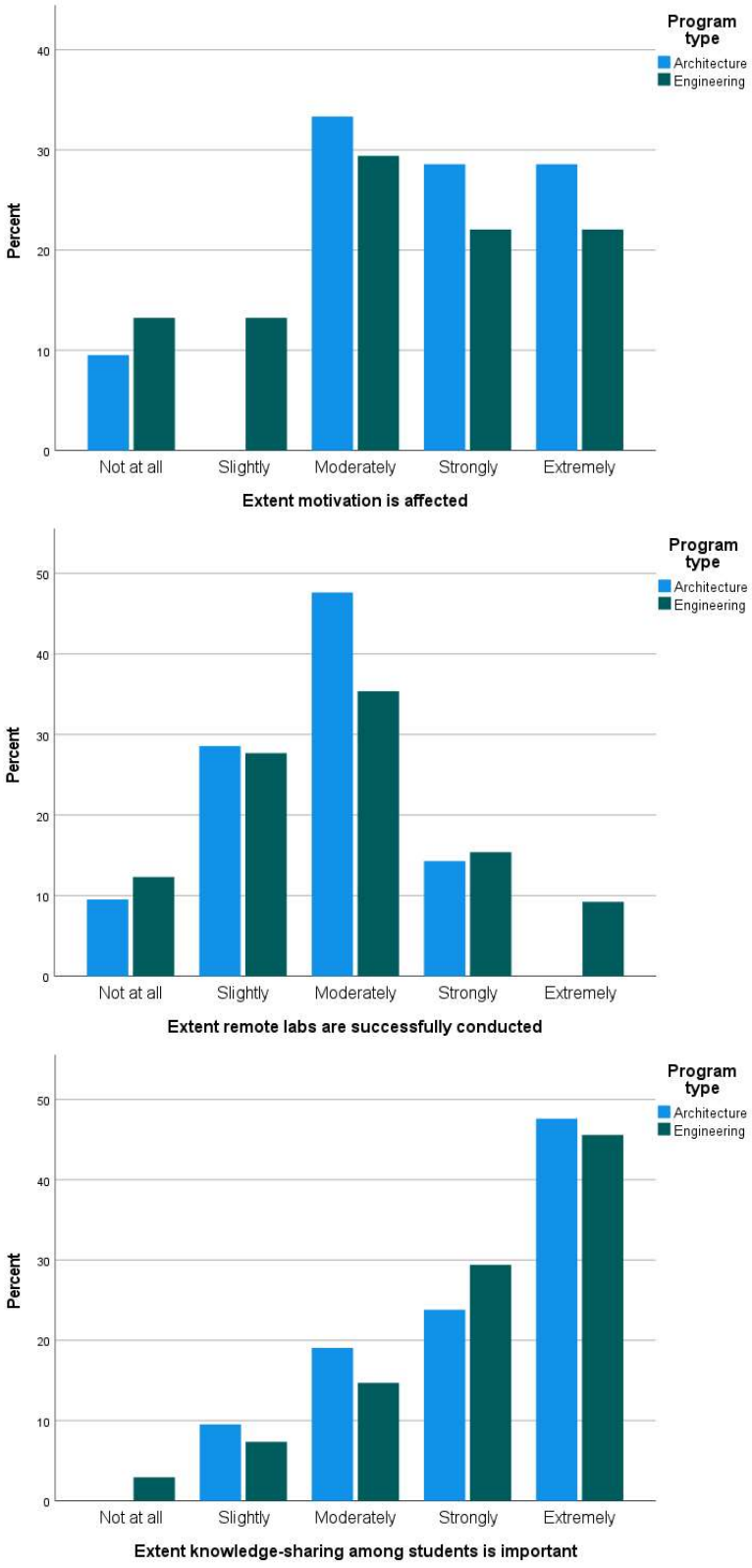


Figure 4. Distributions of student responses by program type

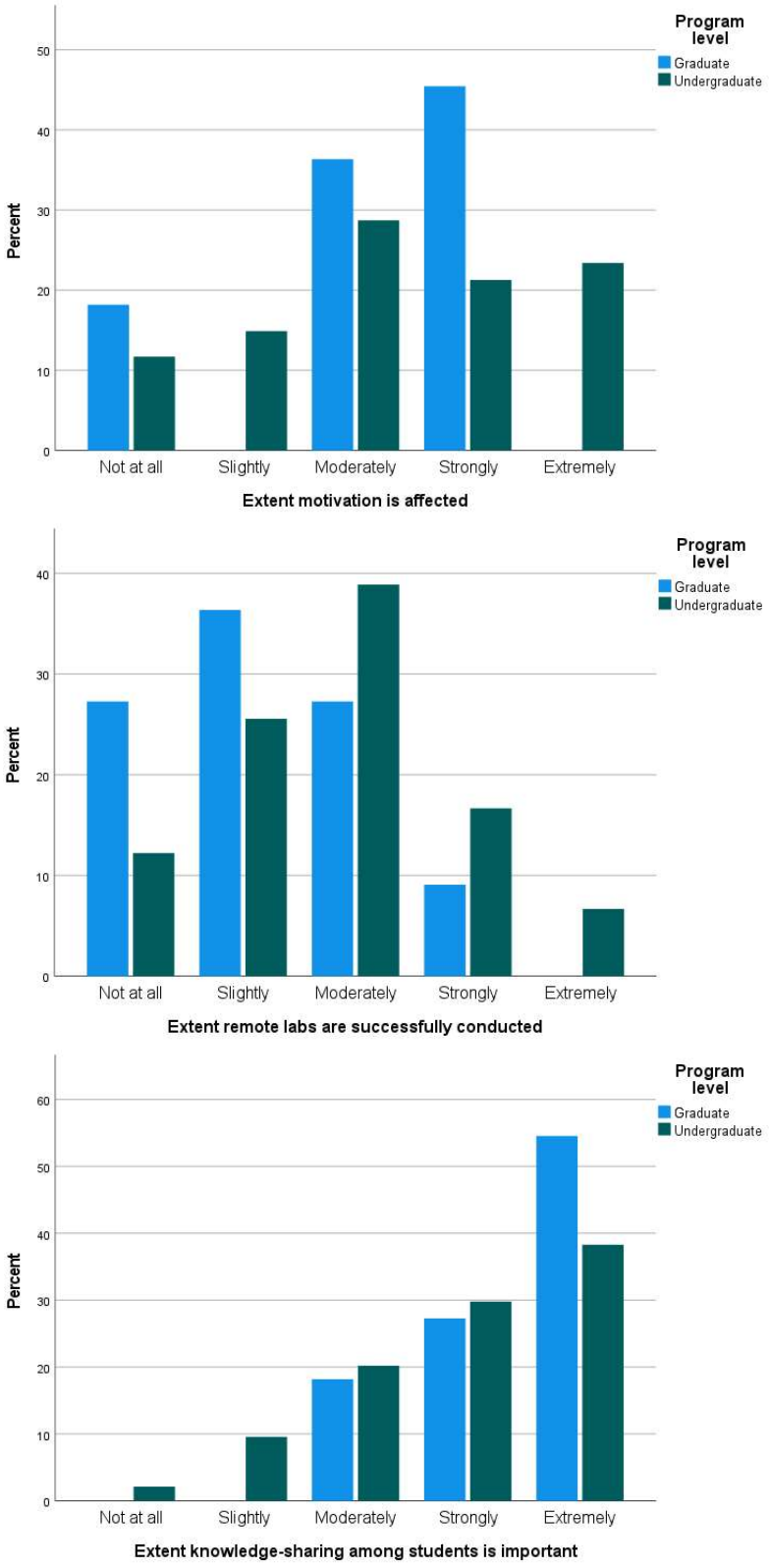


Figure 5. Distributions of student responses by program level

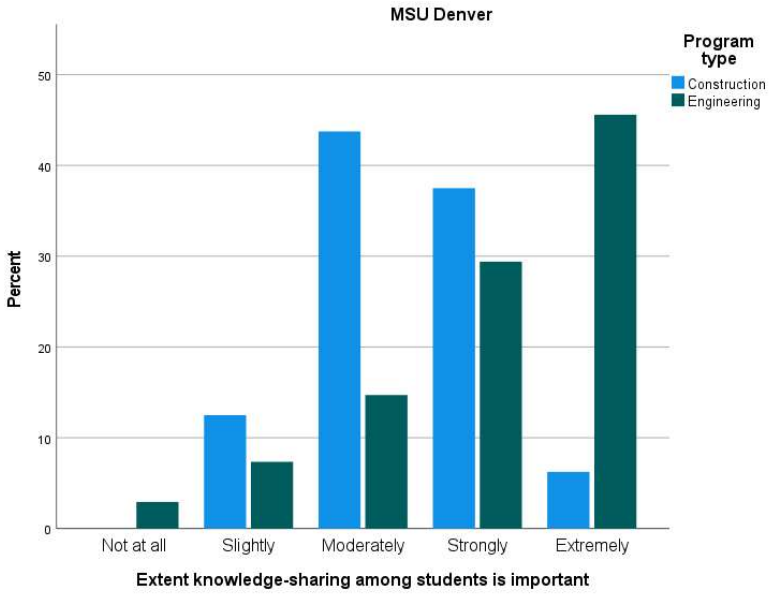


Figure 6. Distributions of student responses for construction and engineering programs

5. Findings and discussion

By analyzing the results using the Mann-Whitney U test method, the survey provides insight into students' experience with and perceptions of remote learning during COVID-19 by institution, program type, and program level.

Regarding the level of student motivation, as shown in Figure 7, the survey results suggest that there were no significant differences across institutions in the way in which COVID-19 affected student motivation. As expected, we observe that most students felt that their motivation was either moderately, strongly, or extremely affected, with a statistically significant similarity in the distribution of responses. Likewise, when comparing architecture and engineering program students, see Figure 8, COVID-19 affected motivation similarly. When comparing graduate and undergraduate programs at MSU Denver and University of Pécs, see Figure 9, motivation was affected similarly for graduate and undergraduate students.

Regarding the conduction of remote labs, as shown in Figure 10, we can also conclude that there were no significant differences across institutions in the perception of how successfully remote labs were conducted. The majority of students from both MSU Denver and University of Pécs reported remoted labs as being slightly or moderately successfully conducted, with the overall pooled distribution of both institutions is positively skewed. This suggests a somewhat less favorable view of how remote labs were conducted that is consistent across institutions. Moreover, when looking at the program type and program level, see Figure 11, and Figure 12, respectively, graduate and undergraduate, and architecture and engineering students, respectively, did not have statistically significant differences in their attitudes towards the quality of remote labs.

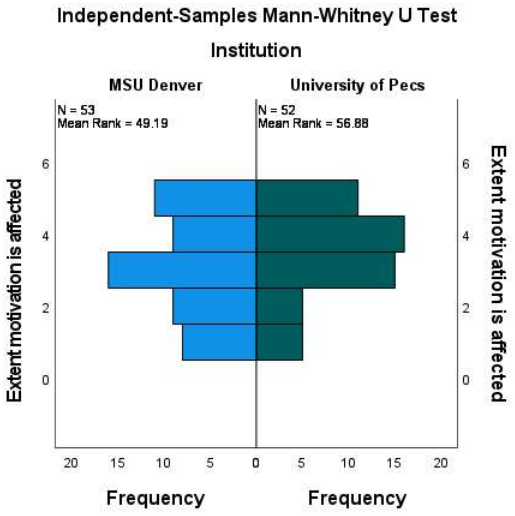
In all the categorical groups, the distribution of the responses to the extent to which remote labs were successfully conducted is positively skewed, such that there was a larger percentage of students that viewed remote labs as only being slightly successfully conducted or not at all successfully conducted than students who viewed remote labs as being strongly (very) or extremely successfully conducted.

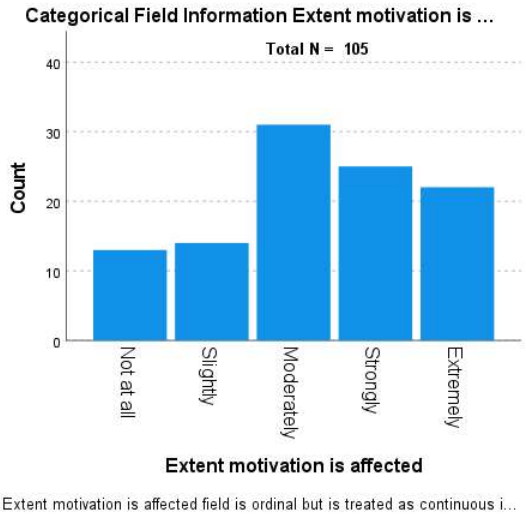
Regarding students' perceived importance of knowledge-sharing among students, the results suggest a statistically significant difference across institutions, as shown Figure 13. University of Pécs students generally reported that knowledge-sharing was more important to them than MSU Denver students, with most University of Pécs respondents reporting knowledge-sharing as "extremely" important. Meanwhile, MSU Denver students exhibited greater variation in responses, with most students reporting that knowledge-sharing was "strongly" (or very) important, but still a significant percentage of students reporting knowledge-sharing as "moderately" or "extremely" important. Thus, the distribution of responses for MSU Denver is more normally distributed on degree of importance, while distribution of University of Pécs responses is negatively skewed, indicating greater importance. However, when looking at the program level, there are no significant differences in the distribution of responses. When pooled across institutions, graduate and undergraduate students both view knowledge-sharing as important, with knowledge-sharing being "extremely" important to over 40% of all students, followed closely by more than 30% of students viewing knowledge-sharing as "strongly" important.

One of the significant findings is that University of Pécs students generally placed greater importance on knowledge-sharing among students than MSU Denver students. One explanation for this difference between institutions may be due to different baseline experiences with other student-to-student interactions during non-pandemic times and its relative perceived scarcity or abundance. For example, a response indicating a low importance of knowledge sharing may be due to a perceived lack of student-to-student interactions in general, such as due to living off campus. Thus, students that have few or lower-quality experiences in the past may place less importance on it for academic success.

On the other hand, a response indicating low importance may also be due to perceived abundance of student-to-student interactions in general, such as living in dormitories or university-based communities or studying on campus. Individuals with many or high-quality student-to-student interactions in the past may not see the need for more interaction or may even be unaware of the effect it has had on their academic outcomes. To disentangle the mechanisms responsible for the observed variation, further studies are needed.

When comparing architecture and engineering program students, see Figure 14, or graduate and undergraduate students, see Figure 15, COVID-19 affected importance of knowledge-sharing among students similarly. It is noted that the smallest sample size is in this category and caution is needed in the interpretation of the results.

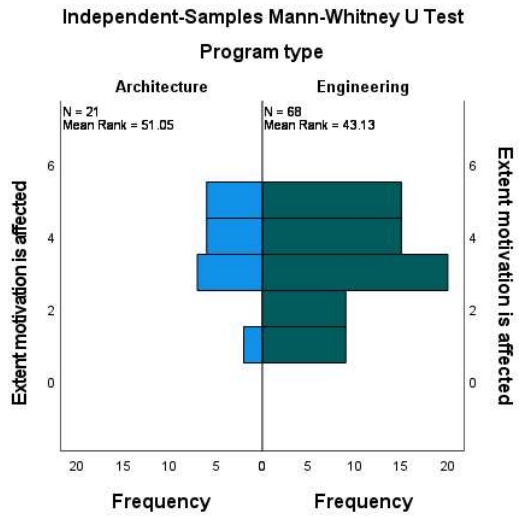


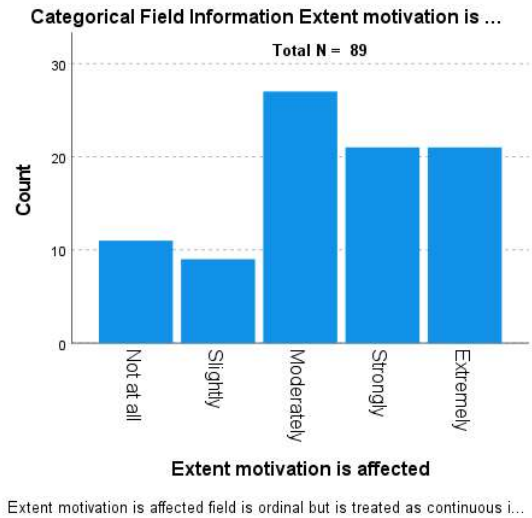


Null Hypothesis	Test	Sig.[a,b]	Decision
The distribution of Extent motivation is affected is the same across categories of Institution.	Independent-Samples Mann-Whitney U Test	.183	Retain the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Figure 7. Extent motivation is affected Mann-Whitney U-Test by institution

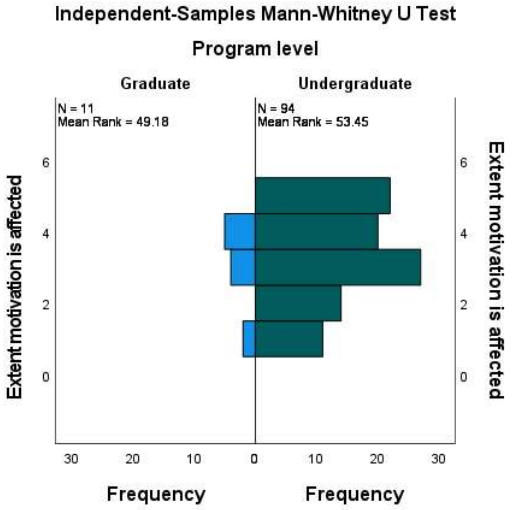


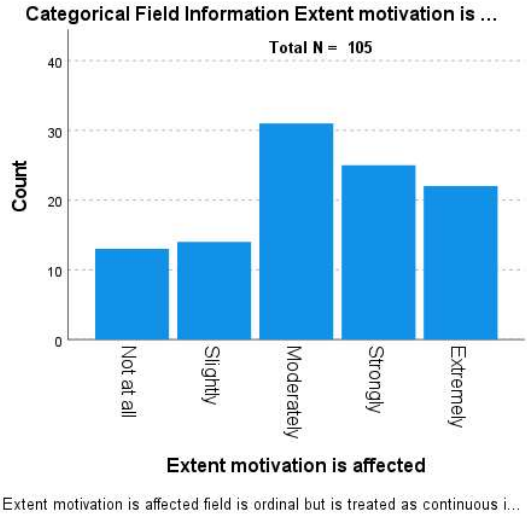


Null Hypothesis	Test	Sig.[a,b]	Decision
The distribution of Extent motivation is affected is the same across categories of Program type.	Independent-Samples Mann-Whitney U Test	.206	Retain the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Figure 8. Extent motivation is affected Mann-Whitney U-Test by program type

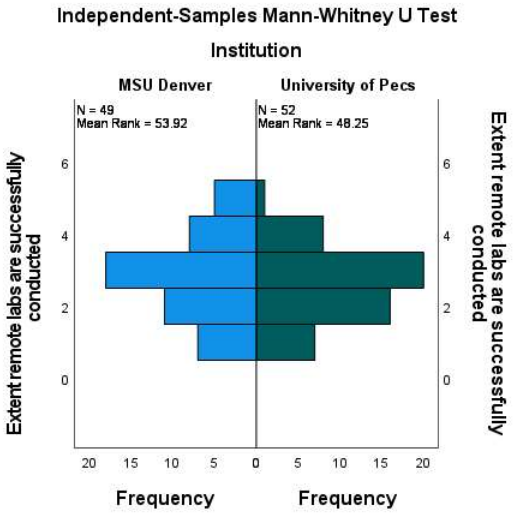


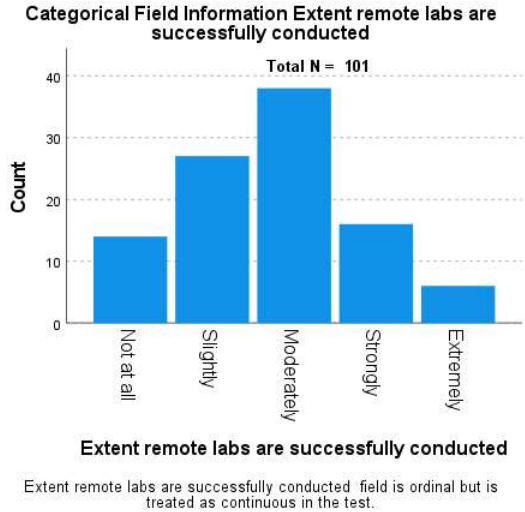


Null Hypothesis	Test	Sig.[a,b]	Decision
The distribution of Extent motivation is affected is the same across categories of Program level.	Independent-Samples Mann-Whitney U Test	.652	Retain the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Figure 9. Extent motivation is affected Mann-Whitney U-Test by program level

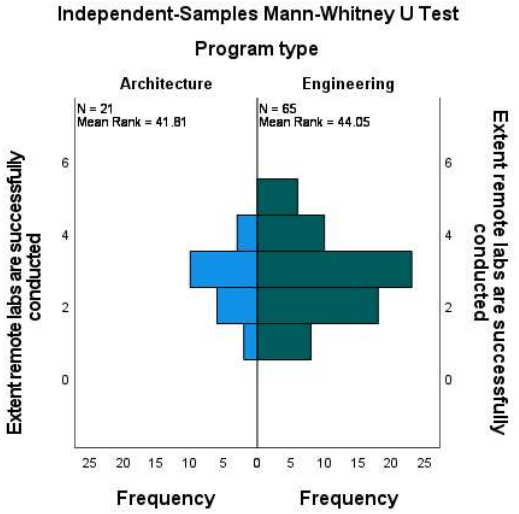


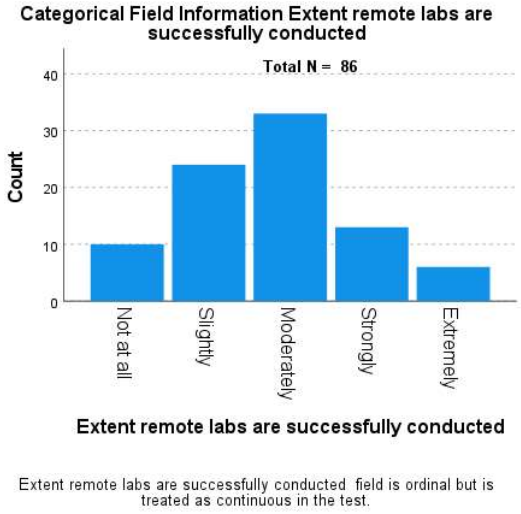


Null Hypothesis	Test	Sig.[a,b]	Decision
The distribution of Extent remote labs are successfully conducted is the same across categories of Institution.	Independent-Samples Mann-Whitney U Test	.311	Retain the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Figure 10. Extent remote labs were successful Mann-Whitney U-Test by institution

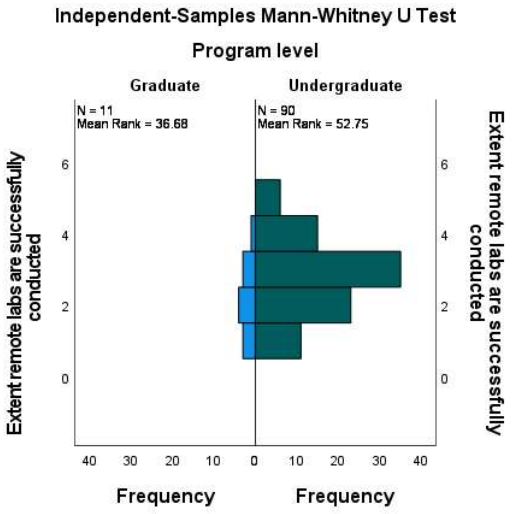


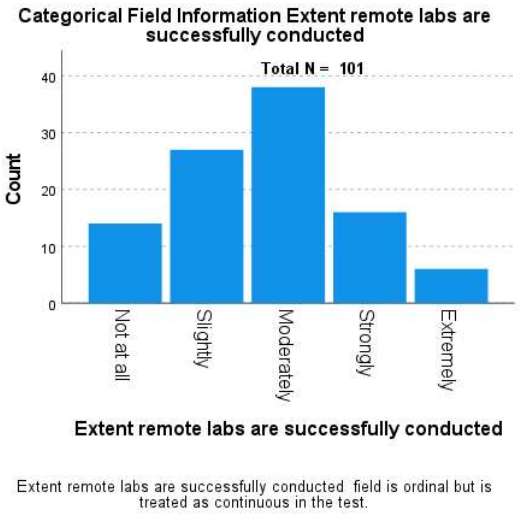


Null Hypothesis	Test	Sig.[a,b]	Decision
The distribution of Extent remote labs are successfully conducted is the same across categories of Program type.	Independent-Samples Mann-Whitney U Test	.709	Retain the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Figure 11. Extent remote labs were successful Mann-Whitney U-Test by program type

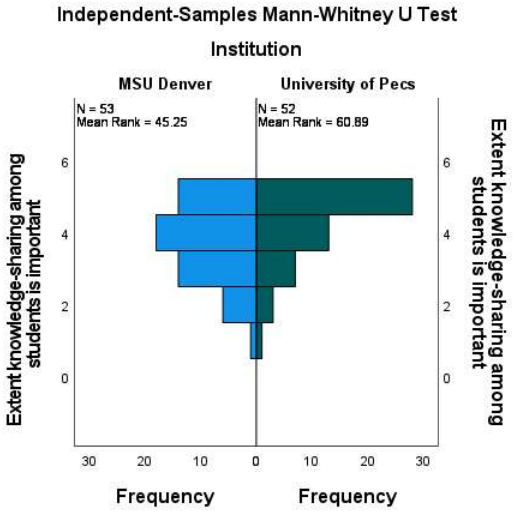


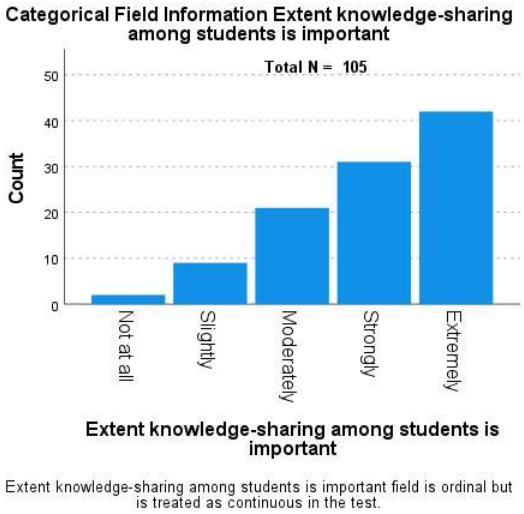


Null Hypothesis	Test	Sig.[a,b]	Decision
The distribution of Extent remote labs are successfully conducted is the same across categories of Program level.	Independent-Samples Mann-Whitney U Test	.074	Retain the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Figure 12. Extent remote labs were successful Mann-Whitney U-Test by program level

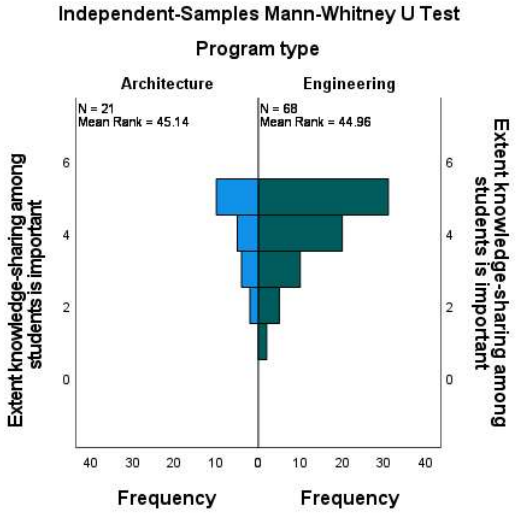


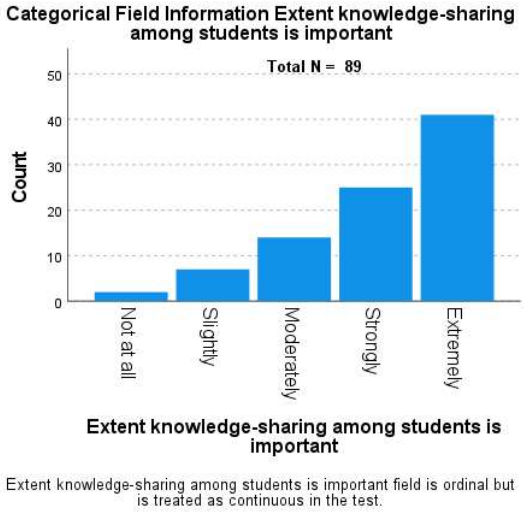


Null Hypothesis	Test	Sig.[a,b]	Decision
The distribution of Extent knowledge-sharing among students is important is the same across categories of Institution.	Independent-Samples Mann-Whitney U Test	.006	Reject the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Figure 13. Extent knowledge-sharing is important Mann-Whitney U-Test by institution

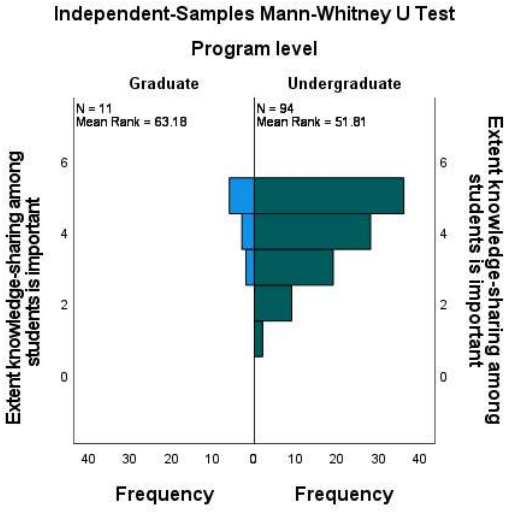


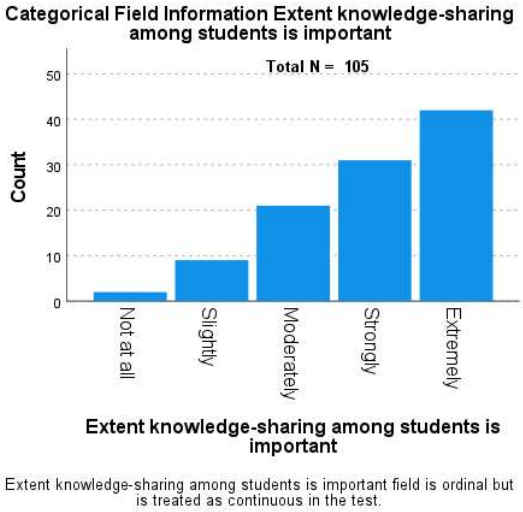


Null Hypothesis	Test	Sig.[a,b]	Decision
The distribution of Extent knowledge-sharing among students is important is the same across categories of Prog. T.	Independent-Samples Mann-Whitney U Test	.975	Retain the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Figure 14. Extent knowledge-sharing is important Mann-Whitney U-Test by program type





Null Hypothesis	Test	Sig.[a,b]	Decision
The distribution of Extent knowledge-sharing among students is important is the same across categories of Prog. L.	Independent-Samples Mann-Whitney U Test	.217	Retain the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Figure 15. Extent knowledge-sharing is important Mann-Whitney U-Test by program level

6. Conclusions and Recommendations

Using a survey design, students' experiences and perceptions of remote-learning during the COVID-19 pandemic across multiple engineering as well as architecture and construction project management programs are assessed. Finding results of a non-parametric statistical analysis suggest no significant differences between MSU Denver and the University of Pécs on the effect of COVID-19 on students' level of motivation or their perception of the extent remote labs were successfully conducted, except that University of Pécs students did generally place greater importance on student-to-student interactions for positive learning outcomes than MSU Denver students. At the program level, aggregating both institutions, no significant differences between undergraduate and graduate students' experiences were found for any of the measured outcomes.

Based on these findings, recommendations are made for improving student perception of and experience with remote teaching and learning. Regarding the conduct of remote laboratories, the results suggest, consistently across institutions, a less favorable view of how remote labs were conducted. Since the transition to remote labs during COVID-19 occurred suddenly, perhaps with the greater preparedness afforded by non-pandemic settings, most labs may yet be effectively conducted remotely by improving the design of laboratory experiments, such as by using advanced simulation software and hardware for engineering and architecture. However, studies are needed to determine to what extent such improved laboratory classes can effectively be held remotely. Furthermore, by extending access to platforms for remote learning groups which can be linked to the class, student-to-student interactions can be improved, however further studies are needed to disentangle the mechanisms responsible for the observed institutional variation.

These recommendations seek to increase the resilience of engineering education by enhancing its preparedness for natural disasters, pandemics, energy crises, wars, or other unexpected circumstances.

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