# Board 190: Work in Progress: A Pilot Study on Faculty Perceptions of the Impact of COVID-19 on Undergraduate Engineering Student Readiness

**Emily Fitzpatrick, University of Nebraska-Lincoln**

Emily is an undergraduate student in Mechanical & Materials Engineering at the University of Nebraska-Lincoln.

**Dr. Jessica Deters, University of Nebraska - Lincoln**

Dr. Jessica Deters is an Assistant Professor of Mechanical and Materials Engineering and Discipline Based Education Researcher at the University of Nebraska - Lincoln. She holds her Ph.D. in Engineering Education and M.S. in Systems Engineering from Virginia Tech.

# Work in Progress: A Pilot Study on Faculty Perceptions of the Impact of COVID-19 on Undergraduate Engineering Student Readiness

## Introduction

The COVID-19 pandemic resulted in widespread school closures across all levels, beginning in March 2020. Since then, K–12 schools and higher education institutions across the globe have been forced to alter their content delivery in order to maintain safe learning environments and comply with local, state, and federal regulations [1]. During 2020 and 2021, many K–12 schools and higher education institutions implemented virtual learning, lost critical instruction time, and were unable to cover the same amount of content as a typical pre-COVID-19 school year [2]. Several studies have investigated these alterations to education in the K–12 setting and their effect on students' learning progress by comparing pre-pandemic data with data after March 2020 [3], [4]. Many of these studies that have investigated COVID-19 learning loss have looked at standardized test data and focused on K–8 students [3]–[5]. For example, a study in the Netherlands [3] investigated the differences in primary school-aged students' general testing trends before and after the start of the pandemic. They found that just an eight-week shutdown resulted in learning losses of three percentile points compared to pre-pandemic data. Notably, students in less-advantaged homes experienced up to 60% greater learning losses. Another study [4] focused on COVID-19 learning loss found that primary school-aged students in the United States are starting school in Fall 2020 about three months behind where they are expected to be in mathematics. Similarly, a study that focused on grades 3–8 found that math achievement dropped across the first two years of the pandemic [5]. These studies show that students who were in K–12 grades during 2020 and 2021 likely missed crucial instruction related to mathematics and science, which are critical baseline concepts for students pursuing an engineering degree [6]. Learning loss is important to understand because gaps created in a student's knowledge base in the K–12 setting can have drastic consequences on their subsequent higher education and as they prepare themselves to enter the workforce [7]. Moreover, learning loss from COVID-19 is expected to have lasting economic impacts, even for students in schools that quickly returned to their prior performance levels [7].

While much of the research on learning loss has been focused on K-12, at the higher education level, some studies have investigated the impacts of the pandemic on student learning experiences. For example, Shin & Hickey [8] identified negative effects on students learning related to motivation, lack of feedback, and insufficient workload adjustments. However, while studies have established that learning loss exists for primary and secondary school-aged students, few studies have investigated specific areas of learning loss of students who have now transitioned to higher education. Presently, the majority of first-year engineering students were high school sophomores when the pandemic began, and third-year engineering students were high school seniors. Accordingly, it is reasonable to suspect that the learning loss that these students experienced in high school will continue to impact them in college. Moreover, these studies of primary school students lead us to believe that learning gaps exist for students who are starting their engineering education and will continue to exist for the next several years as students who were in primary and secondary grades in 2020 and 2021 begin to reach the college level. Thus, it is imperative to understand how learning loss that students experienced in secondary grades due to the pandemic is impacting their transition to college-level engineering courses.

In order to fill this research gap, the purpose of this study is to investigate the impacts of the pandemic on first- and second-year engineering students' readiness for engineering coursework from the perspective of instructors who teach first- and second-year engineering courses. By identifying weaknesses in students' development, this research will enable us to recommend adaptations that can provide more localized support in undergraduate engineering programs to better prepare students for their future engineering careers. Accordingly, this paper addresses the following research question:

> What impacts has the COVID-19 pandemic had on first- and second-year engineering students' readiness for engineering coursework, according to instructors who teach first- and second-year engineering courses?

## Methods

We use an exploratory qualitative approach to answer this research question. In this study, we implemented semi-structured interviews with two faculty members who teach first- and second-year engineering students. This study is intended to pilot our interview protocols and overall research approach. Future work will include more participants and more refined data collection and analysis.

### *Participants and Setting*

The participants in this study were faculty members at a large, public, land-grant university in the mid-west who teach required courses in the first two years of mechanical engineering curriculum. To best analyze the key differences in students' knowledge bases while taking first- and second-year mechanical engineering courses, faculty members were selected based on the courses they teach and how much experience they have teaching relevant courses. Faculty members who teach first- and second-year mechanical engineering courses and who had experience teaching pre-pandemic were invited to participate in the study. For the purposes of this pilot study, we include two faculty members who were interviewed using the pilot interview protocol. These two faculty members fit the selection criteria and present contrasting views on student readiness for engineering coursework. Professor A teaches an introductory chemistry course and is involved with a bridge program (i.e., courses between completion of high school and start of college). Professor B teaches an introductory mechanical engineering course. Both faculty members have at least five semesters of experience teaching their respective courses.

### *Data Collection and Analysis*

Faculty members were asked to participate in 45-minute-long semi-structured interviews aimed at uncovering differences they noticed since the COVID-19 pandemic in their classes. Interview questions were developed by the research team in order to answer the research questions. The interview protocol was piloted with two faculty members, and that data forms the basis of this paper. The interview protocol will be modified based on the results of the pilot interviews to better address the research purpose. Participants were sent the interview questions prior to the interview to allow them to gather class data and reflect on the differences beforehand. Interviews were conducted via Zoom and were transcribed by a professional transcription service.

The interviews were analyzed using thematic analysis, wherein the author team identified themes within and across the interviews about the perceived impact of COVID-19 on engineering student readiness. One author conducted the initial data analysis and identified initial themes. The author team then met to discuss to consensus. The author team found that themes within each participant's interview were unique from the other participant and, as a result, opted to present the results by person.

### *Limitations*

This study is not intended to definitively identify areas of learning loss, nor is it intended to be generalizable to a broader population. Rather, this pilot study is intended to begin to explore potential areas of learning loss in order to inform future larger-scale investigations into the impact of pandemic learning loss on engineering readiness.

### *Positionality of Authors*

Author 1 is a second-year undergraduate student studying mechanical engineering. She conceptualized this project with Author 2 as a result of her own experiences as a student affected by the COVID-19 pandemic. During lockdown, Author 1 was a junior in high school and noticed the great loss of content due to the emergency education strategies employed at her school. For the rest of her time in high school and early college careers, she continued to notice the repercussions of the pandemic on her own life. Accordingly, Author 1 was inspired to investigate the consequences of the pandemic on new engineering students on a larger scale in order to provide proper support to those who may be struggling with the transition. Author 2 is an Assistant Professor of Mechanical & Materials Engineering and was trained as an engineering education researcher. Author 2 was a PhD student in Engineering Education when COVID-19 began and focused her dissertation on understanding undergraduate student experiences during the pandemic. Both authors are white and identify as women.

## Findings/Discussion

We found that each interviewee had a different perspective on student readiness, so we opt to organize our findings by person. "Professor A" identified specific areas of learning loss in their introductory chemical engineering course and bridge program. On the contrary, "Professor B" did not notice areas of learning loss that they attributed to COVID-19.

### Professor A

### *Context*

Professor A has taught a variety of chemical engineering courses at the collegiate level for over nine years, from upper-level labs to introductory classes. Of particular interest is their experience teaching an "*Introduction to Chemical Engineering I*" course for freshmen. This course is the primary focus of our discussion with Professor A, as we seek to gain insights into first- and second-year engineering courses taught by experienced professors. Professor A has taught the introductory course consistently since the Fall of 2020, which was right after the initial shutdown due to the pandemic. While it would have been preferable for Professor A to have taught this course consistently prior to the pandemic, they still identified notable findings to support this study. In addition to Professor A's experience with the chemical engineering introductory course, Professor A has also had experience teaching an engineering readiness course for freshmen. This program, which is held for a week prior to the start of the fall semester, is designed to prepare

students for engineering coursework and fill in any gaps. Since Professor A has had copious experience with the program, Professor A gained insight on the impacts of the pandemic across the years. Although not a standard course, notable changes may offer valuable information on the direct impacts of pre-engineering high school students' learning loss.

***Curriculum-Based Difficulties***

Despite not teaching *Introduction to Chemical Engineering I* prior to the pandemic, Professor A explained that they felt a "drop off" between freshman students in Fall 2020, where students had in-person instruction for most of their high school career, versus Fall 2022, where remote learning was more prevalent in students' high school careers. *Introduction to Chemical Engineering I* covers fundamental skills required for chemical engineering, beginning with unit conversions. Professor A identified unit conversions as being the most notable curriculum gap compared to previous semesters. This struggle for students resulted in a need to allocate more instructional time towards establishing a stronger foundation, as a holistic understanding of unit systems is imperative for all aspects of engineering. Although Professor A was unable to identify any other direct curriculum gaps in the introductory course for chemical engineering freshmen, Professor A noticed a drop in students' general problem-solving skills. In the introductory course, students are building skills to apply to a bigger, more complex picture. Learning how to translate word problems into a proper solution is a big focal point of Professor A's course. Professor A explained the increasing struggle that students are having with their ability to solve such problems; the process of translating a word problem, selecting the proper formula(s), and executing those formulas has become more difficult for students, according to Professor A. This lack in problem-solving proficiency, along with unit conversion difficulties, is important to recognize and understand as these are key components of engineering. In addition to gaps noticed in the chemical engineering course, Professor A has also noticed greater difficulties in students' ability to utilize basic algebra and trigonometry skills compared to pre-pandemic students, amongst students in the engineering readiness course.

***Student Behavioral Changes***

In addition to difficulty with unit conversions and general problem solving, Professor A noticed many student-behavior changes post-pandemic. Students in Professor A's Fall 2020 class had experienced less than one semester of online classes while students in their Fall 2022 class could have had several semesters of experience with virtual instruction. Professor A attributed this increased experience with virtual instruction with student habits, such as choosing not to turn in assignments, skipping class, and deliberately not showing up to exams. Professor A noted that their class syllabus is well-defined, yet they have noticed an increase in students' failure to fulfill class requirements. Beyond trends of decreasing attendance and student punctuality, Professor A also noticed a decrease in class engagement. Post-pandemic, especially regarding more recent semesters, Professor A has increasingly struggled with students' responsiveness and ability to be actively involved in class discussions and examples. Professor A makes sense of this trend by connecting the passive nature of virtual instruction by Zoom calls. With synchronous virtual learning, it is likely that many students got used to sitting at home with their cameras off, barely paying attention to class. Because of this habit, many students are likely to engage less in their in-person classes. In addition to passive class attendance, Professor A also noted a decrease in office hour attendance.

### *Resulting Changes in Instructional Strategies*

Beyond asking Professor A to directly identify any noticeable changes in students' performance, abilities, and behaviors post-pandemic, Professor A was also asked to identify any alterations made to their class/pedagogical approaches they have made due to what they have noticed in the classroom. Professor A explained that they changed their approach to in-class examples by decreasing speed and increasing explanations/thought processes. In addition, Professor A tried to bring in more physical equipment to class in order to promote interest in students, connect applicability, and increase engagement.

## Professor B

### *Background*

Professor B is an assistant professor in the mechanical engineering department of the university. Over the course of six years teaching at a collegiate level, Professor B has taught two courses at their current university, including a second-year mechanics course and fourth-year/graduate-level course on continuum biomechanics. The primary reason Professor B was identified as a faculty member of interest was due to their experience teaching the second-year engineering mechanics course called *Mechanics of Elastic Bodies.* This course is required for all civil, mechanical, and architectural engineering students at the university and is comparable to *Mechanics of Materials* or *Mechanics of Elastic Solids* courses at other institutions. In order to enroll in Mechanics of Elastic Bodies, students are required to successfully pass *Calculus III* and earn a C or above in *Engineering Statics*. Professor B has taught the second-year course for six semesters (i.e., one semester per year). For context, Professor B was teaching their third semester of *Mechanics of Elastic Bodies* by the time COVID-19 impacted education in the United States. Professor B explained that they were unsure whether changes they noticed should be attributed to the pandemic or attributed to changes in their teaching style, saying:

> When COVID hit, I was only in my third semester teaching [Mechanics of Elastic Bodies] … I was still learning and trying to optimize my class. For some of the changes I have noticed over the years, I would be tempted to attribute them mostly to my changes in teaching style and ability.

### *Statics Readiness Program Assessment*

Considering the extent of Professor B's experience, Professor B did not identify any particular qualitative differences in their students across the years surrounding the pandemic. However, Professor B was able to provide some quantitative data on a prerequisite exam. The *Statics Readiness Program* (SRP) is an exam that tests student's proficiency in Engineering Statics concepts. Since *Mechanics of Elastic Bodies* is dependent upon such principles, the SRP is required for all students enrolled in the course.

Although the data is limited, it is worth noting that there was a significant drop in class average in 2022. This suggests that students who experienced virtual instruction in high school are struggling more than previous years.

### *Early-Career Professor Realities*

Professor B discussed the challenges that early-career professors face when it comes to teaching, reflecting on their focus in the first semesters of teaching as compared to the later semesters:

> Yeah, so when you first start teaching, there's two big challenges: one is usually you **have to relearn a lot of the concepts** that you're teaching, because you haven't seen these concepts since you were an undergrad, a lot of them, and that was the case for me. Even though I went out and got a PhD in solid mechanics, at the graduate level, that framework is a lot different, the theoretical frameworks is a lot different than the undergraduate level. So, I had to refresh myself on these concepts and that's difficult. So now you're refreshing yourself, and then you got to go into a class and teach the stuff and you're just not going to be as on it, that first one or two times, because you haven't mastered it yet. You haven't re-mastered it yet. Maybe that's the basis of it. And as a result of that, your focus is more on just delivering the concepts and you have **less ability to think about how you deliver**. Like you're just trying to survive. Now that I've tried this several times, I can put more attention on how I deliver and a lot of competence with concepts and the mastery of them. And I can think about it frees up mental space when you're in front of 50 people to think about what question can I pose here and how can I get people working together in the classroom and things like that that can be really powerful. [emphasis added]

Professor B claimed that their students' performance, as measured by their class average, has improved since COVID-19. However, they attribute this change to their growing experience with teaching.

### *Second-Year Engineering Course Logistics*

An additional aspect regarding the realities of Professor B's teaching experience over the years is the fact that *Mechanics of Elastic Bodies* is a second-year engineering course. Students that enroll in this course must successfully pass *Engineering Statics* with a grade of a C or above. Since *Engineering Statics* is a course with a relatively high rate of D/F and withdrawals of around 25%, it is likely that the students who suffered deep repercussions from COVID-19 did not complete Statics with the necessary requirements to advance in the engineering curriculum. As a result, it is logical that Professor B did not notice as many consequences resulting from COVID-19 as Professor A mentioned. This principle may encourage further studies to focus more on first-year course instructors in order to identify the most direct impacts.

## Conclusion and Future Work

The COVID-19 pandemic has had profound impacts on students, creating significant challenges for educators and institutions alike. Understanding the long-term effects of the pandemic on engineering education is crucial. This pilot study represents an important initial step in a longitudinal process that aims to explore the true impacts of COVID-19 on education on a larger scale. As the pandemic continues to shape our world for years to come, finding effective and rigorous methods to examine the issue with depth and precision is vital. In this paper, we present our pilot study's findings that provide insights into the immediate effects of COVID-19 on students' learning experiences. This study lays the groundwork for future research that should build on our findings and expand the scope of the investigation to better comprehend the pandemic's long-term implications for engineering education.

A critical concern about engineering student retention is raised by these results. If a pattern emerges in which second-year engineering course instructors report fewer pandemic-related impacts, it could indicate that students who experienced significant challenges either dropped out of the engineering program or their educational deficit resolved in earlier semesters. Given this

possibility, it is imperative that retention data is investigated to develop greater understanding of the circumstances. If engineering retention is decreasing, prioritizing the identification of measures to assist those who have been adversely affected by the pandemic is critical. This proactive approach is essential to mitigate potential drop-out rates among engineering students.

This pilot study made significant progress in identifying ways to select the most effective candidates for interviews. The results of the faculty members that were interviewed suggest that changes can be made to strengthen the recruitment process. Comparing the results of Professor A and Professor B, it is apparent that Professor A noticed more impacts on their students. Although Professor B did not observe any significant effects, their teaching experience greatly influenced their perspective. As a relatively new professor teaching a second-year engineering course, Professor B was unable to identify any drastic changes in their students. Therefore, interviewing more experienced first-year course instructors is likely to produce more direct results.

The study identified the next steps for further investigation, including examining the retention rates of engineering students to identify any weaknesses within engineering programs. If there is a drastic increase in dropout rates, efforts should be made to identify the reasons and develop solutions to mitigate the difficulties. The consequences of the pandemic on early engineering education are severe, and students deserve support to overcome the challenges they face.

**References**


[1] A. Schleicher, "The impact of COVID-19 on education: Insights from education at a glance 2020," Organisation for Economic Co-operation and Development, OCED, 2020.

[2] R. Jamshidi and E. A. King, "The transition from in-person to online classes," in *ASEE Annual Conference and Exposition, Conference Proceedings*, Virtual, 2021, pp. 1–9.

[3] P. Engzell, A. Frey, and M. D. Verhagen, "Learning loss due to school closures during the COVID-19 pandemic," *Proc. Natl. Acad. Sci.*, vol. 118, no. 17, p. e2022376118, Apr. 2021, doi: 10.1073/pnas.2022376118.

[4] E. Dorn, B. Hancock, J. Sarakatsannis, and E. Viruleg, "COVID-19 and learning loss—disparities grow and students need help," McKinsey & Company, 2020.

[5] M. Kuhfeld, J. Soland, and K. Lewis, "Test score patterns across three COVID-19-impacted school years," *Educ. Res.*, vol. 51, no. 7, pp. 500–506, Oct. 2022, doi: 10.3102/0013189X221109178.

[6] M. Kuhfeld, J. Soland, and K. Lewis, "Test Score Patterns Across Three COVID-19-Impacted School Years," *Educ. Res.*, vol. 51, no. 7, pp. 500–506, Oct. 2022, doi: 10.3102/0013189X221109178.

[7] E. A. Hanushek and L. Woessmann, "The economic impacts of learning losses," Organisation for Economic Co-operation and Development, OECD Education Working Papers No. 255, 2020. doi: 10.1787/21908d74-en.

[8] M. Shin and K. Hickey, "Needs a little TLC: Examining college students' emergency remote teaching and learning experiences during COVID-19," *J. Furth. High. Educ.*, vol. 45, no. 7, pp. 973–986, Aug. 2021, doi: 10.1080/0309877X.2020.1847261.