Exploring Mechanical Engineering Students' Perceptions of Preparedness for Work

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Introduction

Engineering undergraduate students' readiness for work and their mastery of specific competencies (e.g., technical skills, communication skills, etc.) has long been of interest to the engineering education community [1]–[4]. Critiques of new engineers' competencies date back to the 1918 Mann Report and have continued through the last century. More recently, a 2012 American Society of Mechanical Engineers report claimed that new graduates lack proficiency in areas like practical experience, problem solving, and design [2]. Other recent studies have identified teamwork and communication skills as lacking amongst new engineers [5]–[7]. Martin et al. [8] attempted to categorize what industry expectations are of engineering graduates, dividing attributes into technical and non-technical competencies. They categorized the technical competencies into two distinct areas which they termed the science of engineering and the practice of engineering. While they defined the science of engineering as a graduate's ability to use his scientific and mathematical know-how to solve industry problems, the practice of engineering is the graduate's ability to recognize an issue in the industry and use their school knowledge to find a solution to them. Meier et al. [9] found that while academia's expectation is that new engineers are competent in the science of engineering, industry expects that the engineer is well-grounded in the practice of engineering. Altogether, these studies and reports show that engineering undergraduates' preparedness for work in industry is a key concern in engineering education.

Compounding this preparedness problem is the COVID-19 pandemic, which prompted rapid changes to the higher education system and caused significant disruptions to both teaching and learning. During this period, most institutions shifted to emergency remote learning which affected both how academics taught and how students learned. Studies have shown that this shift to online instruction disrupted in-person laboratory courses, causing engineering students to lose opportunities for hands-on learning [10]. Moreover, some instructors were faced with a need to remove content from their courses in order to adjust to lost instruction time [10]. These COVID-related challenges lead us to believe that the pandemic may have impacted students' preparedness for work. To date, limited studies have investigated the impact of the pandemic on students' readiness for the workplace. Accordingly, the purpose of this study is to understand how students, whose education was disrupted by the pandemic, perceived and described their preparedness for the workplace. We address the following research question:

> How did mechanical engineering students perceive their preparedness for work during the first year of the pandemic?

Methods

This study takes a constructivist approach to explore commonalities and differences among students' perceptions of industry preparedness [11]. We do not aim to identify an objective truth about students' experiences, but rather to identify commonalities in their constructions and interpretations of their experiences.

This paper draws from data collected for a larger, comparative case study [10]. Data were collected from mechanical engineering students who were taking second- and third-year courses during March 2020. Participants were recruited from two large, public, comprehensive universities and were interviewed about their experiences taking courses during the pandemic. This study was approved by the appropriate ethics review boards prior to data collection.

Participants and Settings

Participants were 11 mechanical engineering students who, at the time of the interview, were taking 2nd or 3rd year mechanical engineering courses in March 2020 at one of two institutions: a large, public, comprehensive university in the United States and a large, public, comprehensive university in South Africa. Participants completed a screening survey and were selected to interview based on their perceived level of difficulty completing courses during the pandemic. All participants had transitioned to online classes as a result of the pandemic. All participants have been deidentified in the data analysis and reporting in order to protect their identities.

Data Collection and Analysis

The data for this study consists of one, approximately 60-minute semi-structured interview with each participant, conducted via zoom between September and November 2020. This paper looks specifically at participants' responses to the questions:

1. How prepared do you feel for your first job post-graduation?
2. Did taking courses online impact how prepared you feel?

The data was analyzed using descriptive coding, where labels were assigned to the data that summarized the basic topic of the excerpt [12]. The relevant data to answer our research questions were first extracted from the bulk of existing already transcribed data from [10]. The data analysis was carried out in two phases, the first phase involved generating codes and then collapsing them into subcategories. The second phase of the analysis involved categorizing and integrating themes across subcategories. In each phase, the analysis was initially conducted by Author 1 and then checked by Authors 2 and 3. The authors agreed on the coding, so negotiation to consensus was not necessary.

Positionality

The author team consists of three Ph.D. students in Engineering Education Research and one Assistant Professor of Mechanical and Materials Engineering who holds a Ph.D. in Engineering Education. Two of the authors identify as women and two identify as men. Three authors have undergraduate degrees in engineering and one in applied mathematics & statistics. All authors have completed their M.S degrees in engineering. The authors have a combined experience of working in industry and academia in the U.S., Nigeria and South Africa. Their combined experiences include studying at university during COVID, working within industry during COVID, and preparing students for industry prior to COVID.

Limitations

The purpose of the original data collection was not to answer this research question, hence only 11 of the available 23 transcripts could be used in this analysis. Further, the data obtained is only representative of one institution type (comprehensive, public) and was collected in only one region in each country. The results in this study are intended to be transferred to other contexts, but are not intended to be generalizable.

Findings

Two broad categories of 'impact' and 'no impact' arose from the data analysis process. *Impact* refers to students who reported that COVID-19 had an influence on their perceived level of preparedness for the workplace, while *no-impact* refers to students who reported that COVID had no influence on their level of preparedness for the industry. Three subcategories emerged within *impact* and *no impact* and were classified as: 'prepared,' 'unprepared', and 'indifferent.' These subcategories represent the participants' perception of their preparedness for work. The findings are summarized in Table 1.

Table 1: Perception of Preparedness and Impact of COVID-19 by Participants

	Impact	**No Impact**	**Total**
Prepared	2	2	**4**
Unprepared	6	0	**6**
Indifferent	0	1	**1**
Total	**8**	**3**	**11**

Impact

Eight of the 11 participants, or 72.7% of the participants, reported perceiving that COVID-19 had an impact on their preparedness for work. Two of these participants believed that the pandemic impacted their preparedness positively and made them feel more prepared, while six believed that the pandemic had a negative impact on their preparedness and made them feel less prepared.

Prepared

Two students believed that the pandemic, though sudden, made them better prepared for the workplace. One of the students began learning computer coding through one of their courses and felt that this new skill positioned them to be better prepared for the workplace, saying, "I'm more prepared, sort of, actually, because I think we started leaning a lot more on like coding and stuff. So, I think that would help in what I'm trying to do after the degree."

The other student who felt prepared as a result of the impact of the pandemic claimed that they developed better in terms of personal growth and organization. They reflected that the transition to online instruction led them to spend more time on the internet and allowed them to learn from online resources and gain better computer skills. The student believed that these skills would prove to be useful in the industry, saying:

> I was able to actually learn how to work on my own during this time and I was able to actually learn how to get stuff on my own.... So, it's helped me in that way […] I've built

> so many skills, working on the computer, working on the net, using so many resources, like my way of processing data has changed. My planning and scheduling has changed. Like I didn't even know I could become a better planner because of this lockdown, which is pretty cool.

Unprepared

While two students felt that the pandemic made them more prepared for industry, six of the eight participants in this category indicated that the pandemic had a negative influence on how they felt prepared for the workplace. All students in this subcategory were concerned that COVID had interrupted their professional development. Four students highlighted that they had missed out on the hands-on and practical component of their engineering career development, which they felt was essential for preparing for work in industry:

> It's definitely more the hands-on collaborative work, kind of troubleshooting, figuring stuff out, design process stuff that I'm more – feel like well if I don't get to do that then it's definitely going to be a problem.

Another student explained that when their laptop crashed, they faced a real-life scenario in their engineering field, which made them realize the importance of practical work, and how much they valued that. They felt that transitioning to online classes robbed them of practical experience and limited their ability to communicate with others:

> I really came to realize just how much I value being able to do practical work and to be able to actually see the real-life model, to see the little design things and understand why they put that there… I personally think it's a lot better to just study on campus than it is to study online, because the practical aspect it's, it's, it's too important. Even, from the perspective of Engineering in Society, like you just have to, to be able to talk to someone instead of just typing behind a screen.

One student raised concerns that their training during COVID could be perceived as inadequate or incomplete by potential employers, which could result in employers lack of confidence in their readiness for industry. Another student stated learning engineering online was challenging and that it would have a slightly negative impact on how prepared they felt for industry.

No Impact

Three of the 11 participants indicated that the pandemic had no impact or influence on their state of preparedness for the workplace post COVID. Students who felt that the pandemic did not impact their preparedness felt either prepared or indifferent.

Prepared

Two of the three students in this subcategory reported that the pandemic did not have any influence on their level of preparedness for the industry. Moreover, these participants claimed that they had felt prepared for work before the pandemic started. One of the students further stated that their learning at university was misaligned to the workplace preparedness for their career:

> I think I was prepared a long time ago for what's next, at least in the workplace. I think the educational system doesn't necessarily prepare you for like the workforce. […] I don't think I'm learning much more value to what I want to do with my career.

The other student reported that what they were learning was unrelated to their chosen field of study, hence the pandemic had no impact on their level of preparedness. The participant felt ready to take on a professional job. The student further asserted that the university learning was constrained to develop people for limited engineering jobs:

> I wanted to go into a little more of an unconventional, like, design type engineering, which is what I thought I was coming here to learn, but that was not the case. I honestly think our education is catered to that maintenance and retroactive engineering job. So, I don't think I was ever prepared for what I want to do from school, so I've had to do that on my own. I don't think that's changed because of COVID.

Indifferent

One student felt that the pandemic did not impact their preparedness and felt neither prepared nor unprepared. This student believed that normalcy would return once the pandemic was over and they would have enough time to catch up. The student said, "this is just year one, and I still have two years after here. I [will] start taking more practicals. I can do the catch-up."

Conclusion

This study can provide information that could assist students and academics to better prepare for a future pandemic or crisis like situation. The results of this study are not intended to be generalizable but focused on this subset of students who had their classes disrupted during COVID. Furthermore, by understanding how students' preparedness for the workplace has been affected during COVID, and more specifically identifying which aspects have been affected, we can help identify gaps in students' perceived industry preparedness. These identified areas could help inform both the universities and industry to design targeted learning interventions that can be implemented to address these gaps.

Furthermore, understanding student perceptions provides insight into their level of motivation, their affective states and actions. These states and actions could affect their learning at the university and future performance in the workplace. By gaining a deeper understanding into these motivational based factors, transitional programs can be enhanced to assist students better with their transition to the workplace.

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