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”Examining the Changing Perceptions of Graduate Students’ Role as Teaching Assistant with Online and Hybrid Labs during COVID-19” (Instruction)

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Examining the Changing Perceptions of Graduate Students' Role as Teaching Assistant with Online and Hybrid Labs during COVID-19" (Instruction)

Abstract

The transition from traditionally face-to-face "in-person" courses to hybrid/online laboratory courses as a result of the COVID-19 pandemic has fundamentally altered how these labs are delivered in the mechanical engineering curriculum at Clemson University. This paper seeks to capture the graduates' and undergraduates' changing perceptions of the roles and responsibilities that graduate laboratory assistants (GLAs) have in the delivery of course material within the context of this transition. GLAs from the mechanical engineering laboratory courses were invited to participate in a survey to provide feedback on how they perceived their own roles and responsibilities as GLAs for in-person labs compared to their roles after the labs had transitioned to hybrid/fully-online formats after the onset of the COVID-19 pandemic. Junior- and senior-level undergraduate mechanical engineering students currently enrolled in a hybrid/online lab were also invited to participate in a survey to provide similar feedback on how they perceived their GLAs pre- and post-transition to hybrid/online lab modality.

The analysis of the survey responses then informed the selection of two experienced GLAs to participate in more in-depth individual interviews to share their experiences during this transition and discuss best practices for moving forward. An overarching theme of the results was that while undergraduate students consistently viewed their GLAs' roles as those of graders, knowledge resources, and facilitators, the GLAs began to identify strongly as facilitators only after the transition to hybrid/online labs. Interview participants expressed frustration with the lack of meaningful interaction with students in the hybrid/online course modality that warred with their desire to help students grow and think more deeply about course material. Both undergraduate students and GLAs alike agreed on a need for change in several key aspects of the hybrid/online lab delivery in order to improve its sustainability as a lab course modality.

Introduction and Purpose

In many universities, graduate students have been recruited as economical and valuable additions to the teaching staff. They serve as a cost-effective solution to increasing face-to-face interaction with students while reducing the teaching and/or grading burden on senior staff and instructors through service as a graduate teaching assistant (GTAs). There are both benefits and drawbacks to the graduate assistant position [1], but one prevalent theme in existing literature is the murky and ill-defined nature of a GTA's practical role in academia, as it sits firmly in the grey area between teacher and student that often comes with unclear expectations [2], [3].

Benefits to becoming a GTA can range from financial (e.g. graduate stipend) to professional growth, though the difficulty of achieving the latter can be a function of how much the university invests in preparing these GTAs to carry out their pedagogical duties. Generally, GTAs are selected for their content knowledge of a given area, but pedagogical knowledge is not always considered in the selection process [4]. This results in some GTAs being more prepared than others in commanding a classroom and promoting student engagement and success. The

discrepancies in preparation for their roles as a GTA can be glaring; some programs require graduate students to take a semester long course to learn about and prepare their online or face-to-face pedagogical approach, and others offer no training at all [4]–[7]. Given that time pressure has been recognized as one of the primary disadvantages of a graduate student's involvement as a GTA [8], care should be taken to strike an effective balance between these relative extremes of training. Stress arising from this time pressure can be exacerbated by the fact that a GTA's teaching duties and PhD research does not often have a strong correlation, particularly in the physical sciences [8]. While a previous case study indicated high levels of satisfaction from students when assigned a full-time and full-service GTA to help guide them through coursework, the authors recognize that this is not a sustainable strategy for large courses at most universities due to the high workload and time pressure demands [9].

Regardless of the level of preparation for teaching F2F laboratory courses, many GTAs found themselves facing uncertainty in their roles as the onset of the COVID-19 pandemic necessitated a change in course modalities and limited in-person teaching opportunities for most universities. Several studies in other fields have brought attention to the fact that the use of an online tool to mediate teaching and learning can alter an instructor's role within a course [10]. In one study, they found that the GTAs felt their role evolved from that of a "main communicator with students" to more of a "facilitator of communication between students" in the face of the transition to using online tools [10]. While arguably most STEM departments were initially caught unaware by this unprecedented conversion to hybrid/online courses, how these courses are implemented moving forward can improved by listening to those who had to help adapt the courses quickly to the new modality. Since high quality teaching arises through intentional practice and careful cultivation, we ought to take this opportunity to translate lessons learned from the transition into building a repertoire of best practices to handle a growing online course load. Furthermore, there have been studies that suggest higher-order learning increases with a well-developed online course, so we should consider how to best support our GTAs in the transition to online so they can help guide undergraduates to these higher learning gains [11].

For the mechanical engineering laboratory courses at Clemson University, this rapid transition was primarily driven by a subset of GTAs in the department known as graduate laboratory assistants (GLAs). Their contractual duties for a F2F lab course include preparing and delivering lecture material, maintaining the equipment, guiding students through the lab activities, handling student inquiries, and assigning grades. However, during the transition to hybrid/online labs, pre-recorded lecture and experiment videos were used in an effort to standardize the teaching between sections. Additionally, students were not able to engage physically with the equipment for experimentation as they normally would due to social distancing guidelines. These are the two predominant differences observed between how the labs were conducted in the different course modalities. We should note that in a traditional F2F lab course, it is relatively easy for GLAs to gauge the success of a given lab session based on a combination of verbal and nonverbal student feedback; however, in an online modality, receiving this informal feedback from students can be rather difficult, making it challenging to adapt future lab sessions accordingly [12]. The role of a GLA in fostering a positive lab climate is essential to student satisfaction and retention [13]. Thus, leveraging the collective experience of GLAs on how they maintained this positive lab atmosphere during the transition to hybrid/online labs could provide a valuable framework to develop meaningful GLA training modules to address the

unique needs brought about by this abrupt transition to hybrid/online labs. This could better inform the future conversion of traditionally in-person courses to online, should it become necessary or useful for the university to do so.

In order to begin building an effective training module to prepare future GLAs for the unique challenges of conducting an online mechanical engineering lab, it seems essential to first gauge how GLAs viewed their role in the F2F lab, and how they may have felt their role fundamentally changed (or didn't) as a result of the abrupt transition to an online course modality. Due to the exploratory nature of the study, no specific theoretical framework was selected the results; instead, this study sought to outline a preliminary conceptual framework to better understand how a course modality might shift the self-perceived role of a GLA and what factors most heavily influence their perceived satisfaction with their role.

Methods

In this multi-method approach, digital surveys were sent to all GLAs currently employed by the mechanical engineering department who had at least one semester of experience leading traditional "face-to-face" (F2F) in-person junior- or senior-level labs prior to the rapid transition to hybrid/fully-online labs after the COVID pandemic forced a change in course modality. Participation was optional and had no impact on their employment. A little over half of the eligible GLAs opted to participate in the self-developed survey (N=5). After the informed consent, the initial portion of each survey captured basic demographic information (gender, number of semesters served as a GLA, course taught, etc.), followed by questions that asked about what roles that GLAs felt they filled in a traditional F2F lab and then later in a hybrid/online lab, and if they feel these roles had changed any. Ten roles were offered as choices, although students had the ability to type in new roles under "other"; these ten role descriptors were the ten most common answers from a pilot study of this question in an attempt to capture their own language in describing the roles. While each has a slightly different connotation to different readers, it should be recognized that considerable overlap could exist between these identified roles depending on how the students chose to interpret the role descriptors. For instance, a facilitator is commonly interpreted as a "guide-on-the-side" who helps connect students with the resources necessary for success; meanwhile, a lecturer might be considered more as a "fount-of-knowledge" who primarily has a one-way interaction with students through lecture. The survey also asked about their perceived workload and average number of hours per week dedicated to GLA duties pre- and post-transition and included several free response questions at the end that asked about the benefits and challenges they experienced in making the rapid transition from F2F to hybrid/online labs.

After the survey data was analyzed, two of the GLAs self-selected to participate in 30-minute individual interviews to follow-up on their responses to the survey. The goal of the individual interviews was to provide deeper qualitative context to the GLA experience and some of the salient themes arising from the free responses of the GLA survey. A limitation for the semi-structured interviews is that the questions were determined in advance and were not informed by the survey data. Several examples of the pre-selected semi-structured interview questions are provided in Appendix A. Key questions that we sought to answer from the GLA perspective were:

1) *Did GLAs experience a change in how they perceived their role within the lab environment during the transition to hybrid/online labs? If so, how did that change manifest?*
2) *What benefits, challenges, or best practices did GLAs identify from their experiences transitioning from F2F labs to hybrid/online labs?*

Recruitment flyers were also sent to all undergraduates currently enrolled in either the junior- or senior-level mechanical engineering labs to invite them to participate in a similar digital survey. A total of 51 undergraduate mechanical engineering students responded to the survey (N=51), out of approximately 300 eligible students. Respondents were 80% male and 20% female, with 53% being enrolled in the junior-level labs and 47% enrolled in the senior-level lab. The average student-to-GLA ratio in these labs is typically 16:1. Both courses have group activities, although the junior-level lab has a slightly stronger focus on individual work. The reason sophomore-level lab students were excluded from the study is that they had not yet completed a traditional F2F mechanical engineering lab prior to the start of these hybrid/online labs; thus, they would lack a relevant baseline to which they could compare their hybrid/online mechanical engineering lab experience. The structure of the survey was similar to the GLA survey but much shorter, focusing on what roles that the undergraduates would assign to their GLAs both pre- and post-transition to hybrid/online, and whether or not they felt their interactions with their GLAs were affected by the transition. There was one free response at the end that prompted recommendations for how to improve the labs and their delivery moving forward. Key questions that we sought to answer from the undergraduate perspective were:

1) *Did undergraduates feel that the role of their GLA had changed as a result of the transition from F2F to hybrid/online labs?*
2) *Do undergraduates identify specific weaknesses that GLAs could address in their laboratory role to improve the online labs moving forward? How could these be addressed in GLA training?*

Interview responses were audio-recorded and transcribed verbatim by the primary researcher and verified. After all identifying information was removed from the interview transcripts, the interview responses were shared with a small group of engineering and science education graduate researchers for help with coding. Descriptive and in vivo coding methods were used for first cycle coding, and pattern coding was used for second cycle coding. This project was conducted with approval of the institution's IRB, project #IRB2020-375.

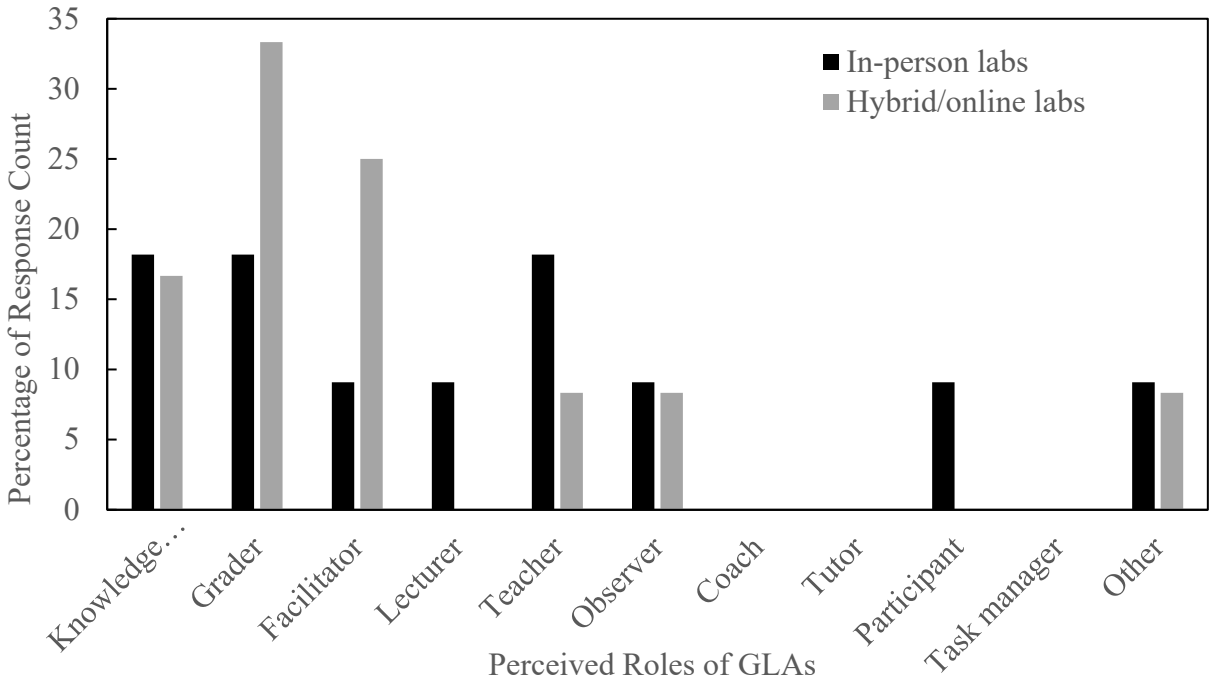
The graduate perspective on the role of GLAs in the lab

Before any change in roles could be commented on, the initial self-perception of a GLA's role and responsibilities in the laboratory classroom had to be assessed to provide a baseline for a "normal" in-person semester. Perhaps not surprisingly, all GLAs surveyed indicated that they noticed a change in their role and responsibilities since the transition to online/hybrid labs, with 60% responding that they felt their role had changed significantly. Over half of the GLAs indicated that they felt the time commitment and workload of the hybrid/online labs were higher than the traditional F2F labs, with only one GLA indicating that they felt the workload was lower

in the hybrid/online labs. This is consistent with the gentle shift in the average number of hours per week that they spent completing their GLA duties in traditional F2F labs compared to online. 60% of the GLAs indicated that they would spend 10-15 hours per week on GLA-related responsibilities when conducting traditional F2F labs, compared to an average of 15-20 hours per week after the transition to hybrid/online courses.

With regards to self-perceived roles prior to the transition, there was no clear "top role" in which GLAs saw themselves (Figure 1). However, after the transition to online labs, the GLAs felt more strongly about identifying themselves as graders and facilitators, and less as lecturers and participants. This shift in self-identification may be due to the strong associations of the words "teaching" with "lecturing", as the GLAs were no longer responsible for preparing full lectures for their sections after the transition to hybrid/online courses, though they could still provide supplemental information.

Figure 1: GLAs' perceptions of their role within the classroom



From both the free-response answers of the survey and the individual interviews, several salient themes could be identified, many of which were later echoed by the undergraduate students, predominantly observations that meaningful interactions with students and the level of student engagement was lower in a hybrid/online environment, as well as a desire for greater hands-on components or use of interactive simulations or virtual labs to supplement the instruction. Some quotes representing these themes are presented in Table 1.

From GLA interview responses, GLAs found that maintaining a positive lab climate in an online or hybrid course is difficult, and this is likely the reason it impacted the feelings of fulfillment by the GLAs who experienced the abrupt transition to online classes. During the interviews, there was a frequent pattern of identifying an obstacle to improving the

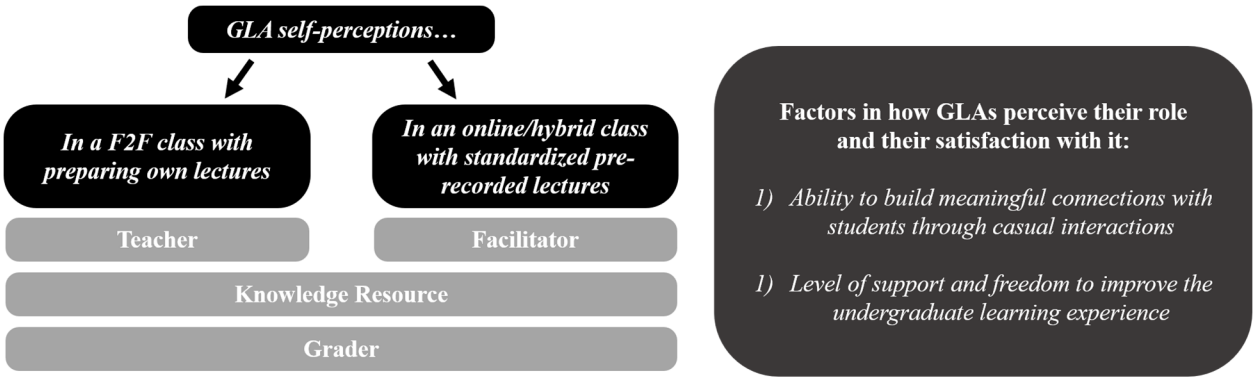
undergraduate learning experience, and then immediately expressing frustration with their inability to overcome that obstacle, either due to lack of time resources, training, or other departmental support. For instance, several GLAs commented that they felt the learning gains were less because students were "missing the point" of the labs, as "we're not interested in *what* you got as a result. We are more interested in knowing *why* you've got what you got." This could mean that a targeted pedagogical training intervention specific to online-specific strategies to promote deeper, more critical thinking might be useful to GLAs and increase their self-perception of their role [6]. Strong peer support and a mentor system might also help relieve some of the pressure from adjusting quickly to a new role as a result of the transition to hybrid/online labs [14].

Table 1: Salient themes from the graduate perspective and supporting quotes

1) Lack of meaningful, organic student interaction and low student engagement	▪ "The interaction with students in the online sessions is practically nil. I'm just speaking at them, not… receiving anything in response." ▪ "I receive almost no feedback from the online students whatsoever, unless I ask a direct question and do not answer move or talk until somebody else feels obligated to answer" ▪ "It is considerably more difficult to engage the students… Moreover, I find the work less engaging and less personal as I am not connecting with students as much... I just wish I could do more and help my students more." ▪ "That not having that interaction with the students and just being a guy in the computer is just something that is not fulfilling."
2) Difficulties without hands-on lab component / desire for interactive simulations or virtual lab	▪ "Students did not seem engaged and found it difficult to understand some engineering concepts without being able to interact in a hands-on setting" ▪ "Now [students] are not doing the experiment…They're just… watching videos of someone doing the experiment, and it's like, you watch people drive a car, and then ask them, 'Okay. You watch enough people drive a car, now come here and drive this car.' And that's not how it works." ▪ "Students can go into the lab 'virtually', do the experiment anytime they want, and again we can have fun with it… Create noise [in the data]. This gamification aspect … is very important. Students go there and are curious to see what's going on."

From the graduate responses in this study, we would like to propose the following preliminary conceptual framework in Figure 2 to capture how the course modality affects the self-perception of GLA roles as well as key factors that affect GLAs' satisfaction with their self-perceived roles. It would be interesting in the future to delve into how specifically GLAs felt their role differed from teachers to facilitators, and how they might best be supported or trained in those separate roles as opposed to being holistically supported by the department in a broader "GLA" role.

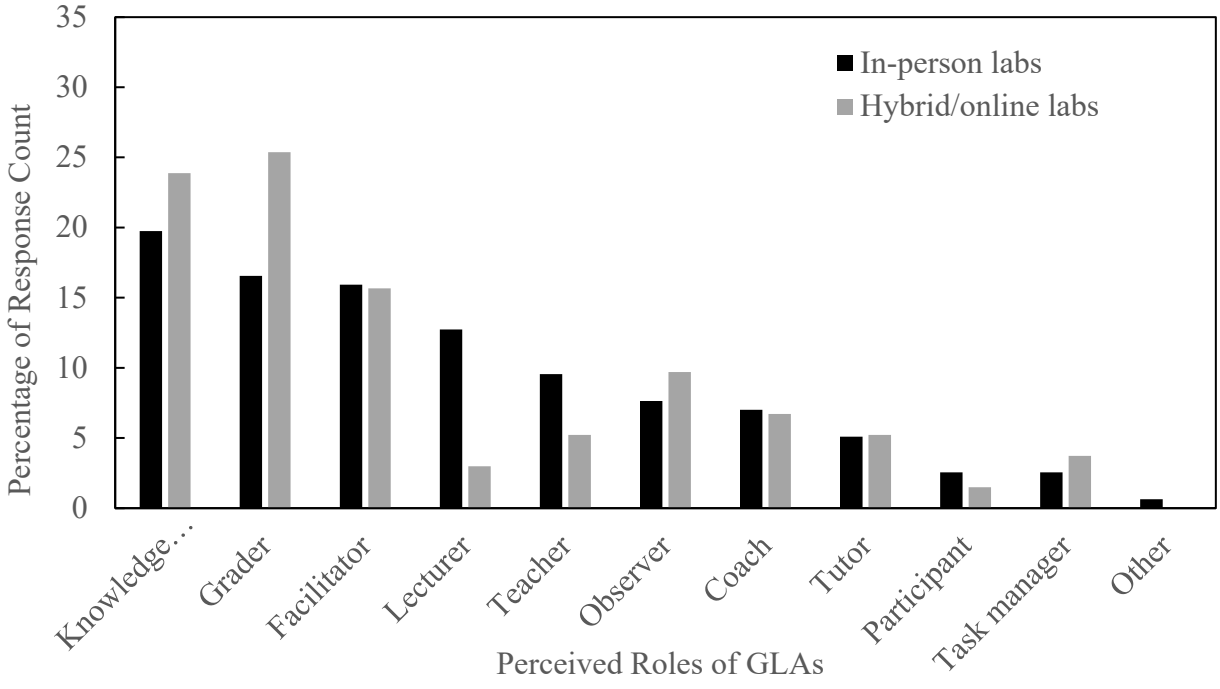
Figure 2: Preliminary outline of conceptual framework for GLA perceptions based on course modality and factors influencing perceived satisfaction with that role



The undergraduate perspective on the role of GLAs in the lab

When asked about how they perceived their GLA's role in the classroom prior to the transition to hybrid/online labs, students were allowed to select up to three words to describe this role. Ten pre-written options were randomized and made available for their choosing, along with an option to write in their own as "other". Students were later prompted to identify their GLAs' role in the hybrid/online labs after the transition. The results are summarized in Figure 2.

Figure 3: Undergraduate perceptions of their GLA's role in the classroom



Students consistently identified the top three roles of their GLAs as being knowledge resources, graders, and facilitators for both F2F and the hybrid/online labs. It is interesting to note that after the transition to hybrid/online labs, fewer students identified their GLAs as being

lecturers or teachers. After the transition to hybrid/online labs, students most often cited "grader" as their GLA's primary role in the course, a trend which GLAs mirrored in their self-perceptions. Furthermore, it appears that undergraduates felt that GLAs always served strongly in a facilitator role regardless of course modality, despite GLAs feeling more like facilitators after the switch to hybrid/online labs.

Despite the top three roles remaining consistent, only 12% of the undergraduate students felt that they interacted with their GLA was the same after the transition as it was in the F2F labs. An overwhelming 88% of undergraduate respondents felt that their interactions with their GLAs had changed, with 45% indicating that they felt their interactions were "extremely different" compared to prior semesters. While GLAs interviewees thought that they were more accessible to students with online office hours and more frequent emails back-and-forth with students, 47% of students felt that it was harder to get in touch with their GLA after the transition to hybrid/online labs than before to talk about assignments, deadlines, and course expectations.

Lastly, when asked if they had recommendations for the department to improve the implementation of hybrid/online mechanical engineering labs moving forward, two common themes emerged, summarized in Table 2. First, there was a call for a more "hands-on" aspect to the labs; the second was a split response to the format of the labs. Approximately half of the students who commented on the online modality of the course indicated a positive reaction to the video lectures and experiments, while the other half indicated a strong dislike for this format. For example, one student noted that "the lecture video aspect is great. The ability to pause and rewind if something didn't seem clear at the time is better than an F2F lecture [in my opinion]. More video lectures!" However, a less enthused student commented "Get rid of the pre-recorded lectures! It is much better to have the lectures face-to-face so that we can ask questions when we do not understand something." Responses that specifically mentioned GLAs or TAs indicated that a higher level of interaction with their GLA was desired than was received in the hybrid/online lab course.

From undergraduate responses, it appears that an intervention on how students can better engage themselves in online classes might be beneficial to both the students and their GLAs, as student attendance and engagement has been shown to have a strong impact on student satisfaction with a course's learning environment and satisfaction with their GTA [15]. An intervention to encourage undergraduates to be an active participant in their online courses would also be beneficial in increasing learning gains, as others have noted that achieving quality student-to-student and student-to-instructor interactions require different strategies in online formats than F2F and could be considered just as important as content coverage when it comes to calculating the academic rigor of a course or lab [16].

Several undergraduate students also commented on the feasibility of employing interactive simulations or virtual labs to help replace some of the "hands-on" learning that was "lost" in the transition to hybrid/online courses. However, they did not have a clear idea of how that could be done for some of the more complex engineering modules in the course; this was a noted obstacle by the GLAs as well.

Table 2: Major themes and supporting excerpts from undergraduate survey open response

1) "Hands-on" aspect of the labs	▪ "Maybe try to include some data collection, because that part of the lab, which is very important, is now non-existent" ▪ "The people who are… fully online are at a disadvantage when writing the report because they have never physically interacted with the equipment" ▪ "The video lectures and video lab experiments get the point across, but they are not engaging… making the experiment more interactive in some way would be valuable… as opposed to just watching a video" ▪ "This class was basically data post-processing 101"
2) Course modality and organization	▪ "It is difficult to connect the pre-recorded lecture material to the lab activities." ▪ "Having good alternatives [or simulations] for students who wish to do the labs online" ▪ "Having actual discussions led by the TA would be beneficial" ▪ "Have more information ready. Back in the classrooms, at the very least you can ask the TAs for help, but with everything virtualized people don't want to stand out." ▪ "The mandatory session at the beginning of each module should include frequently asked questions from previous years. I understand that they want us to come up with the questions ourselves, but... I had questions that I didn't even know how/what to ask."

Recommendations

Based on the results from this study, several recommendations can be made to help improve the implementation of hybrid/online mechanical engineering labs moving forward. The first would be to develop targeted training interventions specific to online-friendly strategies for promoting student engagement and interaction within an online classroom. Since pedagogical knowledge is not often explicitly taught to GLAs prior to their assistantship, it would be good practice to identify useful online strategies to help them better adjust to managing a hybrid or online lab environment in a facilitator role. Making the training specific to their intended role and classroom modality is likely to ease anxiety for GLAs and make them feel more comfortable and satisfied in their role in the classroom [17]. Better preparing the GLAs to manage the in-person or online classroom and deliver high-quality instruction to undergraduates not only reduces the stress on GLAs, but it also strongly benefits those GLAs who are seeking a career trajectory in academia by giving them a stronger background in teaching.

A second recommendation would be to convert some of the engineering lab modules to interactive online simulations or virtual lab setups to re-introduce some of the "hands-on" experience that was lost in the rapid transition to online labs. The need or usefulness of a virtual

lab or simulation was stated by both GLAs and undergraduates as a way to improve their satisfaction with the lab courses, but a clear path to developing and maintaining those resources was not defined. Therein appears to lie a major drawback in the current available resources to mechanical engineering labs; when executed correctly, virtual labs have the potential to offer similar learning gains, but they are difficult to program and maintain without substantial financial, technical, and professional support from the university [18]. It may be worthwhile to consider collaborating with other universities to build a network of virtual labs to help share the cost of development and maintenance, though this would still introduce its own complexities of managing and actively maintaining that collaboration [18]. It should be noted that other STEM disciplines such as biology have already successfully developed these types of collaborations and video/simulation repositories (e.g. JoVE, Harvard's LabXchange, etc.); however, labs specific to mechanical engineering curricula are currently more difficult to locate.

Limitations

There are significant limitations to the generalizability of this study, namely in its narrow focus on mechanical engineering labs with a small sample size of available GLAs. If GLAs from a different STEM department followed a similar transition from primarily F2F live lecturing to leading virtual labs with accompanying pre-recorded lectures and experiments, these recommendations may be relevant to help that department improve their implementation of the labs. This transition from live lecturing in F2F labs to standardized, pre-recorded lectures likely contributed to the strong shift in self-perception of GLA roles, so the conclusions in this paper may not apply to lab courses whose GLAs continued to deliver live, self-developed lectures during the transition to an online/hybrid modality. A good avenue of future study would be to compare how other STEM departments within the college or other mechanical engineering departments across the nation were able to transition their lab experiences from a traditional F2F to hybrid/online formats. A similar study could be setup to examine how GLAs in those departments were traditionally utilized in the F2F labs compared to how they were involved in the labs after their rapid transition to being hybrid or fully online.

Conclusion and Future Work

To add to a limited body of knowledge on the subject, this multi-methods study employed a combination of surveys and individual interviews to paint a broader picture of how the perceptions of GLA roles within the mechanical engineering laboratory courses could shift due to a shift in course modality. A preliminary conceptual framework was proposed to help describe the roles perceived in F2F labs compared to hybrid/online labs, as well as describe major factors affecting GLA satisfaction with their self-perceived roles. The experiences of graduate students in mechanical engineering are generally under-studied and not yet well understood, so undergraduate perceptions of their GLAs were also surveyed to compare how the GLAs' students saw the GLAs with how the GLAs saw themselves in each mode of course delivery.

As the labs shifted to hybrid/online format, GLAs identified themselves more strongly as graders and facilitators as opposed to teachers and lecturers; this could be attributed to the use of pre-recorded standardized lecture and experiment videos in the hybrid/online format, whereas

GLAs were used to preparing their own lecture materials in the F2F lab modality. Meanwhile, undergraduates identified the role of their GLAs as knowledge resources, graders, and facilitators regardless of the course modality, although they identified GLAs less often as lecturers in the hybrid/online format. From analysis of survey free responses and interview responses, several recommendations were made to improve the implementation of online mechanical engineering laboratory courses moving forward. In future phases of this work, we would like to collaborate with other STEM departments to learn how they handled the rapid transition of their labs from in-person F2F to hybrid/online formats, and how this affected their GLAs. This will help build a foundation to better support GLAs and other graduate teaching assistants in the future across other STEM disciplines.

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Appendix A. Examples of pre-selected semi-structured interview questions

- How would you describe your role as a GLA conducting in-person labs, prior to the onset of COVID-19?
- How would you describe your role as a GLA now, conducting either fully online or hybrid labs during COVID-19?
- Have you noticed any change in your role or responsibilities as a GLA since the transition to online/hybrid labs?
- What are challenges you have faced when conducting online/hybrid labs this semester?
- What strategies have you found useful when conducting online/hybrid labs this semester? (*Follow up:* Are these strategies similar to or different than those used when conducting in-person labs?)