

Hands-Off: Perceptions of Biomedical Engineering Technology Internships under a Global Pandemic

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Abstract

Internships are an integral component of bio-medical engineering programs, as they provide students with hands-on experience working in real-world settings. To fully capture the benefits of an immersive environment, internships are traditionally conducted in person. In this pilot study, we assessed the extent to which virtual internships could provide similar benefits. We surveyed student interns (n=9) and their supervisors to evaluate the benefits of the internship experience for both the student and the supervisor/site, the learning objectives and experiences that students and supervisors find most important, and strategies for maintaining these important learning objectives in a virtual setting. Supervisors indicated that the most important objectives were real-world experience, increased confidence and working with others; while students said that getting hands on experience with various medical devices and preventative maintenance procedures and gaining experience with troubleshooting were most important. The study identified challenges associated with internships and outcomes and experiences that were important to include in a virtual alternative. The results of this study can be applied broadly to ensure that internships, regardless of modality, are worthwhile experiences for both students and supervisors.

Keywords

Internship; Biomedical Engineering Technology; Clinical Engineering; Experiential Learning; Virtual Internship

Introduction

Identified in the late 2000s as a high impact practice (HIP), internships in fields such as biomedical engineering technology/clinical engineering have been shown to provide numerous benefits in terms of student success [1]–[7]. Student learning and development during the internship experience occurs in the professional, academic, personal, and civic domains and can include knowledge, skills, and attitudes/values in each domain [1]. Specific examples of ways students benefit from internships include improving technical and soft skills, gaining confidence and an understanding of how the industry works, getting opportunities to interact with professionals, and acquiring real world experience [2]–[4], [6], [8]. Much of the existing research focuses on these benefits to students, while attention to other aspects of building effective, reciprocal internship practices is more limited.

Benefits of Internships

There are few studies, for example, that focus on the benefits of the internship to the internship supervisors and the organizations they represent. While scholars recognize that mutual benefit is a goal of internship practices, most of the published studies focus on contributions the students make to the supervision site, ranging from picking up extra workload, motivating staff members to get involved in professional activities, and gaining a stronger appreciation for the skill sets that new hires bring to the table, such as relieving work load and motivating staff members (at the supervision site) to get involved [3], [6]. Part of the relative lack of scholarly attention may not be due to lack of interest. There are considerable administrative and logistical challenges to studying impact on internship sites, including divergent views on the significance of conducting such research and the investment of time that it requires.

A number of studies do focus on the concept of reciprocity more broadly, aggregating it across multiple HIPs, including internships, service learning, and study abroad. The concept of reciprocity considers students, faculty, and community members as co-educators and co-learners [9]. A recent study by Sauder et al, for example, used survey-based research to highlight the divergent perceptions of all stakeholders, including students, faculty, and employers, related to internships across multiple disciplines [10]. Another recent study examined perceptions of internships in engineering, finding that both supervisors and students could benefit from more formal training prior to the internship [11]. While this desire for more training often emphasizes workplace or career-ready training, the present study seeks to further examine the reciprocal benefits of internships in the field of bio-medical engineering, with an emphasis on providing proactive guidance, whether for the university coordinator, the instructor, the students, the site supervisor, or all of the above. Ultimately, the goal is to identify, design, and implement internship experiences that maximize these reciprocal outcomes, regardless of modality.

Virtual Internships

Prior to the pandemic, there were no known studies that has examined how the important outcomes and learning objectives of a biomedical engineering technology/clinical engineering internship could be maintained through a virtual experience. Other fields, where remote work is more available (i.e., information systems/information technology), had successfully adapted traditional internships to a remote format [12], [13]. Several engineering disciplines, including biomedical engineering, have also offered virtual internships, mainly focusing on engineering design [14]–[16]. For example, one faculty team employed a simulation of the experience that students might have at engineering company, designing hemodialysis membranes and robotic legs, to allow educators to assess key aspects of engineering thinking [14]. Much research still needs to be done on identifying the affordances of virtual internships, such as accessibility, as well as the opportunity costs associated with the loss of physical proximity. The distinctions have become increasingly salient as more employers appear to be ready to adopt permanent, post-pandemic hybrid or remote work policies [17].

Virtual internship became a more prevalent object of study during the Covid-19 pandemic when, in many cases, students were forced to quickly shift from in-person to virtual internships. Several recent publications have discussed development of virtual internship opportunities in response to the pandemic. [18], [19]. Similar transitions to virtual formats have been described

for other related forms of experiential learning in biomedical engineering. In one case, virtual reality technology was used to create experiential learning environments of interdisciplinary settings, which focused on collaboration and equipment malfunctions [20]. In another, a clinical immersion program for biomedical engineering students, where participants evaluated clinical needs to address in a capstone project, was effectively pivoted to a remote format [21]. Largely out of necessity, these studies have focused more on the adaptation process than the systematic measurement of reciprocal outcomes or virtual internship designs. While the immediate needs for virtual internship opportunities, caused by COVID-19, may be dwindling, these modalities will likely have a role in addressing access and equity in both the workforce and higher education in the near future [13], [18].

Equity and Access

There is emerging evidence that the availability of hybrid or remote work options may be especially beneficial to women and workers from populations historically under-represented in STEM fields [22]. Indeed, taken as a whole, HIPs have been shown to provide particular benefits to students from these under-represented groups who participate in them, but they have also been criticized for limitations on access and inclusion [23], [24]. Like other STEM fields, biomedical engineering technology is actively seeking strategies for increasing the diversity of its work force [25], as well as providing career opportunities for both traditional and non-traditional students, the latter of whom often have work and family commitments outside of school, making participation in conventional internships more challenging [26]. The present study explores the implications not just of offering internships in one format versus another, but the extent to which it may be advisable to provide multiple pathways to and through internships as part of the biomedical engineering technology curriculum.

The Study

Context and Intervention

Students in the Biomedical Engineering Technology associate degree program at *State University*, a commuter campus of a large, public, research-intensive university located in the mid-Atlantic region of the United States, are required to complete a semester-long, internship, typically in a hospital's clinical engineering department, as the last course for their degree. The overall goal of the internship is to provide the student with 400 hours of hands-on experience in an actual work environment on patient care and life support equipment. The internship supports all five of the program's student outcomes, shown in Table 1.

Table 1 Biomedical Engineering Technology Student Outcomes.

1. An ability to apply knowledge, techniques, skills, and modern tools of mathematics, science, engineering and technology to solve well-defined engineering problems appropriate to the discipline.
2. An ability to design solutions for well-defined technical problems and assist with engineering design of systems, components, or processes appropriate to the discipline.
3. An ability to apply written, oral, and graphical communication in both technical and non-technical environments; and an ability to identify and use appropriate technical literature.
4. An ability to conduct standard tests, measurements, and experiments and to analyze and interpret the results.
5. An ability to function effectively as member of technical team.

In addition, a number of required topics are covered during the internship. Students and supervisors are given a checklist of things that the interns should see and do by the end of the internship. These include equipment inspection and maintenance on a wide variety of medical devices; test equipment operation; documentation; medical device repair and troubleshooting; familiarization with safety policies; and professional development. Students are then asked to summarize their experience in a journal and final paper. The students write a daily journal, outlining the activities that they participated in each day. In their final paper, they summarize experiences with hospital departments, functions, and equipment; write an overall evaluation of the internship experience; and outline an example of the process that they used to solve a technical problem.

Due to the COVID-19 pandemic, some students were unable to complete an in-person internship in a hospital setting during the summer of 2020. Many hospitals suspended all internships during the early part of the COVID-19 pandemic, and some did not allow them to return during summer 2020. Other students opted not to do in person internships due to personal or family concerns about COVID-19. Therefore, we designed and taught a virtual course for these students, aiming to meet similar goals, objectives, and required topics of the internship. We employed a variety of strategies, using both synchronous and asynchronous online content, to meet these requirements. A series of equipment videos, webinars, and short online training courses allowed the students to learn equipment inspection and maintenance procedures and test equipment operation remotely. We designed troubleshooting assignments using videos, images, verbal descriptions of device malfunctions, and service manuals to give students the opportunity to practice troubleshooting without actually being in the presence of the devices. We also invited a number of guest speakers to discuss different aspects of the job with the students and to answer questions in a virtual format. This was particularly important as, by not doing in-person internships, the students were missing the opportunity to see how things work in the clinical engineering departments and to make connections in the industry. In addition, the students participated in practice interviews and virtually participated in team assignments using Zoom (or a similar platform).

Methods

Our data collecting methods included surveys given to both virtual internship students (n=3) and in-person students (n=6) during the summer or fall semester of 2020. A total of 11 students enrolled in internship classes during these semesters, and nine completed the survey. Surveys were also given to professionals who supervised in-person internship students between 2016 and 2020 (n=5). All surveys were disseminated electronically via Qualtrics. Email links were sent to ask students and professionals to complete the anonymous survey in August of 2020.

Students and professionals were asked to rate the importance of each learning objective or experience on a scale of 0 to 4, with 0 being not important and 4 being very important. The rated learning objectives are shown in Table 2.

Table 2 Learning Objectives for the Internship.

1. Familiarizing student with various medical devices/ preventative maintenance procedures.
2. Learning how things work in the biomedical/clinical engineering department.
3. Developing communication skills.
4. Gaining experience with problem solving and troubleshooting.
5. Making professional contracts.
6. Gaining confidence
7. Improving technical skills.
8. Teamwork.

Participants were also asked to rate the importance of maintaining each of the learning objectives or experiences in a virtual alternative to an internship using the same scale. In addition to ratings, participants were also asked to leave comments on open-ended questions pertaining to the above learning objectives. Additional open-ended questions asked about benefits and challenges of internships to students and supervisors/sites and about virtual alternatives to an internship.

Descriptive statistics were used to evaluate the numerical ratings, and Wilcoxon tests were used to compare supervisor and student responses. Open-ended responses were coded thematically by two of the researchers, an instructor and a student. Their findings were checked by an educational research expert.

Results

Traditional In-person Internship

Figure 1 shows the average ratings that students and supervisors provided for the importance of each learning objective or experience in an in-person internship as well as the average rating from all survey participants. Supervisors indicated that it is most important for students to learn how things work in a biomed/clinical engineering department, gain confidence, and learn to

work with others in the department. Students, on the other hand, felt that getting hands on experience with various medical devices and preventative maintenance (PM) procedures and gaining experience with troubleshooting were most important during their internship. Both supervisors and students indicated that making professional contacts was least important for students during their internship. Two of the objectives were found to be significantly more important to supervisors than to students. These include students gaining confidence during their internship ($p = 0.06$) and teamwork ($p = 0.09$). This disconnect between supervisor and student perceptions aligns with the findings of Sauder et. al, particularly students having different perceptions from other stakeholders [10].

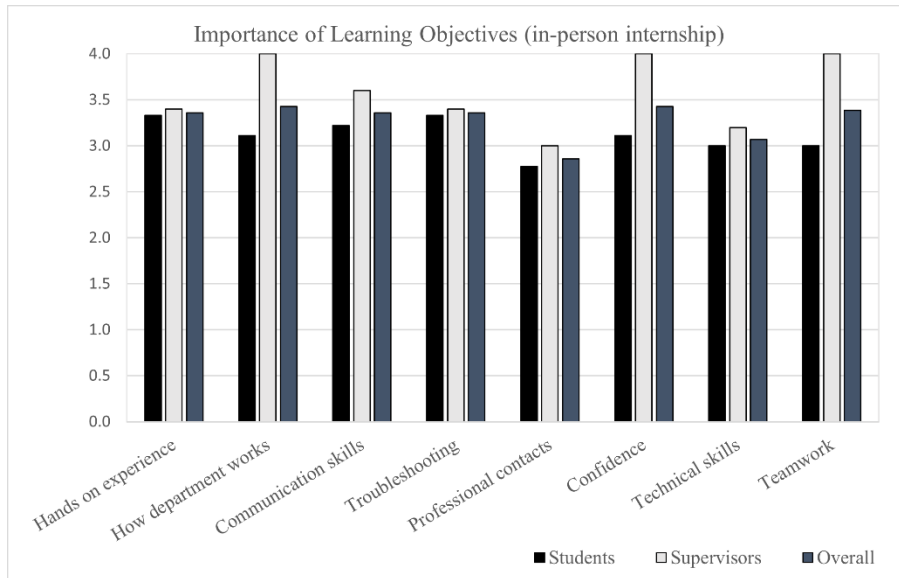


Fig. 1 Relative Importance of Learning Objectives in an In-Person Internship

Virtual Internship Alternative

Figure 2 shows the average ratings that students and supervisors provided for the importance of maintaining a learning objective or experience in a virtual alternative to an internship as well as an average rating for all participants. Supervisors felt that familiarizing students with various medical devices and PM procedures, learning how things work in a biomed/clinical engineering department, and developing communication skills were the most important objectives to maintain in a virtual course. Students thought that making professional contacts and teamwork were the most important objectives to keep in the virtual course. While students found making professional contacts to be most important to maintain, supervisors felt this was least important.

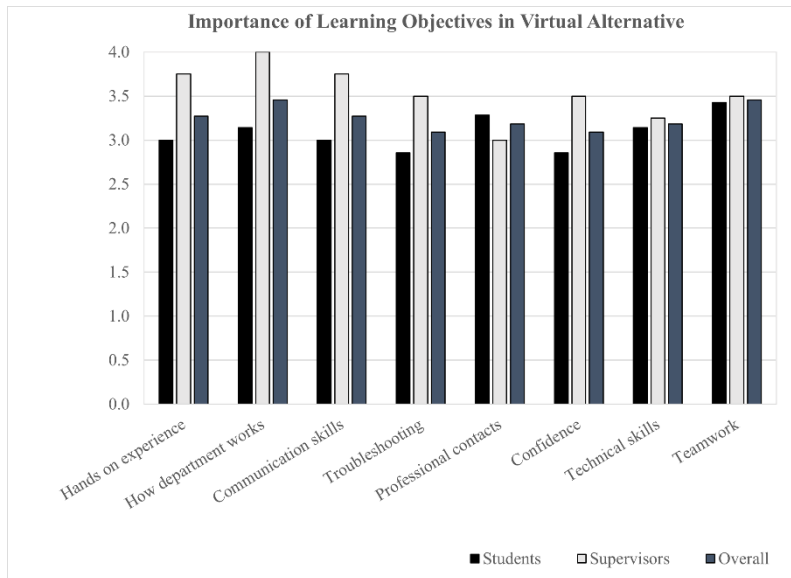


Fig. 2 Relative Importance of Learning Objectives in a Virtual Internship

In addition to the results from the rated portions, the open-ended questions also gave immense insight to the importance of the internships. One student explained the importance of communication, “being able to talk professionally with the nurses and clinicians and be able to explain technical terms in language they understand.” Another student stated “the ability to ask questions and keep on learning” is another important aspect to the internship experience. The professional supervisors also commented on aspects but from a different point of view. One supervisor stated: “[students get] to see what it is like in a real-world environment and to work with a wide variety of individuals and personality types” to give an overview on the importance of internship over the years. These quotes reinforce the importance of the internship and the difficulty of replicating some of the experiences and benefits.

Benefits and Challenges

The survey also identified benefits and challenges to both students and their supervisors and departments. Top benefits to students include getting hands on experience and on the job training, meeting professionals, and getting a better understanding of the job by seeing how a hospital works. The benefit to supervisors and departments that was most commonly identified was having the chance to hire someone already familiar with job and location and to observe the intern’s skills before deciding whether to hire them. Other benefits to supervisors and departments identified in the survey include a temporary expansion of staffing, helping to promote the field, the possibility of learning different troubleshooting techniques from the intern, and having the opportunity to assist a new biomed in getting their career started and figuring out their interests. The benefits to students identified here align well with those discussed in previous studies [2]–[4], [6], as do a number of the identified benefits to supervisors [3], [6]. A few benefits to supervisors were not highlighted in previous publications, such as the supervisor learning new troubleshooting methods from the intern and opportunities to promote and grow the

field. A number of challenges for students were identified, including communication, staying engaged, learning quickly, and proving themselves to get hired. The most common challenges for supervisors were finding the resources to train students effectively and avoid having students sit idle when things get busy as well as getting interns approved. The benefits and challenges identified by the students completing in person internships and those taking the virtual course were similar.

Suggestions for improving a virtual internship alternative were also outlined in the survey. These include exposing students to equipment in specialized areas such as the operating room (which we are not able to replicate on campus), facilitating relationship building with supervisors and other professionals in the field, and including more troubleshooting practice. Some supervisors who responded to the survey stated that they did not think virtual internships are sufficient in this field. One supervisor stated “as a hiring manager a virtual internship means very little to me. It may check the box for a college or HR Dept, but it does not add value to a candidate in my eyes.” and another stated, “I don't think a virtual internship is adequate for this field.”

Discussion

Traditional In-Person Internships

Overall, our study showed that internships play an important role in student learning, especially in such a hands-on field as biomedical engineering technology. Internships give students hands on experience and, just as importantly, experience with how a department works. Supervisors and students had somewhat different views of what is most important in an internship. Supervisors indicated that learning how things work in the department, gaining confidence, and working with others were most important for students. Students themselves found getting hands on experience with devices, procedures, and troubleshooting to be most important.

Furthermore, students and supervisors/ facilities receive multiple benefits from participating in the internship. The benefits to students included meeting health care technology management professionals to expand career connections and relationships. Students also benefited from seeing how the hospital works and gaining a better understanding of the biomedical engineering technician position. One student is quoted saying the internship “bridges the gap between the classroom and life,” demonstrating that the internship gives students the opportunity and environment to use their knowledge in a real work environment.

Paired with the benefits, there can also be challenges to both parties of participants. For the students, noted challenges are staying engaged, communicating effectively with staff, applying classroom knowledge, and absorbing everything. The internship experience can be overwhelming at times, and it can be challenging for students to remember everything the learned and to apply it to device troubleshooting and problem-solving situations. There can also be a lot to learn and see during the internship period, making it difficult to absorb everything that

is offered. Similar challenges were identified by students completing in person internships and virtual alternatives.

Lessons learned from this study are helpful in improving future internship experiences, whether in person or virtual. From a student perspective, staying engaged during the internship, asking questions, and seeking out opportunities to learn will lead to the most rewarding experience. Participating in networking events with alumni and other professionals prior to starting the internship may help students to better know what to expect during the internship and to become familiar with various hospitals and companies.

From a faculty perspective, it is important to consider how classes are preparing students for internship as well as how to optimize the internship course design. Student needs, as well as those of the supervisor, internship site, and future employer, should be considered when designing an internship course. This study reinforced that while we want to make sure that the students are getting to experience as much as possible and doing things that will prepare them for a job in the field, it is also important to make sure that what the students are required to do is reasonable to the department. Academic programs must balance the risks of overburdening the internship sites and the requirements so that everyone has a positive experience. In addition, faculty can help to shape a positive internship experience by preparing students for the internship throughout the curriculum. The importance of communication was mentioned in our survey. We have thus increased focus on communication skills in classes leading up to internship. For example, we have added practice with professional email writing, simulated situations where students talk with nurses and other staff with non-technical or different technical backgrounds and provided experience calling tech support in our classes to better prepare students for their internship and career.

Our survey also showed how internships can benefit the professionals who supervise student internships. Benefits to the supervisors and facilities differ than those of the students. These benefits include having temporary expansion of staff and having the opportunity to hire someone with facility specific experience. Supervisors are able to see the interns' strengths and identify any weakness in the event that the intern can be hired for full time employment within their organization. Supervisors can evaluate the intern's soft-skills and make suggestions. Supervisors and departments also benefit from having the opportunity to promote and grow the profession of healthcare technology management. There are also challenges to the supervisor and department. For the supervisors, struggles are seen in having the resources to train students effectively, especially when things get busy, getting approval from their facility, and being a good a teacher. One supervisor explained their own stance on the challenges of the internship by saying, "making sure you give the student every opportunity to see, work with and understand required medical devices and department functions."

Virtual Internship Alternative

All students who took the virtual alternative to the internship during the Covid-19 pandemic graduated on time and gained employment in the field following completion of the degree. Overall, the goals and objectives of the course were met, but our study reinforced the importance

of a hands on, in-person internship experience in this field. In fact, several supervisors, who regularly supervise our interns and hire our graduates, commented that they did not think a virtual internship was adequate in this field.

Although a virtual alternative to the internship is not likely to be a part of the program long term, we did find value in the experience. One benefit of this experience is improving accessibility. We now have a framework in place that can be used if student is unable to complete an in-person internship in the future. In addition, the content and strategies developed for this course can be applied to complement in-person internships. Some virtual learning could be added to the internship course or used in courses leading up to the internship to help students better prepare for the experience. For example, some remote troubleshooting activities that we used in this course would be good practice for students to learn how to troubleshoot a problem over the phone.

Another component of this virtual alternative to the internship that can be leveraged to enhance student experience in the future facilitating student connection with a broader and more diverse group of professionals. We effectively used web conferencing for a number of guest lectures and question and answer sessions. Continuing this practice in the future will allow us to diversify the professionals that our students can meet leading up to their internship. In addition, online videos and trainings can be used to provide the students with extra practice, review, or introductions to different models of equipment prior to or during an in-person internship. Tools that we were not able to utilize in this iteration of the course, which would be beneficial if we needed to teach this class again in the future or as a compliment to an in-person internship, are virtual reality or immersive 360-degree videos. These technologies could be used to help students learn how things work in a biomed/clinical engineering department, which was very important to supervisors that oversee interns and employ graduates, as well as to introduce students to particular medical devices.

Limitations

While our study gave insight into the benefits, challenges, and important aspects of internships from student and professional perspective, it was limited by small sample size. The virtual internship was limited by the timeline. The survey was conducted following completion of the course, so input from the survey was not used in this iteration of the course. Accreditation requirements, as well as acquired feedback, make it unlikely that we will offer a completely virtual internship again. However, despite the limitations, the results of this study, as well as our experience, will guide us in strengthening the internship experience for students in the future.

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