Bridging the Gap: A Mixed-Methods Study of Engineering Internships Through Surveys and Interviews

Abigail Nichole Lehto, Utah State University

Abigail Lehto is a PhD student studying engineering education at Utah State University. She has a M.S. in engineering education and a Bachelor's degree in mechanical engineering, both from Utah State University. Abigail's research interests are engineering research with underrepresented groups, and industry-academia connections in engineering.

Prof. Ning Fang, Utah State University

Ning Fang is a Professor in the Department of Engineering Education at Utah State University, U.S.A. He has taught a variety of courses at both graduate and undergraduate levels, such as engineering dynamics, metal machining, and design for manufacturing

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Abigail Lehto, Ning Fang
Engineering Education Department
Utah State University

Abstract

Undergraduate students in engineering often seek industry internships to expand their knowledge of industry and apply skills they have learned from their education. Existing research reports that students have an overall positive experience and experience learning gains in their internships. However, existing research has two important gaps. First, most research relies on surveys alone for data collection, with no subsequent interviews. Interviews provide more in-depth information on student experiences. Second, most research focuses on the overall experience and skills that students learned in internships, with few further investigations on specific aspects that contribute to the overall experience of student internships. The present study addresses these research gaps by using a mixed-methods approach involving surveys and semi-structured interviews with a group of engineering students who recently completed their summer industry internships.

The results from surveys show an overall positive experience for student interns and found potential challenges, benefits, and perceptions that students reported from their internship experiences. The results from interviews further reveal that the main challenge students faced was with the organization of industry versus the more familiar organization of academia. Students noted a lot more freedom in their internships and looked to their industry mentors to help create structure. The main benefit students noted from their internships was being offered long-term employment or extensions of their internships from the companies they interned with. Students noted an overall positive perception of internships and emphasized that the importance of having an internship was for them to reach their educational goals. The findings generated from the present study not only corroborate the generally positive perception of student internships reported in the literature but also provide new insights into the multifaceted nature of student internship experiences, especially challenges and personal growth opportunities.

Introduction

As engineering students move through their education, they learn many skills that they will utilize in industry jobs following their graduation. They also, while still in college, seek internship opportunities to apply skills they have already learned and learn new skills that will make them more marketable to future employers. Relevant research in this area shows that most engineering students perceive their internship experience to be positive [1,2,3,4,5,6,7,8].

Recent studies related to students' engineering internship experiences reported that, during their internships, students learn how to present ideas and see how the industry operates, as opposed to the more technical or analytical skills that they may learn in academia [2,8,9]. Engineering professors believe that some skills should be taught to students but do not fit seamlessly into the engineering curriculum. Professors also believe that internships do well at teaching these skills [10].

However, existing research has two important gaps limiting an in-depth understanding of student internship experiences. The first research gap exists in methodology as many existing quantitative studies (conducted by other researchers) in this area rely on survey instruments *alone* for data collection, with no subsequent interviews [2,6,7,9,11]. Interviews can provide more in-depth information and a better understanding of student internship experience. The present study (conducted by the authors of this paper) bridges this first gap by using a mixed-methods approach that includes both surveys and semi-structured interviews.

The second gap of existing research exists in empirical data because existing studies (conducted by other researchers) focus on the overall experience and skills that students learned in an internship [1,3,4,5,8,10,12,13,14]. Although it is important to understand the overall experience of student internships, understanding what specific aspects contribute to the overall experience would help the engineering education community develop more effective approaches for university-industry collaboration. The present study (conducted by the authors of this paper) bridges this second gap by focusing on specific aspects, including challenges, benefits, and perceptions, that contribute to the overall experience of student internships.

This paper is submitted to the ASEE Gulf Southwest Conference 2024 under the third track of the conference - Global/Industry/Community Collaboration, specifically for its two topics on Empowering Engineering and Computer Science Education and Research as well as Community and Industry Engagement. In the remaining sections of this paper, a relevant literature review is provided, followed by a description of the research methodology employed in the present study. The results are presented with a discussion. Conclusions and implications are made at the end of the paper.

Literature Review

Student Internship Experiences

Many studies relating to student internship experiences reported common findings and reported students having overall positive experiences with engineering internships [1,2,3,4,5,6,8]. When talking about experiences, existing research also focuses on the skills students are learning or utilizing during their internships. The common non-technical (soft) skills students utilized internships to develop or improve were: communication, teamwork skills, and networking skills [1,3,5,9,14,15]. The common technical (hard) skills or knowledge students utilized internships to develop or improve were: familiarity with the industry climate and operation, problem-solving skills, and the application of their education to hands-on experiences [1,5,6,7,12,13,14].

Also among the research on student internship experiences is a discussion of students learning more about how different jobs in the engineering industry operate and what a day as an engineer looks like.

Specific experiences noted in this area were students working with their mentors to create goals and expectations [11], and using their role to network with others in industry [1]. In addition to this, students mentioned making connections from their education to industry tasks [1,6], and sometimes having a negative experience due to the feeling of being in the incorrect field [6].

While existing research on student experiences in engineering internships provides insights into an overall positive experience and student learning about industry, more research is needed on the specific aspects that contribute to student internship experiences.

Research Methods

The majority of research on student internships in engineering fields utilizes either qualitative or mixed-methods methodology [1,3,4,5,8,12,13,14,15]. Most mixed-methods studies utilize surveys and interviews for data collection, and most qualitative studies collect data via interviews. The majority of quantitative studies on student internships in engineering fields use surveys for data collection [2,6,7,9,11]. However, surveys utilized in existing quantitative research focus on only one aspect of the student internship experience, such as learning gains in specific skills, mentor interactions, or overall experience [2,7,9,11]. The main skills focused on in these studies are problem-solving skills, communication skills, and technical skills related to a specific engineering discipline [2,7,9,11]. While one study by Murad and Rose [6] does look at multiple facets of the internship experiences for student interns, it focuses only on civil engineering students' perspectives [6].

The present study looks to fill the gap in research methodology by developing and implementing a survey that collects data on the multiple facets of students' internship experiences. By collecting this data, researchers (i.e., the authors of this paper) aim to create a complete picture of student internship experience in engineering fields. Instead of focusing on one specific aspect of an internship experience, or the overall experience itself, the present research focuses on multiple specific aspects that contribute to an overall internship experience. In addition to these aspects, the present study introduces the new aspects of challenges, benefits, and perceptions students encounter during an internship experience.

Methodology Employed in the Present Study

Research Question

The overall research question that the present study seeks to answer is: How do engineering students perceive an industry internship experience? To answer this research question, a mixed-methods study that included quantitative surveys and qualitative interviews was conducted.

Sampling

The sample for the present study was chosen via quota sampling. Initially, all eligible engineering students at the authors' institution were given the opportunity to apply for the summer internship program. Students who were selected for internships were sent to the program's industry partners. During the middle and the end of their internships, students were invited to participate in the present

study and offered Amazon gift cards as compensation for their participation (i.e., surveys and interviews) in the present study. The quota for the sample in the present study is having a summer internship through this program.

The method of quota sampling was chosen to ensure some uniformity in the internships students were participating in. The program offering and placing students in internships worked with industry partners to place students with companies they were interested in and where students' skills could help the company. By effectively placing students, there is more benefit to both students and industry partners.

It needs to be pointed out that the present study is part of a sponsored program that aimed to recruit 14 engineering students for internships in 7 companies and organizations in the summer of 2023 (May through August). The financial constraints of the program did not allow for more student participation. Therefore, the present study only focuses on these 14 engineering students whom we have recruited from 53 student applicants through a competitive selection process.

These 14 students included 4 students from the Department of Biological Engineering, 4 students from the Department of Electrical and Computer Engineering, and 6 students from the Department of Mechanical and Aerospace Engineering at the authors' institution. Among these 14 students, 8 are male students and 6 are female students. The limitation of this sample size will be addressed in future studies when more funding support is available so we can send more students for summer internships.

Data Collection

Data for this mixed-methods study was collected via a survey administered to the students at the mid and end points of their internship experience. A semi-structured interview was also completed at the end of the students' internship experience. Quantitative data came from the surveys and qualitative data from the semi-structured interviews. Survey questions focused on students' overall experience, perception, learning gains, and likeliness to accept a job from the company where they interned. Survey questions were based on a 5-point Likert-scale with 1 indicating the most negative responses and 5 indicating the most positive responses.

Interview questions focused on students' experiences, challenges students faced during their internships, and students' perceived benefits of internships. Initial interview questions were related to student survey responses; further questions were then asked based on initial responses. Interviews were completed via Zoom and recorded with the interviewees' permission. Interviewees were also informed of the anonymity of their responses (i.e. individual responses would not be shared with industry partners). Transcripts of the recorded interviews were reviewed and compared with recordings for accuracy.

Data Analysis

From the quantitative surveys, mean scores out of 5 from the mid- and end-point responses were calculated and compared via a t-test. Results from the quantitative surveys gave researchers potential interview points for the semi-structured interviews. Transcripts of the semi-structured interviews were

coded using three categories of codes: challenges, benefits, and perception. The challenges code indicates struggles students may have had, or aspects of the internship they noted as being difficult. The benefits code indicates aspects students noted as being helpful or valuable outside of the internship itself. The perception code indicates aspects related to students' experience and views on internships.

Results and Discussion

Survey Comparison

Results of the t-test showed no statistically significant difference in means from the mid- to end- point survey responses (p = 0.477). This result speaks to the consistency of students' internship activities because there is no significant change (positive or negative) in perception, learning gains, or likeliness to accept a job from one point in the internship to another. Students reported a mean of 4.14 out of 5 for overall experience, and 4.64 out of 5 for the perception of industry internships.

The scale of 5 indicates the most positive experience or perception. Students also reported a mean score of 4.50 out of 5 for understanding industry jobs, and a 4.07 out of 5 for understanding industry trends. These results are consistent with the topics of survey questions, which are shown in Table 1. Mean scores from the mid- and end-point surveys are shown in Figure 1. The full survey is included in Appendix I.

Table 1. Survey Questions and Topics

Question Number	Question Topic
1	Overall experience
2	Perception
3	Learning gains: New knowledge in your academic discipline
4	Learning gains: Understanding of what industry jobs look like
5	Learning gains: Understanding of current and future trends of the industry field in which you do internships
6	Learning gains: Problem-solving skills
7	Learning gains: Communication skills
8	Learning gains: Team-working skills
9	Likeliness to accept a job from internship company

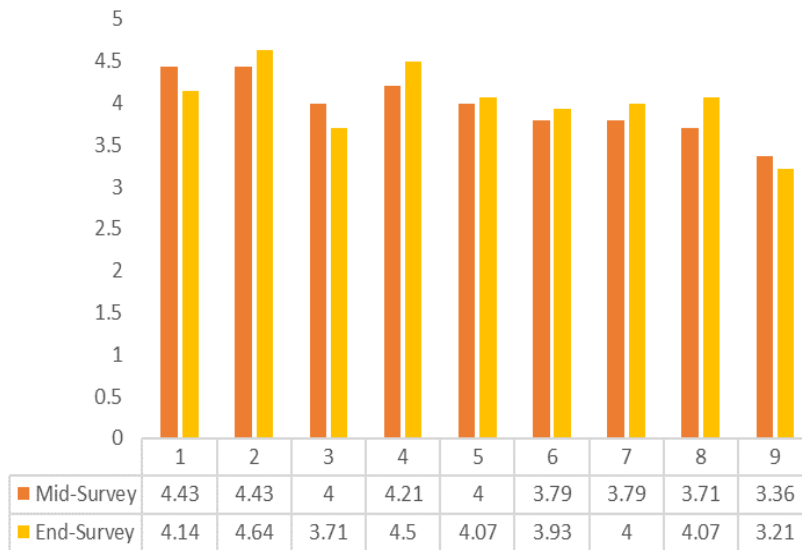|	1	2	3	4	5	6	7	8	9
Mid-Survey	4.43	4.43	4	4.21	4	3.79	3.79	3.71	3.36
End-Survey	4.14	4.64	3.71	4.5	4.07	3.93	4	4.07	3.21

Figure 1. Mean Scores from the Surveys

Mean scores from the mid and end-point surveys show overall positive results in all the categories. This result is consistent with existing literature. There are slight changes from mid- to end-point scores, which is a point of interest that was further addressed in the subsequent semi-structured interviews. Particular points of interest are in the overall experience, learning gains in knowledge related to academic discipline, and the likeliness to accept a job. These topics are of interest because the mid-survey mean is higher than the end-survey mean.

Semi-Structured Interviews

Results from the semi-structured interviews fall into three main categories: challenges, benefits, and perceptions. Again, challenges were related to anything students found difficult during their internship experience. Benefits were related to anything students found helpful or valuable from their internship. Perceptions were related to students' views on industry internships.

Challenges

The main challenge students noted in their internships was the difference in the organization of industry tasks versus academic tasks. Students noted that they were more familiar with an educational setting and highly structured academic tasks, as opposed to the open-endedness presented in industry tasks. Some students also struggled with the iterative process of problem-solving often utilized in industry settings, as opposed to the clear step-by-step processes utilized in solving engineering problems in their academic courses. Students expressed that both of these challenges were overcome by being proactive and communicating with their supervisors.

Another challenge students faced in their internships was not being far enough along in their academic coursework to fully understand some aspects of their internship. A common skill noted with this challenge was with computer programming languages or programs that were different than those used in education, but that were specific to the company or profession. Students noted being able to find answers when they needed to and highlighted the importance of asking questions to help with understanding. When this challenge was mentioned, students tended to report that they did not have as much understanding as their mentors, but had enough understanding to be able to complete the tasks they were assigned. While students reported these challenges, they also acknowledged that the challenges they faced helped them to grow individually, and thus contributed to an overall positive experience.

The following are example comments from a student intern (interviewee):

"I think the biggest thing I recognize is the difference between being a student in an academic environment and being more of an apprentice really in an industry environment. The learning mechanisms are different to where you're in an industry environment you just do the best you can and you turn in what you can do and then an advisor or a mentor or someone will sit down with you and go through your work and mark it all up and say, here's what you did, here's what we're expecting, and here's how you can do better next time, and then you do better next time. In an academic environment, you have study guides, you have textbooks. You can learn algorithms and figure it out on your own for the most part and get a grade, but in industry, it feels a lot more like you're flying blind and trying to teach yourself and figure things out, which is fine."

Benefits

Students found many benefits from their internship experiences. One of the commonly noted benefits was students being offered long-term positions at the companies they interned with. Students farther along in their education saw this as a goal of their internships and felt satisfaction in seeing it come to fruition. Some students were also offered extensions of their summer internships through the school year. Students saw this as an opportunity to gain more experience in industry and to continue working on projects they had been assigned over the summer.

Students also noted the benefit of having the opportunity to network with other professionals and companies in the engineering industry. In conjunction with this, some students noted the value in being able to see how industry operates and be exposed to industry jobs before graduation. Interns noted that this was helpful in making decisions on if they wanted to work in a particular field or not.

The following are example comments from a student intern (interviewee):

"I feel like it's really hard to know what like a day-to-day engineering job might look like, you know? Like this internship gave me like opportunity to see lots of different engineering companies. Things that people do; like really small companies, really big companies, and what they do. Like, what is it an everyday operation looks like? So that was kind of neat. And it's

not something that I could have imagined before. I just didn't have the information to think about."

Perceptions

When asked about their perceptions of industry internships, many students noted that the tasks they completed during their internship were not what they expected to be doing initially. One student noted that they expected to be working in a cubicle on a computer, and ended up being assigned more hands-on tasks. The student noted this as a positive attribute in their experience.

Another student noted that they thought they would be doing tasks similar to other internships they had previously completed, but their tasks ended up being vastly different. This student acknowledged that engineers of the same discipline could be working at different companies and doing completely different things. They also noted how their experience gave them more insight on what type of job they may search for upon graduation.

Overall, students expressed a positive perception of internships. Students considered an internship to be an essential part of their education and were grateful for the opportunity to be able to complete an internship and gain work experience in engineering fields before graduation from their programs.

The following are example comments from a student intern (interviewee):

> *"I think in general more of an effort should be made to inform students just how critical an internship is as being a bridge between you know, academia and actually being employed."*

Feedback was also received from industry mentors about student internships. Industry mentors who worked with student interns expressed how well the interns were prepared for industry in terms of technical knowledge. They commented on the benefit of interns coming to them with a solid knowledge base and the ability to adapt quickly in order to apply that knowledge. Many industry mentors also noted that they would give interns open-ended tasks and allow them to as questions as they saw fit.

One mentor noted that in industry settings, there is not time for mentors to go through a task step-by-step with their interns. This being the case, the partner added that the interns had to solve open-ended problems more independently, and this may have been challenging at first, but the interns learned and adapted well. Overall, industry partners were impressed with their interns, and reported a positive experience in student internships.

Conclusions and Implications

The present study looked to add to existing research by focusing on the multifaceted aspects of engineering students' industry internships. Using a mixed-methods approach, the present study collected data via surveys and subsequent semi-structured interviews.

The results from the surveys show an overall positive experience of student internships and learning gains in technical skills (such as problem-solving) and non-technical skills (such as communication). The results also show students gaining an understanding of industry operations and standards. The results from the semi-structured interviews show engineering students finding challenges, benefits, and overall perceptions from their internship experiences.

The main challenge students faced was with the structure and level of organization of an industry setting versus an academic setting. Students were more used to the high level of structure in academia, so the structure of industry was challenging. Students also noted the challenge of learning new computer programming languages or programs specific to the profession or company they interned with. Students overcame challenges by being proactive and communicating with their mentors. Students found benefits in their internship experiences, with one of the main benefits being employment opportunities at the companies students interned with. Students also noted the benefit of being able to see how an industry operates and decide if they wanted to work in this industry or not.

Overall, students had a positive perception of industry internships and noted how their experiences had been valuable to their educational and career goals. The results from the surveys corroborate previous research findings [1,2,14,15], while results from the semi-structured interviews add to the empirical data in this area of research with a focus on challenges, benefits, and perceptions that may contribute to an overall positive internship experience.

The findings from this research have implications for engineering students, engineering faculty, and industry partners. Students may look at others' perceptions of internships to help in their decision whether or not to complete an internship while in school. Engineering faculty may utilize these findings to adjust their course activities to help students better prepare for the structure and tasks in industry settings. Finally, industry partners may utilize these findings to help student interns transition from academic environments to industry environments more effectively, and thus create less confusion among interns. Overall, the findings from the present study can be utilized to help create positive internship experiences for engineering students and improve university-industry collaboration.

Acknowledgments

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ABIGAIL LEHTO
Ms. Lehto is a Ph.D. student and Graduate Research Assistant in the Department of Engineering Education at Utah State University. She has earned her B.S. in Mechanical Engineering and M.S. in Engineering Education. Her research interests include student engagement of engineering students, first-generation college students in engineering, student and faculty experiences in engineering internships, and industry-academia connections.

NING FANG
Ning Fang is a Professor and Department Head of the Department of Engineering Education at Utah State University. He has taught a variety of courses at both graduate and undergraduate levels, such as Engineering Dynamics, metal machining, and design for manufacturing. His research in engineering education is in broad areas of engineering learning & problem solving, technology-enhanced learning, and K-12 STEM education. His research in engineering focuses on the modeling and optimization of metal machining processes. He earned his Ph.D., M.S., and B.S. degrees in mechanical engineering.

Appendix I: Questionnaire Survey for Student Interns

Q1: Please enter your first name.

Q2: Please enter your last name.

Q3: Please enter your student ID number.

Q4: What organization are you completing an internship this summer?

Q5: Indicate your overall experience with industry internships on a Likert scale of 1-5:

	Highly Negative (1)	Negative (2)	Neutral (3)	Positive (4)	Highly Positive (5)
Overall Experience: (1)	○	○	○	○	○

Q6 Indicate your perception with industry internships on a Likert scale of 1-5:

	Not at all important (1)	Slightly Important (2)	Important (3)	Fairly Important (4)	Highly Important (5)
Perception: (1)	○	○	○	○	○

Q7: Indicate the extent to which you have learned the following competencies through your industry internships on a Likert scale of 1-5: 1: I have not learned anything at all. 5: I have learned a significant amount.

	I have not learned anything at all (1)	I have learned very little (2)	I have learned some (3)	I have learned quite a bit (4)	I have learned a significant amount (5)
New technical knowledge in your academic discipline (such as mechanical engineering, aerospace engineering, electrical engineering, computer engineering, or biological engineering) (1)	○	○	○	○	○
Understanding of what industry jobs look like (2)	○	○	○	○	○
Understanding of current and future trends of the industry field in which you do internships (3)	○	○	○	○	○
Problem-solving skills (4)	○	○	○	○	○
Communication skills (5)	○	○	○	○	○
Team-working skills (6)	○	○	○	○	○

Q8: Indicate the extent to which you would like to join the company where you do your internship after you graduate on a Likert scale of 1-5: 1: I definitely will not join the company as an employee if they provide me a job opportunity. 5: I definitely will join the company as an employee even if they provide me a job opportunity.

	I definitely will not join the company as an employee even if they provide me a job opportunity. (1)	I probably will not join the company as an employee even if they provide me a job opportunity (2)	I probably will join the company as an employee if they provide me a job opportunity (3)	I most probably will join the company as an employee if they provide me a job opportunity (4)	I definitely will join the company as an employee if they provide me a job opportunity. (5)
(1)	○	○	○	○	○

Q9: Please describe in detail what you have learned most during your internship experience.

Q10: Please describe the major challenges you have met during your internship experience.

Q11: Please provide suggestions on how your internship experience can be improved.

Q12: Please describe whatever you would like us to know.