Autoethnography of a Researcher Doing Research Studying Undergraduate Researchers

Abstract

This paper presents an autoethnographic exploration of an undergraduate engineering student's experience being simultaneously involved in both traditional engineering research and engineering education research. Additionally, the engineering education research focused on understanding undergraduate engineering students' own research experiences through the lenses of epistemology and identity. In many ways, it is a meta-level view of the topic of interest (an undergraduate student experiencing what it is to be a researcher while researching that very experience). In this paper, I discuss my experiences both in engineering education research and in my technical engineering research. I discuss what I have learned about undergraduate research experiences (UREs) through my engineering education research, and how this makes me uniquely qualified to then analyze my own experience in a technical engineering URE. I thoroughly analyze both my engineering education URE and my technical URE and discuss the methods used to do so. Finally, I discuss limitations associated with this analysis, which include my own bias and the biases of my research associates.

Introduction

This paper explores the identity and epistemology of an undergraduate student participating in both engineering education research and technical engineering research. Insights gained in this analysis may inform a larger engineering education study, in order to improve the interview protocol and gain inside perspective on the accuracy of the analysis methods. This paper also compares two very different research experiences, allowing contextual conclusions about effective undergraduate research experiences to be drawn. I am able to take a unique perspective on this study and on my own experiences in an undergraduate research experience (URE). This ethnography is about me and my own experience within undergraduate research; therefore, this is an autoethnography. This work can contribute to an understanding of UREs and their effect on student identity and epistemology. It should be noted that this paper was written with two co-authors, one of whom wrote the reflections analyzed in this paper, and another who also analyzed those reflections in order to confirm their accuracy and reduce bias. In order to preserve the autoethnographic nature of this work, we have chosen to write the paper from a single first person view point.

Background on UREs

Improvement of student outcomes and retention rates in undergraduate science, technology, engineering, and mathematics (STEM) education is necessary due to the increasing need for STEM graduates who are capable of working in a rapidly changing, multidisciplinary environment. One mode of reaching both these ends, suggested by The President's council of Advisors on Science and Technology[1], is an increased inclusion of UREs in undergraduate experiences. Studies have shown that UREs complement the undergraduate experience[2], advance students' understanding of their field[3-4], and increase the retention of students in STEM[5-6]. However, not all students have the opportunity to participate in undergraduate research experiences. Therefore, there is a need to implement research experiences into the classroom

setting. This paper is part of a larger mixed-methods study to examine the development of undergraduate researchers' identity and transformation of their epistemic beliefs through UREs, and this specific paper will look deeply into one researchers' research experience. The larger research study makes use of grounded theory, using students' perspective to generate the theory, not just confirm existing theories. The analysis in this paper provides valuable insights into understanding undergraduate research from the student perspective, as this experience is self-analyzed, to better understand the theory of the larger study. The larger study and this paper specifically use identity, epistemic thinking, and situated learning analytical lenses to understand how students integrate in a research setting.

Identity

Identity relates to who an individual strives to be or currently is[7]. While there have been several studies done surrounding different types of identities – science, mathematics, engineering, etc.[8-11] – little has been done examining identity in the context of research experiences. However, it is known that UREs impact students' intellectual and professional development[12-13]. This includes, but is not limited to, students having a deeper understanding and clarification of their career goals[13-15], working independently, and thinking as a scientist[12]. Additionally, students felt like researchers by presenting their work, conducting independent research projects, receiving affirmation from their mentor or other members of their research community, and contributing to their field of knowledge[16].

Epistemology

Epistemic thinking pertains to the nature of knowledge, the justification of truth, the complexity and understanding of knowledge, and the development of knowledge[17]. In the context of a research experience, examples of epistemic thinking include variances between classroom thinking and laboratory thinking, verifying knowledge or results, building knowledge – either self-knowledge or knowledge in a specific field, and the combination of multiple ideas or revenues to generate knowledge. Based on the work done by Chinn et al.[17], epistemic thinking can be broken down into five constructs: 1) epistemic aims and epistemic value, 2) structure of epistemic achievements, 3) source and justification of knowledge and epistemic stances, 4) epistemic virtues and vices (motivations), and 5) processes for achieving epistemic aims. People develop epistemic aims such as knowledge, understanding, and true beliefs, as they strive to gain knowledge and understanding. However, epistemic thinking is situation specific, and individual's own perceptions about the processes to produce knowledge must be analyzed in a context-specific setting.

Lave and Wagner's theory of situated learning

Lave and Wagner's theory of situated learning concentrates on the correlation between learning, identity, and membership in communities of practice[18]. Communities of practice shape individuals' values and perceptions, as well as their interaction with others in a learning environment. Studies have looked at the role of a research community of practice in tandem with UREs and discovered that students learn best by performing authentic tasks and that the knowledge gained is socially, culturally, and physically situated[18-19]. Therefore, through the

analytical lens of situated learning, students build knowledge, beliefs, and identities within a community of practice[18].

Justification of autoethnography as sound research methodology

The engineering education research referenced in this paper is part of a larger mixed-methods study focused on how undergraduate students' conceptualization of research and epistemic thinking affect the formation of their researcher identities. This paper is an autoethnography of an undergraduate student experiencing that which she is researching. In an ethnography, the researcher immerses themselves in a particular social situation for an extended period of time in order to understand how people in that particular social situation live[20]. In order to do this research, I immersed myself in the social situation of participation in a technical undergraduate research experience. As an undergraduate researcher doing this research on undergraduate researchers, I was both the researcher and the subject of this research. I was able to take a unique perspective on this study and on my own experiences in an URE. This ethnography is about myself and my own experience within undergraduate research, thus is an autoethnography. I hope to provide a credible account of my experiences that is accurate and relatable and can contribute to an understanding of the effect of UREs on student identity and epistemology.

Biographical context

With two years of engineering education research on undergraduate engineering students' research experiences under my belt, I embarked on my own technical engineering research experience as an undergraduate student. I had years of experience learning about what types of experiences typically play a role in undergraduate students developing identities as researchers. I knew the theory behind identity development and epistemology. I had heard all kinds of examples of both positive and negative experiences and how those experiences shaped lives and identities.

This background information allowed me to approach my own technical engineering research experience with a uniquely analytical perspective. It was an immersive expedition into the very experience that I had put so much effort into studying. This allowed me to not only reflect on my experience but also compare it to the experiences of others. I was able to inspect the development of my own researcher identity in a thoroughly informed manner. This unique combination of research experiences gave me the ability to write this paper analyzing my own experience in engineering research as an undergraduate.

My involvement in engineering education research

My first experience with research was working for a professor in the engineering education field. This professor was my professor for my first engineering class freshman year. A casual conversation in the hallway my sophomore year where I expressed an interest in engineering education turned into an offer of a paid engineering education research position. Research was not something that I had previously considered, especially a project that would take place during the school year. But the prospect of having a paid position working for a professor who I really admired was amazing. I hoped to learn more about the behind-the-scenes aspects of education with which I was unfamiliar. I hoped to get paid to learn about something I really cared about, and I hoped to gain a mentor in the process.

The purpose of this first project was to study undergraduate researchers. Specifically, how undergraduate researcher's participation in undergraduate research affect their researcher identity and epistemic thinking. This was a bit intimidating at first, studying other undergraduate researchers when I myself was just barely an undergraduate researcher! I have been working on this same project for several years now, and through delving deeply into this topic have become knowledgeable on how concepts of identity and epistemic thinking are impacted through UREs.

My involvement in technical research

My second research position was in technical engineering research. I got involved in this research as part of a class, unlike many of my peers who start research in this area because of a true passion for the topic being studied. Through my other research experience, I heard many stories about engineering students' technical research, and I hoped that I would learn from a "real engineering" research position. I also thought this type of experience of would round out my education and better prepare me for a future industry-based position after I graduated.

This experience lasted only one summer, and I had already had two years of engineering education research experience when I participated. This research was quantitative and traditionally technical, whereas my involvement in engineering education was mostly qualitative and based in the social sciences.

Comparison of experience

These experiences have been extremely different, not just in content but also the type of research and methodologies. These differences led to different types of epistemic thinking and personal assessment of my researcher identity while participating in each research group. The engineering education research group was collaborative, whereas the technical research required more individual work. The technical research was results-oriented whereas the focus of my engineering education research was on the methods used to obtain results. In engineering education, the qualitative data can be messy and ambiguous, whereas with the data in my technical research there was always a clean, objective result. Another significant difference in my experience of these UREs is that I participated in the technical research for approximately three months whereas I have been doing engineering education research for closer to three years. These differences, and the insights into undergraduate researcher identity and epistemologies that they highlight, are discussed in the results section.

Methods

Throughout my technical undergraduate research experience, I wrote weekly reflective journal entries on my experiences, focusing on my epistemic thinking, researcher identity, and my perception of the research process. In addition, at the end of the summer I responded to the interview protocol questions that I ask the subjects in my engineering education research. The journal entries and interview responses were compiled into one long document.

Approximately four months after the reflective writings were compiled, this document was analyzed by myself and one other member of my engineering education research team using open coding[21-22]. During open coding, each coder read the document and highlighted sections that stood out, applying codes to tag those important sections. These codes came from the text

and also from our experience working with a codebook in our analysis of other peoples' research experiences.

We then went back through the codes and extracted the important ideas we saw in the analysis. In the results section, these coders explain their analysis, which describes important themes coming out of my experiences, including important quotes from the document that support our claims. Throughout this document, the findings are related back to theory and compared to our findings from other undergraduate researchers' research experience.

Limitations

In my engineering education research, I have been exposed to all types of good and bad research experiences. This exposure may have predisposed me to believing that certain qualities in a research experience will or will not lead to a positive research experience. The knowledge that made me more aware of my experiences also biased me to have certain notions about "good" and "bad" research experiences. I learned what research is through participating in research but that definition has also been molded in unknowable ways by hearing and reading 100+ different definitions of what research is. This bias does not discredit my work but does limit the interpretation and should be considered by readers throughout the following sections.

Additionally, I was only doing technical research for a short time compared to the engineering education research. I also went into this research without passion for the topic, unlike my engineering education research where I was excited by the content. These are important factors to consider when understanding the differences between my perceptions of the research experiences.

Results and discussion

Several important themes came out of my reflections. In this section, these themes are discussed, compared to theory, and related to my findings in my own engineering education research. These data are analyzed approximately four months after the conclusion of the reflective writing, so there is a gap in time between the original reflections and the resulting analysis. This gap is important as it allows time for reflection, which is essential when trying to process an experience[23].

Community and hierarchy

I often reflected positively about the sense of community that I felt in my engineering educational research group. I reflect that despite my status as an undergraduate researcher, I am treated as an equal member of the team. I acknowledge the potential for the existence of this hierarchy and note its absence.

> "I genuinely feel included as a member of the community. I always felt like I could ask questions and it wouldn't bother people to have to help me understand things. […] This makes it possible for me, a lowly undergrad, to have conversations with my professor or the graduate students on the project and still feel like a respected member of the team. I sometimes get lumped in with the grad students on the team, which is kind of funny, but also makes me feel like I belong on the team. […] I like the team that we work with, and feeling comfortable with these people has made me feel comfortable in my identity as a member of this research team."

An important component to developing a researcher identity is community. This idea is supported by Lave and Wagner's theory of situated learning[18], I have seen this in my engineering education research, and it is highlighted in my own self reflections. Many students that I have studied recognize a hierarchy in their research group, where undergraduate researchers are on the bottom, followed by graduate students, with professors with Ph.D.'s at the top. Other interviewees had completely different experiences, where they felt that they were an equal member of the community, as reflected that I did. I reflect on how inclusion in this engineering education research community strengthens my identity as a researcher. This sense of community often strengthens and encourages an undergraduate student's researcher identity, while feeling like the least significant member of a team can discourage the development of such an identity, as expected from Lave and Wagner's theory of situated learning[18] and my own experience with engineering education research.

I also reflect on the community from my technical engineering experience. In this experience, I did not feel invested in or part of the community. I was sitting on the outside looking in and felt that I was lowest in the hierarchy. This was a result of the short time that I was involved in this technical research. I was the newest student with the least amount of experience in this area and the least amount of passion for the research topic. This led to me working more independently.

> "I could see that there was […] community where people knew each other and knew about each other's work. But I was never a part of that. Part of that was the way that my professor treated me differently. It was necessary to treat me differently in that I needed to be caught up on things, but it singled me out in a way that made me feel inferior, and perhaps affected other's perceptions of my capabilities."

I felt like my group did not understand what I was good at; therefore, I was perceived to know less. Other people's perception of my competence as a researcher greatly impacts my researcher identity. When I was lumped with grad students and talked about as a researcher in my education research, I felt included as a researcher. When starting my new experience and, necessarily, being acknowledged by the group to know less, made me feel less like a researcher compared to my peers. This affected me so greatly because, due to my experience in engineering education, I already felt like I was a competent researcher. I expected to feel the same way in this new experience but realized that my novice status in this new setting precluded my being recognized as an experienced researcher. My status did not simply transfer across disciplines and communities.

Several subjects in our engineering education research discuss being uncomfortable in the beginning of their research experiences because they do not have enough background information. This time of introduction to the project is something important for both students and professors to consider as it can lay the groundwork for the rest of undergraduate's research experience. Getting plugged into community can smooth this transition from novice to experienced researcher.

I reflect directly on the differences between the two research communities in a journal entry:

> "I feel a lot less comfortable in my [technical research] than I do in the [engineering education research project]. Maybe it's because the material is all new to me, or maybe with time I will feel more comfortable, but I'm not sure. I do notice that there is a sense

> of community between the people there, and I just don't really feel like I'm a member of that community yet. But I certainly feel like a full member of the [engineering education research project]."

I feel more comfortable in a community where I am confident in my knowledge. This sense of detachment from the community in my technical research, due to the newness of the experience and the brevity of my time working there, led to a sense of detachment from the research project as a whole.

> "I know from my [engineering education] research that often presenting or making a final project (such as a poster) often feels rewarding or makes a student feel like a real, accomplished researcher. […] So while this kind of final product has in the past made me feel recognized as a researcher, this time I feel very detached from the whole thing."

I never took ownership of that project or felt responsible for its outcomes because I felt detached from my work. This is very different from my passion for my engineering education research and demonstrates the importance of community in an undergraduate research experience.

Independence

Independence is, to many of the subjects of our engineering education research, essential to becoming a researcher. The technical research did not afford me the opportunity to become independent as a researcher. This was due to my own lack of understanding of the work that was being done and the goals and methods behind the research. I knew that I did not know these things. Ironically, this pushed me to be independent in a different way- to learn the background knowledge on my own. This led to me feeling ownership about my own, personal knowledge gathering. However, since I was only contributing to my own knowledge and not to the greater knowledge, this kind of independence did not make me feel more like a researcher.

> "The work I've done will benefit only the [race] and is completely useless to the greater society. That makes it feel more like a science project or something than actual research.

My researcher identity in this instance is driven by not only being involved in a community of practice but personally making a meaningful contribution to that community. This idea of research being beneficial to society is expressed by many subjects of my engineering education research. Feeling like they are making a meaningful contribution positively impacts researcher identity, as it does my own. It is essential that undergraduate research students be given opportunities to make meaningful contributions through their experiences and understand the broader implications of the research project as a whole.

Mentorship

A driving force behind the culture of the community in a research experience is the research advisor. The research advisor also often determines the level of independence in research afforded to the undergraduate. This means that the advisor has a lot of influence over an undergraduate student's researcher identity, as many of the subjects of my engineering education research view independence as essential for feeling like a researcher. Some subjects discuss feeling a lack of independence because their advisor just tells them what to do, while others feel like their advisor trusts them to make decisions and regulate their own tasks. For example, I reflect in my own writing:

> "I don't feel like a researcher as I do it because I am just doing what the grad student tells me to do with no independent thought. I can't even offer independent thought because I don't know enough"

I am reflecting on my own knowledge in this situation, and because I know that I do not know enough, I am simply following instructions instead of working independently. This type of reflection is extremely common in undergraduate students who feel that they lack independence in their research. My novice status and lack of experience in technical research necessitated this kind of oversight, however I could recognize the lack of independence due to my experience being independent in my other research.

In my first research experience, I was fortunate to have an organized, supportive mentor who was involved in the growth of my researcher identity. I went into my second research experience expecting a similar situation but came away frustrated by a more hands off approach to mentoring. This was frustrating for me because I went into the situation with different expectations. This approach to mentoring did, however, offer me the independence to pursue knowledge for myself. I was pushed to figure many technical things out for myself, instead of being handed the information. Learning in this manner leads to more effective learning, and I felt an increased ownership of the knowledge that I gained in this manner. A balance between guided learning and independent study is important in effective mentorship.

Communication and understanding are also essential for effective mentorship. I reflect that the lack of communication with my advisor led to me feeling less important:

> "I definitely feel like my work (and by extension my time/my person) are unimportant to my advisor. This is leading to me feeling rather uninspired to work hard and generally unmotivated to do anything above and beyond. "

This negatively affected my researcher identity and left me feeling unmotivated and uninspired. These negative or ambivalent feelings about research are often expressed from subjects who do not plan to pursue research in the future. This indicates that motivation and researcher identity are linked. Communication between the undergraduate student and their mentor is essential so that the mentor makes the undergraduate students' work, and by extension the undergraduates themselves, feel valued and motivated to succeed.

Communication is also essential in determining appropriate tasks for the mentee. Due to the short time frame of my research experience and the infrequency of our communication, my mentor in my technical research experience did not know my background knowledge. In other words, my advisor lacked epistemic metacognitive knowledge of my experiences and knowledge. This led to situations where my advisor expected too much from me, and I could not complete the tasks assigned. Other times the expectations were too little, and I found myself running out of work. This made me feel uncomfortable, as I was not sure how to tell my advisor about these issues. This held me back from growing as a researcher.

> "I've only met with my advisor maybe 4 times. [My advisor] doesn't know what my strengths/weaknesses are and so can't use my skill set. I haven't really ever felt like I understand what is happening or what the next step is, which makes me feel like I'm not really a researcher."

An effective research mentor has an understanding of the undergraduate students' background knowledge and researcher identity. This understanding is developed through effective communication about expectations and experience, often requiring investment by the mentor in the mentee as a person. Many of the subjects of my engineering education study appreciate most mentors who invest in the growth of their mentees, rather than just in the tasks that must be completed. Awareness that stems from effective communication can lead to more effective mentoring and increased growth in the students' researcher identity.

Additionally, an undergraduate researcher must learn to communicate their needs to their advisor. When I ran out of work I would need to ask my advisor for more because no one would know. Developing a space where this back-and-forth communication between undergraduate and advisor is comfortable leads to effective communication.

Epistemology: confidence and identity

Confidence in my knowledge of the research methodology and topic (epistemic metacognitive knowledge of my knowledge of the research topic) significantly impacts my identity as a researcher. My advisor not knowing what I knew, as addressed previously, inhibited me from contributing my full potential to the team. This in turn affected my identity as a researcher in that context.

On the other hand, due to my years of experience, I am very confident in my knowledge about my engineering education research. I comment:

> "I feel that I understand the greater purpose behind the work that I'm doing, and that the whole team is moving towards that same goal."

This confidence in my skills and understanding of the project gives me the confidence to participate fully and contribute to the community. This is a prime example of epistemic metacognitive knowledge affecting researcher identity. It is essential that the goals and methods be understood by the undergraduate researcher, as this simultaneously enables inclusion in the community independence in research tasks, both of which strengthen researcher identity.

Learning the background information independently at my technical research experience and feeling like I finally knew what was happening made me feel good about myself and my abilities as a researcher.

> "It did feel good […] when the graduate student would suggest troubleshooting techniques that I had already tried. […]. This was rewarding because I felt like I knew what I was doing and I knew how to think about the process. I know that I have at least learned how to use the equipment this summer! And it has been good, although frustrating, practice with thoroughly and systematically troubleshooting. I am finally getting to apply all these "problem-solving skills" that I am learning in my engineering classes."

Feeling like I knew what was going on boosted my confidence during my research experience and enabled me to think more positively about the experience and about myself as a researcher.

Research process: methods and personal improvement

I had found that my engineering education research was very methodical; repetition was done in each step, and the methods of reaching our results were well documented. This research process was able to be well understood, practiced, and mastered. Improvement could be seen as the process was refined. I feel like I am always learning and improving through these methods. Although we are working with qualitative data that lends itself to messy data, the research process in my engineering education research is organized and thorough. I was mentored each step of the way, receiving feedback and knowing that I am growing.

Knowing that I messed up, as when coding computer programs in my technical research, is frustrating. However, I find that working with messy, qualitative data that has no right or wrong answer, being in that ambiguous, unknown stage of qualitative research is good and comfortable for me. This is interesting and rather unexpected because ambiguity in methods makes me uncomfortable, while ambiguity in the data is exciting. This indicates the importance of structure in a research experience. Structure and understanding of the process can make working with even messy or unclear data more comfortable for undergraduate researchers.

I reflect on my experience doing the technical research:

> "They seem to be more results oriented than process oriented, so they just want me to get answers, doesn't matter how I go about getting them."

There were no clearly defined methods laid out for me to learn, so I had to just make up my own. This was so different from my engineering education research experience that it caused dissonance with my previous understanding of what research was. I had known that research was thoroughly methodical, but my technical research was not, yet was still research. This caused discomfort as it did not match with my personal perception of the definition of research. Through this discomfort, I was forced to expand my definition of research, an unexpected experience for me, as I thought that since I had heard so many stories of so many different research experiences that I would have quite a broad perception of research. It is only now, through distant reflection on the experience, that I am able to realize this growth. Something that was so difficult when it was happening I am now able to recognize as a positive experience.

This new experience with results-oriented work was a struggle for me at the beginning, especially with my lack of technical knowledge, but it pressed me to work independently to create my own methods. This independence was an excellent opportunity for growth as a researcher; however, I found that without feedback on my independent work, I was unable to improve.

> "I choose the simplest method, or rather the method that I am most familiar with. It may not be the most efficient coding, but it leads to a less frustrated coding. I am able to justify this decision by the results. If the method I choose gets good results, then it must be a good method. Very much the ends justify the means [in my technical research]. No one really looks too much into my method of coding either, so I'm never getting feedback or knowing if what I decided to do is the best decision."

There was no feedback on the process itself in the short time that I was doing technical research. As long as a result made sense, no one asked about the process. This aspect of the research process did not lend itself to my learning and improving. Feeling like I am improving and learning are important to me as I develop as a researcher. Feeling like I am improving at the

methods of research simultaneously makes me feel like I am improving as a researcher. It is important that when undergraduate students are afforded independent work in the research project they receive constructive feedback in order to know how to improve and grow. An important contributing factor here may have been the limited time I was in my second position, as I might have received more feedback had I worked there longer.

Reflections on bias

It is because I have heard about so many different research experiences, both good and bad, in my engineering education research that I know that all technical research is not the same.

> "If this had been my first impression of what research is, I definitely would have thought that research is not for me. This makes me sad for all the people who […] dislike research because of one negative experience. I can see through the interviews we've been doing and now through personal experience just how different research experiences can be from one advisor or field to another. I wasn't expecting that at all."

It amazes me that even after hearing about so many different experiences, I still felt like my experience was unique and unexpected. This is something that I am only able to recognize now, reflecting back several months after the experience. Reflecting is powerful and has allowed me to make many insights into my technical research experience that I was not able to make while participating or even right after my experience.

In answering the interview questions, I reflect on my own bias in my responses due to having heard 100+ other people answer the same questions in so many different ways. In some ways, this gives me better perspective to answer these questions more thoroughly, taking into account all the different perspectives I have been exposed to. On the other hand, I understand that every answer is given and must be understood through the context of the individual; there is no one right answer, so answering can seem arbitrary. Here is my reflection on rating myself on a scale from 1 to 7 as a researcher which is a key question in my engineering education research interviews.

> "Again, my answer to this is clouded by my knowing what other people think are the criteria for being a researcher. I think that I feel like I'm a researcher. I sometimes get grouped with the grad students on this project, and they're certainly researchers. […] I will rate myself as a 7. This 7 is because I know that I am a researcher on the [engineering education research project]. At [technical institute], I don't feel at all like a researcher. There I feel like a 1. I really just process data, which could potentially be research, although I don't have a clear understanding of what the data means, so it doesn't feel useful to me."

This is an interesting and important answer. Having asked this question so many times, I have a pretty good understanding of the question, yet I am one of very few people who answered with such context specific responses. This could indicate that researcher identity is more context specific than we have been thinking when approaching previous analysis.

In answering the question I am able to outline specifically which ideas I believe affect my researcher identity. Even before doing the previous analysis, I had some ideas of what affects researcher identity, and what affects specifically my identity, from my experiences analyzing

other peoples' research experiences. I mention the hierarchy, and how being included in the group has positively impacted my identity. I also talk about my usefulness, wanting to make a contribution to consider myself a researcher. These are both ideas that are reflected throughout my journaling this summer, demonstrating effective self-reflection. I also reflect on my experience through my answer to "what is research?":

> "It is so hard for me to answer this question. I cannot give a good answer because I have, for the past two years, read literally hundreds of slightly different answers to this question and variations of this question. With all these responses floating in my head, it is nearly impossible to sort out what I think research is from my expectations of how an undergraduate researcher in my position might answer this question. That being said… here is my attempt.
>
> Research is gathering information and processing it in order to make sense of the world around us."

This reflection captures many of my thoughts about the confusion of sorting out what I believe from what I have heard so many other people say they believe.

It is also worth noting again that I only spent a few months performing my technical research, while I have spent years doing engineering education research. This time commitment greatly influences identity. It has been seen in participants in the engineering education research study that identity often grows stronger with time, as knowledge is gained. This has been my experience in engineering education, and is part of the reason that I feel more like a researcher in my engineering education experience.

Additionally, a potential bias is my own interest level in the research prior to the experience. While I was interested and excited in studying engineering education, I was not passionate about my technical research subject. This may have predisposed me to feel less positively towards the second research experience, and this bias should be considered in understanding my perspective.

Conclusions and Future Work

The themes that I see in my own reflections are themes that I see in other people through my engineering education research. These themes include community and hierarchy, mentorship and independence, and methods and personal improvement.

In my engineering education research, I learned that undergraduate researchers who feel like they are a contributing member of the research community have stronger researcher identities feeling motivated and empowered. Many students recognize a hierarchy in academia in which undergraduates are at the lowest level. When undergraduate research students feel like higher-ups in the hierarchy recognize their worth and make them feel included, they feel fulfilled and successful as a researcher. These ideas were strongly reflected in my own experience, as I felt more like a researcher when I was included in the community and when I felt like my work was contributing.

Additionally, I often see that having some level of independence and decision making ability in their research is viewed as a necessary element of being a researcher by many undergraduate research students. This was reflected in my own experience as when I did not know enough to make decisions, I felt less like a researcher. This contrasts my engineering education research

where I was informed and could make decisions. While this was mostly due to the length of experience, this was partly due to mentorship style. It is essential that effective mentors are aware of the undergraduate researchers' background knowledge and that the mentor works to foster growth in the undergraduate student. Just giving the student busy work does not lead to a fulfilling research experience and can turn students away from further participation in research. Future work in this area should investigate effective mentoring and best practices when it comes to mentoring undergraduate researchers.

It is also important to note the significant impact that length of experience has had on my own researcher identity and those of many engineering education research subjects. It is common to see researcher identity strengthen with time. This is important to note when attempting to implement research experiences into the classroom. If students are only briefly exposed to a research project, they may not feel their researcher identity is impacted, whereas those who are exposed to a more lengthy research experience are more likely to be impacted.

Finally, I see in my engineering education research that improvement and being pushed to grow is essential to successful growth of a researcher identity. Many students feel at the start of their involvement in undergraduate research that they are confused and unsure of their role. This progresses as they learn background information and understand the methodology of the project. Students who are not given the opportunity to understand the project and the background information may remain detached from the project and confused. I felt this way in my own experience with the technical institute. After learning the background information and methods some undergraduate researchers feel stagnant, being given only low level, repetitive tasks and not being trusted with independent tasks or making meaningful contributions. To avoid this, it is important that students be given tasks to challenge them to grow once they have become proficient at low level tasks. This is reflected in Lave & Wagner's theory of situated learning[15] where immersion in communities of practice leads to effective mastery. Future studies should further investigate the potential for situation specific researcher identities, as my very different experiences left me with very different feelings about research.

All these themes are so interconnected, each is related to the others in significantly impactful ways. This is important to recognize when implementing these ideas into an undergraduate research experience or into a classroom as it demonstrates the need for balance. No one theme is more important than the others or can make up for the absence of others. It is when all of these themes meld together that a successful undergraduate research experience comes together.

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