Undergraduate Students' Recognition and Development as Researchers

Courtney June Faber, Clemson University

Courtney Faber is a Ph.D. candidate in the Department of Engineering and Science Education at Clemson University and a National Science Foundation Graduate Research Fellow. She holds a B.S. in Bioengineering from Clemson University and a M.S. in Biomedical Engineering from Cornell University.

Dr. Lisa Benson, Clemson University

Lisa Benson is an Associate Professor of Engineering and Science Education at Clemson University, with a joint appointment in Bioengineering. Her research focuses on the interactions between student motivation and their learning experiences. Her projects involve the study of student perceptions, beliefs and attitudes towards becoming engineers and scientists, and their problem solving processes. Other projects in the Benson group include effects of student-centered active learning, self-regulated learning, and incorporating engineering into secondary science and mathematics classrooms. Her education includes a B.S. in Bioengineering from the University of Vermont, and M.S. and Ph.D. in Bioengineering from Clemson University.

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Abstract

The purpose of this work is to investigate how undergraduate engineering students perceive being recognized as researchers and what they identify to influence their development as researchers. Student responses (n=21) to open-ended survey items were analyzed using qualitative content analysis. The students who participated in this study were from bioengineering and material science and engineering departments with varying amounts of research experience (one to five years) and at varying stages in their undergraduate careers (sophomore to senior). All of the students in the study self-identified as researchers. Most of the students perceived being recognized as researchers. They explained that they were recognized as researchers when they were working on an independent project, presenting their work, receiving acknowledgements from research mentors, and talking about their research to people outside their field. Students identified their fellow lab members, family members, college classes, and research experiences as influencing their development as researchers. Results from this work can inform undergraduate research experiences that foster the development of students' researcher identities. These results can also be extended to inform the development of other programs that seek to develop student's problem solving and communication skills in similar ways as research experiences.

Introduction

Recent calls to improve science, technology, engineering, and mathematics (STEM) education seek to produce graduates that are capable of adapting to rapidly advancing, multi-disciplinary challenges [1–3]. In order to be able to approach these challenges, students need to be able to think critically, communicate effectively, and solve complex problems [4]. Many of these skills can be developed in a classroom environment; however, deeper learning has been seen when students participate in learning communities like undergraduate research experiences [5,6]. Authentic research experiences have the opportunity to help students develop critical skills that will be required of them in the workplace and/or future academic studies.

Undergraduate research experiences (UREs) provide students with the opportunity to conduct authentic research in collaboration with graduate student and faculty mentors and make intellectual contributions to their discipline [7]. There have been a number of studies that have investigated the benefits of research experiences for undergraduate students; however, a limited number of studies have investigated students' integration into a research community of practice and development of an identity as a researcher (reviewed in [8]). This area of investigation is important because it has been shown that student perceptions of their research abilities and confidence in conducting research is an integral link between the acquisition and application of research skills [9]. This study builds on a previous study that revealed that students see themselves as researchers because of personal character traits, interest in research, competence in completing research activities, and experience doing research [10]. *The purpose of this work is to continue investigating undergraduate bioengineering (BioE) and material science and engineering (MSE) students' identification with research by focusing on how students perceive being recognized as researchers and what they identify to influence their development as researchers.*

Theoretical Frameworks

Identity

Identity is defined as "the 'kind of person' one is seeking to be and enact in the here and now"[11(p13)]. Identity has been studied in a number of areas including, science, physics, mathematics, and engineering [12–15]. However, there have been a limited number of studies that have investigated engineering students' identification with research during UREs. Students participating in UREs join a community of practice that encourages professional and intellectual development[16,17], as such it would be expected that these students develop an identity within this community through legitimate peripheral participation. Using a social constructivist lens, Hunter et al. [16] studied students' gains while participating in an apprenticeship style research program. Students reported gains in thinking and working like a scientist; clarification, confirmation, and refinement of goals; working independently; and confidence in doing science. Many of the faculty working with these students recognized that during the experience students were becoming scientists, noting that their participation went from peripheral participation towards a centralized role in the community [16]; however, students did not identify their gains as being connected with their development as a researcher. This study builds on the work of Hunter et al.[16] and our previous study investigating how undergraduate engineering students see themselves as researchers [10] to understand what students believe helps them develop as researchers.

Recognition

The conceptualization of identity that guided the development of our open-ended survey questions includes four key elements: competence, performance, recognition, and interest [12,14]. In our previous work, interest and competence along with character traits and experiences emerged as themes that influence undergraduate engineering students' identification as a researcher [10]. Previous work in other areas has shown that recognition by others plays a key role in one's development of a science identity [12,14]. Consistent recognition by established members of a community can help a newer member develop a stronger identification with that community [12]. Additionally, family members' perceptions and expectations about a students' mathematics and science abilities has been shown to influence the student's self-beliefs [18,19].

To further develop our theory on undergraduate engineering students' identification with research, in this study we sought to investigate how undergraduate engineering students' perceive being recognized as researchers.

Methods

Participants and Open-Ended Survey

Undergraduate BioE and MSE students with research experience were invited to complete three open-ended surveys at the end of the Spring 2014 semester. The students who participated in the study had varying amounts of research experience (one to five years) and were at different stages in their undergraduate careers (sophomore through senior).

Each open-ended survey took approximately 15 minutes to complete and included questions to further understand students' perception of research, experiences with research, and views of themselves as researchers. The range of items in the open-ended surveys was informed by the

science identity framework proposed by Hazari et al. [14] and developed in collaboration with experts on engineering and science identity. These open-ended surveys were developed iteratively to ensure that the desired depth of data was collected. For example, in the first survey students were asked, "Do you feel like a researcher?" and all of the students responded with a "yes". In the second survey, this idea was further investigated through two questions aimed at getting more detailed responses from students, 1) "Do you see yourself as a researcher?" with a 7-point anchored scale from "no, not at all" to "yes, very much" and 2) "Please describe three ways in which you see yourself as a researcher.".

Students were also asked for general information including the number of years they had been enrolled, their majors, and their university usernames. The students were asked to provide their usernames so that surveys from the same students could be matched. These general information questions were included at the end of each survey. Students were entered into a drawing for a $25 gift card for completing each survey, and students who completed all three surveys were given a $15 gift card.

For this particular study, we focused on student responses to the items, "Describe a scenario/experience in which you felt recognized as a researcher." and "Please describe the 3 most crucial influences (people, experiences, school-related subjects, etc.) on your development as a researcher in order of most to least important.". These items were all on the second survey administered to students, so we analyzed all of the responses we collected for survey two (n=21).

Analysis

Students' responses (n=21) to the open-ended survey items were analyzed using conventional qualitative content analysis [20]. This approach was selected because it allows for codes and categories to emerge from the data by avoiding the use of predefined codes. This method is useful when existing theories and/or literature are insufficient. In this case of this study, we sought to investigate undergraduate engineering students' identification with research, an area in which current identity theories have not been extensively applied. While the open-ended questions in our surveys were informed by Hazari et al's science identity framework, we did not develop and use *a priori* codes based on this framework because we wanted to remain open to the themes emerging from the data given the difference in context.

Initially, a general understanding of the data was obtained by reading the responses multiple times prior to starting the coding process. Next, phrases in the text were identified and codes were developed to represent key concepts. The codes were then sorted into categories based on similarities to other codes. These groupings were then used to inform how students perceive to be recognized as researchers and what they identify as influencing their development as a researcher.

Results

All of the students surveyed in the study identified themselves as researchers. Previous work revealed that these students felt like researchers because of specific character traits, competence with research tasks, interest in research, and experience doing research [10]. The purpose of this particular study was to further understand students' identification with research by investigating

how they perceive being recognized as researchers and what they believe influences their development as researchers.

Students' Recognition as Researchers

Studies in science identity have shown that recognition by others is an important component in students' development of a science identity[14]. As such, we sought to investigate if and how undergraduate students participating in research perceived being recognized as researchers. The majority of the students who participated in this study perceived being recognized as researchers and described a number of ways including, 1) working on independent projects, 2) presenting their work, 3) receiving acknowledgements from research mentors, and 4) talking about their research to people outside their field.

1) Working on independent projects

Many undergraduate students are introduced to research by assisting a faculty member or a graduate student. As students become more familiar with methods and techniques in the research lab, they are often given the chance to become more self-directed. A number of them described this transition from guided to self-guided research as a time they felt recognized as a researcher.

> "I participated in a summer internship in which I was given much more responsibility in research than I had previously received in school. I was given the freedom and responsibility to design experiments and choose how to analyze the data." Participant 28

2) Presenting their work

One of the outcomes of academic research is presentation of findings at conferences, research meetings, and in journals. The undergraduate students in this study frequently mentioned that they perceived being recognized as a researcher when they had the opportunity to write up their work and present their research at conferences. These conferences ranged from departmental meetings to large national meetings. The presentations gave students the opportunity to describe and justify the work that they did in the lab, placing them in the position of the expert.

> "I also feel like a researcher when speaking about or presenting my research to colleagues within the field of study at say poster sessions, because it makes you feel as though the work you are doing is important to other people and they want to hear about what you've done." Participant 29

> "When I give talks at conferences or when I give a poster presentation, I feel like a researcher." Participant 31

> "I felt like a researcher while presenting our project at the [conference for university program] because I was explaining in detail to others the reasons, methods, and results of our research so far with full understanding." Participant 36

Many of the research groups that the undergraduate students worked in have research group meetings with all of the lab members. These meetings are often a time for members to present

new data, get advice about a challenge in lab, and discuss general lab "housekeeping". Some of the students described that they were recognized as a researcher when they had the opportunity to describe their work during a group meeting.

> "Every other Friday we have a group meeting, composed of both the heads of the lab, [Dr. A] and [Dr. S], and all the graduate and undergraduate students. One meeting, I was recognized for working on my new project, under [Graduate student J], and got a chance to explain to the whole group what my research was about, and how I was working towards my goal." Participant 47

3) Talking about their research to people outside their field

In addition to presenting their work in formal settings like conferences, many of the students talked about their research in informal settings, describing their research to their friends, classmates, and family. Many of the students acknowledged these opportunities as times they were recognized as a researcher. They described that their friends and family were impressed by what they are studying and the amount of effort that they put into their research.

> "I definitely feel like a researcher when I talk to some of my family/friends that aren't necessarily within the field that I am studying. They are always very impressed with how much time and effort goes into the work that I do in regards to research." Participant 29

> "When talking to those not involved in undergraduate research. My roommates think it's pretty cool that I had the opportunity to work in a lab this semester and we sometimes converse about the culturing procedures I get to do." Participant 44

4) Receiving acknowledgement from research mentors

Many undergraduate students are directly mentored by a more senior researcher. This mentor often provides students with suggestions and guidelines for what needs to be done in the lab. A few students described that they felt recognized as a researcher when one of their mentors acknowledged the work and effort that they had put into the project. This acknowledgement was manifested in a number of ways including, verbal acknowledgements and other gestures, such as putting the undergraduate student's name on an abstract or poster.

> "The graduate student mentoring me has put my name on one of his posters and that meant a lot and motivated me to learn more so that I can be of better assistance to him." Participant 45

> "Finishing my honors research, my advisor told me that the work I completed in a little over a semester was more than many graduate students complete for their thesis." Participant 27

Influence on Students' Development as Researchers

The students expressed a number of influences on their development as researchers. This included fellow lab members such as faculty, graduate students, and other undergraduate

students. Students also expressed that family members, college classes, and research experiences also influenced their development as researchers.

1) Fellow lab members

Undergraduate researchers often have the opportunity to interact with more senior undergraduate students, graduate students, and faculty members in the research lab. These other lab members served as resources to the undergraduate researchers, often providing training on new protocols or lab equipment. For many students this interaction also allowed them to imagine what it would be like to be a researcher in the future.

> "Interacting with other people in my research lab has helped me to gain a more realistic idea of the lifestyle of a researcher than I might likely have in my exposure was limited to that which would be gained from university tours, which have a tendency to highlight only the positives of the research experience." Participant 35

2) College classes

One way for students to learn about opportunities for getting involved in undergraduate research is through their major courses. Some of the students recognized that their college classes are what sparked an interest in a particular area of their field and influenced them to join a research team.

> "Intro to bioengineering this previous semester sparked my interest in biology and its applications. I enjoy getting to know how an over looked process like blood clotting works. That class influenced me to join a research team." Participant 44

Students also described that some of their college classes helped them develop as a researcher by encouraging them to think more creatively. Often times learning about the history of discoveries and innovations helped the students understand how far-fetched ideas can lead to new discoveries.

> "My classes at [University X] have taught me how to think outside the box. Hearing about previous innovations in the field have shown me that sometimes one must consider possibilities that are far beyond the realm of common thinking. Sometimes these far-fetched ides become huge innovations and breakthroughs." Participant 2

3) Family members

Some of the students have family members that are in a research field and were either directly encouraged to do research or indirectly influenced to give research a try.

> "Mom and Dad – They both do research and their experience fueled my curiosity to take a chance in the field." Participant 47

Other students describe their family influencing their development as researchers by encouraging the development of specific character traits. This aligns with our previous work that shows that students often self-identify as researchers because they have particular character traits [10].

> "My parents have worked to instill a competitive nature in me since I was a child. I was taught to never be satisfied with 'decent work' or 'skirting by'. I was always taught to go above and beyond and challenge accepted thinking." Participant 2

4) Research experiences

For many students their research experiences in various environments helped them develop as a researcher. These experiences allowed them to develop a range of laboratory skills, work independently on projects, and gain a first-hand idea of what research is like.

> "My internship at [Company X] that helped me understand that I liked laboratory work on the industrial scale." Participant 31

> "Working in a laboratory at a Singaporean university for a summer, in which I was generally left to my own devices, allowing me to plan my own activities and learned to be self-motivated, along with becoming disciplined with keeping records in my lab notebook." Participant 35

> "My experience working as an undergraduate researcher at [Company Y] for a total of 2.5 years, being exposed to a number of different procedures, preserving through numerous challenges to the progress of the project, and viewed the work of several other researchers." Participant 35

Discussion and Future Work

The results from this study expand our conceptualization of how undergraduate students identify as researchers by exploring the construct of recognition and what students perceive as influencing their development as researchers. Students perceived being recognized as researchers when they were working on independent projects, presenting their work, talking about their research to people outside their field, and being acknowledged by their research mentors. Additionally, students reported that their development as researchers was influenced by fellow lab members, family members, college classes and varied research experiences.

While all of the students in this study identified themselves as researchers, not all of the students felt like they had been recognized as researchers. This is interesting to note because in the science identity literature it has been shown that recognition by others plays a key role in one's development of a science identity [12,14]. Further work needs to be done to investigate how recognition by others does or does not influence an engineering student's identification with research and what other aspects of the student's experience are contributing to his or her self-perceptions as a researcher. Some aspects of their experiences that could be investigated in future studies include the role the individual student has in the project, the type of experience the student is involved in, and the culture of the research group the student is working.

The results from this work suggest multiple areas for further exploration in future studies that use semi-structured interviews to allow students to provide more detailed responses allowing the researcher to gain a more complete understanding of the students' experiences and perceptions of themselves as researchers. The findings from this study can be used to inform interview questions for future studies and themes emerging from the initial analysis can be used to inform the analysis of future interviews or open-ended surveys.

Limitations

This study focused on describing how students perceived being recognized as researchers and what they identified influencing the development of their identification as researchers. The influence that various aspects of students' experiences including the type of research experience, the students' role in the research group, and the structure of the research group were not investigated in this study. Given that these components will influence the community of practice the students are integrating into, it is likely that they have an impact on students' development of a researcher identity. This will be an area for further investigation in future studies.

The data from this study was composed of students' responses to open-ended survey questions. This method was selected because it allowed us to collect responses from a relatively large number of students; however, since the researchers could not ask follow up questions the responses to some of the questions are not as in depth as they would been had semi-structured interviews been used. As mentioned in the previous section, the results from this study will be used to inform interview questions and guide analysis of future studies.

Implications for Practice

These findings can inform the development of effective undergraduate research programs that encourage students' development of researcher identities by providing insight into what makes students' self-identify as researchers. Based on the finding of this study, undergraduate research experiences should include opportunities for students to work independently, formally and informally present their research, and have their efforts recognized by their research mentors. Beyond research experiences, this work can be translated to other education experiences that aim to develop open-ended problem solving skills and communication skills similar to those developed through research experiences, and that are relevant for the professional formation of future engineers.

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