Assessing Students' Researcher Identity and Epistemic Cognition

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Dr. Penelope Vargas

Assessing Undergraduate Engineering Students' Researcher Identity and Epistemic Cognition

Introduction and Background

Undergraduate research experiences (URE) give engineering students the opportunity to conduct original research under the guidance of faculty and/or graduate student mentors. Participation within these experiences have had positive effects on students' understanding related to the nature of science and also the students' motivation, retention, and academic performance[1-4]. While UREs can be beneficial to students within undergraduate engineering programs, not all students are able to participate in UREs due to constraints on their time, their financial resources and/or the constraints that limit their institution's ability to offer UREs. There is, therefore, a need to identify the key elements of UREs that can be translated into other learning environments by engineering faculty more broadly so that they can better serve all undergraduate students. In addition, more work is needed to understand how UREs affect students' views of themselves as researchers (identity) and their beliefs about knowledge within engineering (epistemic cognition) so that key elements from UREs can be incorporated into other experiences for students.

Our research goal is to better understand how UREs influence undergraduate student epistemic cognition and identity development and then to develop a new theoretical model using those insights. We anticipate that this new theoretical model will identify the key elements from UREs that influence undergraduate engineering students' identity and epistemic cognition. This overall research scope will be accomplished through a mixed methods, multi-phase, and multi-institution research project. In this paper, we will highlight the design and preliminary results generated when trying to answer the following research question: How do undergraduate engineering students conceptualize and construct what it means to be a researcher?

During Phase One of our project, the research team deployed and analyzed a survey with close-ended and open-ended questions. This mix of questions allowed for a rich set of data that could be explored using both quantitative and qualitative data analysis techniques. These analyses will in turn be used to inform the second phase of the program, namely developing our interview protocol and methods for interview participant recruitment and selection.

The value of students' identities as researchers lies in the alignment of research skills with important aspects of their epistemic cognition (beliefs about knowledge in engineering). Students' perceptions of themselves as researchers will influence their acquisition of research skills and knowledge, and how they utilize those skills and knowledge. To understand students' identity[7-10], and epistemic cognition[11] within an undergraduate experience, we are using situated learning[5,6], role identity, and epistemic cognition as theoretical lenses. Situated learning provides a framework for us to investigate students' identity development and epistemic cognition as they integrate into a research group, which can be recognized as a community of practice[5,6]. Through legitimate peripheral participation within their URE, students will develop their identities as researchers and their beliefs about how knowledge is created and justified within the field. In this initial phase of our work, we are using situated learning to begin to understand the connections between identity and epistemic cognition within a URE.

Executive Summary

Our detailed plan for mixing quantitative and qualitative data and analyses for the entire project is shown in graphic form in Figure 1. A mixed methods approach is appropriate for this study to minimize pre-existing assumptions (such as those related to what research is or what a research experience should be) and to avoid gaps in our understanding (such as those related to epistemic beliefs, which can be challenging to capture through quantitative methods alone)[12].

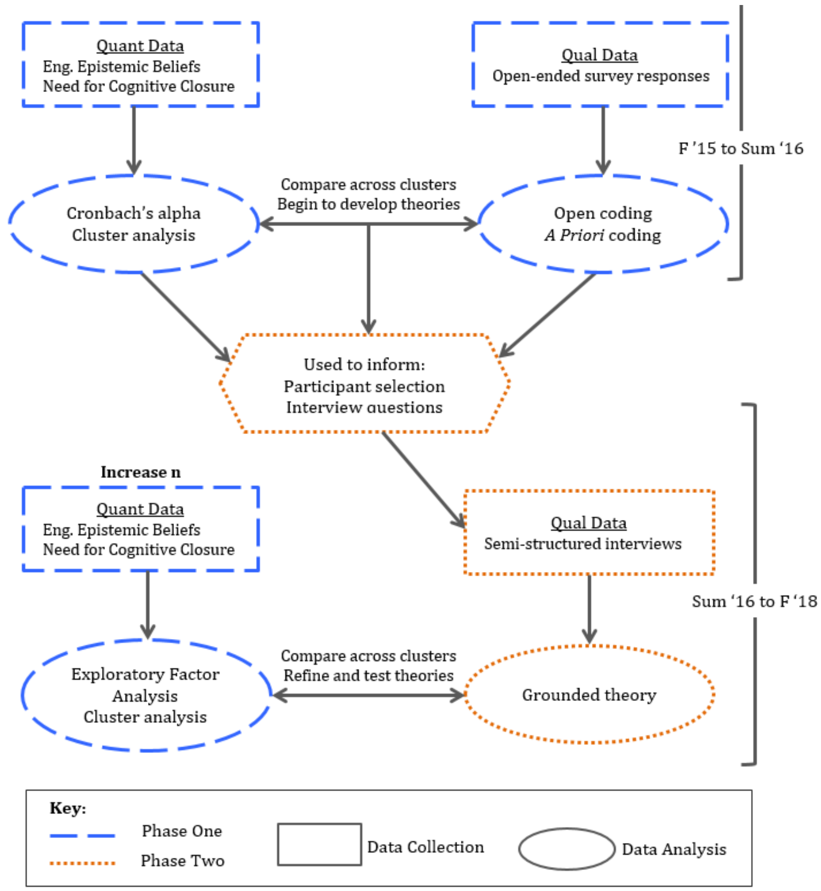

Figure 1. Plan for mixing quantitative and qualitative data collection and analysis. This paper focuses mainly on activities within Phase One of the project.

Our target population for all phases and data types includes mechanical engineering (ME) and biomedical engineering/bioengineering (BME) undergraduate students who have participated in research in some capacity. We selected these two disciplines because of the interdisciplinary nature of research experiences for BME students, and the range of co-curricular activities in ME programs such as co-ops or internships in addition to research.

Phase One: Quantitative and Qualitative Data Collection and Analysis:

A survey with 16 open-ended items pertaining to students' conceptualizations of research and their beliefs about themselves as researchers was developed[13]. This survey also included 45 closed items designed to measure students' engineering epistemic beliefs and need for cognitive closure[14-19], and questions related to participant demographics (self-reported gender, race, ethnicity, year of study, etc.) were placed at the end of the survey.

Prior to deployment, IRB permission was obtained to recruit participants representing a range of institutions. The survey results in this paper were from ME and BME students at five collaborating institutions. These institutions represent a variety of institution types (research-intensive, land grant, undergraduate-serving and minority-serving) and geographical regions within the U.S. (Northeast, Southeast, South, Midwest and West). The invitation to participate was distributed by email from departmental representatives, such as faculty or program coordinators, to potential participants.

A total of 154 participants submitted answers to the open-ended survey questions with 113 participants (73%) completing the entire survey. A majority of the 154 responses were from Institution 2 (49%) and Institution 1 (18%). Institutions 3, 4 and 5 had 12%, 11%, and 10% responses respectively.

Quantitative Data Analysis and Results:
Because of the low number of survey responses to date (154), we report here on the preliminary results in terms of frequencies of student responses to survey questions. Survey items were initially sorted into six *a priori* factors: Closed-mindedness, Discomfort with Ambiguity, Certainty of Knowledge, Sources of Knowledge, Simplicity of Knowledge, and Justification of Knowledge. The internal consistency reliability of each of the factors scales was characterized by calculating Cronbach's alpha. Each scale was refined by removing individual items with low correlations with other items. There were 6 – 7 items in each of the remaining factors (Closed-mindedness, Discomfort with Ambiguity, Certainty of Knowledge, Sources of Knowledge, and Justification of Knowledge). One of the scales, Simplicity of Knowledge, had a Cronbach's alpha below 0.6 and were therefore removed from further analysis.

Based on frequency analysis of quantitative data, our participants considered engineering problems in the classroom to be different than engineering problems in the real world. Although they had mixed beliefs about whether a single answer exists for course problems, most participants believed there is not a single answer for real-world problems. Participants also appeared slightly more trusting of their engineering professors than practicing engineers. We recognize the limitation of this narrow analysis based on frequency of responses and are expanding our data collection.

Qualitative Data Analysis and Results:
Qualitative data collected from the open-ended survey responses, including the unfinished surveys, were analyzed using inductive/open coding where each of the responses were read and key words and phrases were coded to capture the range of ideas found in the responses. Three members of our research team applied standard coding practices for qualitative analysis, including interrater reliability analysis[20]. Multiple researchers on our team developed and continuously improved a codebook as a reference guide for the coding to maintain consistency.

From our qualitative analysis of open-ended survey items, coders found a total of 68 different codes initially developed from the survey responses[21]. Three examples of these codes were 'developing novel/new', 'contribute to science community', and 'utility of research'. The codes were grouped together by their characteristics to begin to develop themes such as "actively seeking new knowledge", "recognition", and "communication of research". We are currently evaluating these codes more fully and may reduce the codes to narrow the themes generated from the results.

Some students defined research as actively seeking *new* knowledge; they conceptualize research such that results must be new. In addition, when students expressed that they did not feel like they were contributing to research, they often mentioned it was because they were staying within what is already known, rather than seeking something new. In contrast, other participants believe that performing research or experimentation alone makes one a researcher. Some students expressed a temporal aspect to their researcher identity, dependent on their level of activity within the research community. This was reflected in comments such as, "[…] I stopped doing research at the end of my junior year (I am currently a senior), so I don't really consider myself a researcher currently […]". Many students discussed how research needed to contribute to society and have altruistic goals, whether through the outcomes of their research, the products they create or improve, or the knowledge that they contribute to the scientific community.

Interview Protocol and Participant Selection:
To date, we have drafted our interview protocol for Phase Two based on results from the initial survey data and our prior work and have narrowed down the methods by which we will cluster our participants to select interviewees. To identify interview participants, we will be using the results of a cluster analysis to identify groups of students with similar epistemic beliefs based on their survey responses[22].

Future Work

The next phase of this work will include increasing our participant pool for the survey and deploying out interview protocol. Although no statistical analysis is currently presented, we believe that these trends presented provide some insight to the views of the cohort. We will continue to run psychometric analyses as we gather additional data. We will continue to distribute the survey to generate a larger participant pool to conduct exploratory factor analysis and cluster analysis. Our evidence-based interview protocol will be a key component of our work and can serve as a tool for other researchers studying epistemic beliefs. In later phases of this work, we will employ grounded theory to develop a theoretical model that captures epistemic cognition and identity development during UREs based on our data from the different phases of this research.

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