Work in Progress: Exploring Epistemic Identity to Support How Engineering Education Research Teams Negotiate Epistemic Differences

Courtney Faber
Engineering Education
University at Buffalo
Buffalo, NY USA
cfaber@buffalo.edu

Lorna Treffert
Engineering Education
University at Buffalo
Buffalo, NY USA
lornatre@buffalo.edu

2024 IEEE Frontiers in Education Conference (FIE) | 979-8-3503-5150-7/24/$31.00 ©2024 IEEE | DOI: 10.1109/FIE61694.2024.10893326

***Abstract*—This work-in-progress research paper describes the epistemic identity of one researcher, Dr. Roberts, working on an interdisciplinary engineering education research team. Engineering education research is an interdisciplinary field that includes researchers from a range of disciplinary backgrounds who each bring their own approaches to the generation, expression, and application of knowledge. These different epistemic identities can lead to tensions that prevent teams from having their desired impact. Our data includes a transcript from a 60-minute semi-structured interview. During the interview, we asked questions to explore specific aspects of Dr. Roberts' epistemic identity, the approaches he used to navigate differences in thinking, and instances of epistemic negotiation in the research team meetings. This data was analyzed using an open coding process defined by Charmaz (2014) followed by the construction of a memo to describe Dr. Roberts' epistemic identity. We describe the results from our initial analysis of Dr. Roberts' epistemic identity.**

Keywords—epistemology, faculty, qualitative research

I. Introduction

Engineering Education (EngEd) Research is an interdisciplinary field by nature - drawing people, theories, and methodologies from a wide range of fields (e.g., engineering, engineering education, sociology). Individuals on EngEd research teams bring their own approaches to the generation, expression, and application of knowledge. These differences in thinking are key to the success of engineering education research; however, they can create tensions that prevent teams from achieving their core goals. One common tension that often arises is around the use of qualitative research approaches. These approaches are common in fields like education, engineering education, and sociology but less common in engineering. As such, many researchers trained to do engineering research are not familiar with qualitative research approaches and how to assess the quality of this research, which can lead to the dismissal of qualitative research findings and studies. By not addressing these types of tensions, the impact of EngEd will remain limited due to issues such as conflicts around the integration of research approaches, dismissals of types of research approaches, and misunderstandings across research and practice.

To support researchers' navigation of epistemic differences, we are studying how differences in thinking are negotiated among members of a single EngEd research team. Through this ethnographic case study, we aim to capture how differences in thinking are negotiated at both the team and individual levels. This work in progress paper focuses on our study of individual researchers' approaches, values, and points of view related to how knowledge is generated, expressed, and applied. The work presented in this paper lays the foundation for us to answer the research questions: How do researchers present their epistemic identities while working on EngEd research teams?

II. Background

The problems that EngEd research seeks to address are complex and require interdisciplinary solutions. At a fundamental level, EngEd research seeks to improve how we educate future engineers. It includes research areas such as diversity, ways of knowing, professional skills, and faculty development [1]. Within each of these areas, EngEd research seeks to address numerous problems, many of which are multifaceted spanning multiple research areas. To have an impact, EngEd researchers must work with a variety of stakeholders who have different goals and approaches to generating and applying knowledge [2], [3]. NSF program calls such as, Revolutionizing Engineering Departments (RED) and Research Initiation in Engineering Formation (RIEF) require researchers from different disciplines for these reasons.

Interdisciplinary collaborations require the integration of multiple disciplines to generate a single approach [4], [5], [6]. Deep integration is difficult due to differences in disciplinary norms, obscurity of domain specific practices to outsiders, conceptual and methodological divides, and conflicting approaches to evaluate success [6], [7], [8], [9]. These difficulties relate to differences in how team members think [10] and are further exacerbated by the fact that practices around knowledge generation in any field are complex [8].

Interdisciplinary research teams risk disorganization and other hurdles due to mismatched foundational assumptions about methods and knowledge production [6], [8], [10], [11], [12]. Given these difficulties, it is common for a single discipline's approach to take priority [10] or for disciplines to work in parallel rather than combining approaches [5], thereby limiting the scope and impact of the work.

Existing work across Team Science and philosophy of science has primarily focused on the broader processes of research integration [13], [14], [15], [16], [17], the structure of knowledge generation [14], [15], [16], [18], and influence of the nature of science on current approaches within interdisciplinary research collaborations [12], [19], [20]. Due to the complexities surrounding differences in thinking, findings cannot be translated from one interdisciplinary context to another without careful consideration of contextual features and interactions [12], [19], [20]. Much of the work looking at interdisciplinary teams has focused on teams within engineering and science [reviewed in 16]. While EngEd research shares some features with these disciplines, EngEd research is unique in that the researchers are often embedded in the field they are trying to impact (engineering) and integrate research approaches across fields that are cognitively divergent (e.g., engineering and sociology) [9], [10], [21], [22]. Given these unique aspects, in order to develop support for researchers, there is a need to study how EngEd research teams negotiate differences in thinking.

At an individual level, beliefs about knowledge generation and application underlie all aspects of the research process and influence a researcher's ability to appreciate the research of others [23], [24], [25]. Multiple EngEd researchers have called for a wider range of research approaches in order to expand the research questions that are addressed [26], [27]. Slaton and Pawley [28] discuss how existing standards for legitimate and significant research in EngEd impact the field's ability to make substantial progress towards increasing diversity and inclusion by encouraging researchers to use specific methods that often include presumptions about human differences. Similar concerns have been raised in the context of feminism [29] and reform efforts in EngEd research [30]. Researchers have also identified differences in thinking as a barrier to institutional change that seeks to support the success of women of color in STEM [31]. As such, research calls for a recognition of the value in differences in thinking to increase equality in research, address complex problems, expand the scope of research, and promote interdisciplinarity and collaboration [24], [28], [30], [32]. To meet this call, we first need to understand how EngEd research teams negotiate differences in thinking [11], [32].

III. Theoretical Framework

In many interdisciplinary spaces, like EngEd research, there is no single set of norms for researchers to navigate or an authoritative set of ideas about what it means to do quality research [19], [33], [34], [35]. As such, these norms must be negotiated by researchers in contexts such as research groups and peer review. Ideas of what it means to do quality research (or good science) are tied up in what it means to be a researcher [19], [36]. As such, it is important to consider epistemic matters alongside identity.

Epistemic identity is a descriptive tool that can be used to better understand these collaborative and cognitive practices in interdisciplinary spaces. The sub-themes or dimensions that define this tool were identified through research identity enactment in two integrative systems biology labs [19]. Epistemic identity includes four interconnected dimensions of identity enactment: 1) belonging and differentiation, 2) perspectives taken, 3) values, and 4) affect or feelings. These four categories integrate how researchers approach knowledge generation, expression, and application (categories 2 & 3) with non-knowledge related values and stances (categories 1 & 4). These non-knowledge related values and stances allow for the exploration of how factors such as academic background, race, gender, and seniority influence how an individual chooses to represent their approaches to knowledge generation and application within a team [21], [22].

The dimension of belonging to a group and differentiation within it includes the problems and projects an individual researcher owns; the individual's sense of being part of a community (e.g., the research group, engineering education, etc.); and the individual's specific function or task in the community (e.g., translating between perspectives in fields, engineering education, method development). Perspective taken in relation to data and others includes epistemic norms, epistemic stances, and views of one's own work/domain (how I see myself), others' work/domain, and others' view of one's work/domain (how they see me). The dimension of values relates to views about what constitutes quality or desirable science (epistemic values) as well as the broader significance of the work (non-epistemic or social values). Our feelings (affect) are closely related to our values. In interdisciplinary collaborations, individuals must manage feelings due to differences in values or perspectives, which can include managing feelings of devaluation from others. Other feelings that may arise that are related to identity include aspiration, desire, esteem, frustration, and joy.

We used the four dimensions of epistemic identity enactment as a starting point for our interview questions and analysis of how an individual's epistemic identity contributes to a team's approach to knowledge generation, expression, and application.

IV. Methods

This work is part of a larger ethnographic study of a single EngEd research team, Team Y. This paper focuses on our preliminary analysis of our interview with one member of Team Y. This team is working on a multi-year, nationally funded research project. The team members are located at multiple institutions across the United States. At the time of our data collection, the team included four faculty (Dr. Peters, Dr. Wilson, Dr. Johnson, and Dr. Roberts) three undergraduate student researchers (Riley, Avery, and Alex), and one graduate student researcher (Eliana). The faculty are the 'permanent' group members and wrote the initial grant that funds their current work.

Team Y's research project is a large, multi-component project in which there are multiple activities that are occurring simultaneously. The project includes elements of both research and practice and seeks to develop and support a community of practice focused on addressing systemic issues in engineering education. While individual faculty lead specific efforts, the team makes a point to collaboratively make decisions and ensure alignment with their larger goals.

A. Participant

This paper focuses on one researcher, Dr. Roberts, who is part of Team Y working on Project X. Dr. Roberts is part of the core team for Project X and was involved in writing the proposal that was funded to support their current efforts. We provide more description of Dr. Roberts' role on Team Y in the results section.

B. Data Collection

Data was collected through a semi-structured interview that lasted one hour. The interview was divided into three parts. Part One focused on questions related to Dr. Roberts' view of research within and outside of Project X. Example questions include, (1) To start, please tell me a little about who you are as a researcher, the types of studies you do, and approaches you use. and (2) From your perspective, what constitutes 'good science' or 'quality work' on Project X? Part Two focused on Dr. Roberts' role on Project X. Two example questions are (1) how would you describe your role on Project X? and (2) How do your experience and background uniquely contribute to Project X?. Part Three focused on Dr. Roberts' view of Team Y's epistemic culture. Interview questions included (1) Describe how Team Y approaches research decisions. (where, when, who?) and (2) How would you describe Team Y's norms around collaboration?. The interview audio was transcribed using Otter.ai. We reviewed the accuracy of the transcription and made any needed edits prior to analysis.

C. Data Analysis

In this WIP, we present our preliminary analysis of the interview with Dr. Roberts. For this analysis, we used the four dimensions of epistemic identity enactment as high-level codes or sensitizing concepts [37]. We identified phrases and statements from the interview that aligned with each dimension and labeled them accordingly. Our approach aligns with open-coding, the first step in constructivist grounded theory [37].

In future work, we will build on this initial analysis by sorting our initial codes into categories and conducting axial coding [37]. These steps will be taken to identify sub-categories under each dimension to more fully understand the dimensions of epistemic identity enactment for researchers on interdisciplinary EngEd teams.

V. Prelminary Results and Discussion

Below we present the ways that Dr. Roberts enacted his epistemic identity based on our preliminary analysis of our interview with him.

A. Belonging to and Differentiation within Team Y

Team Y is an interdisciplinary EngEd research team that includes researchers with various disciplinary backgrounds, knowledge of the project space, social identities, experience in their field, and roles at their institution. Dr. Roberts recognizes this diversity as a core strength of the team and a reason he joined the team:

> We have varying ranges of understanding. And that's one of the things that actually drew me in is that some people understood a little bit more, some people understood a little bit less, but they were all willing to work together. And that diverse perspective actually slows things down quite a bit. But it makes the quality of the work much better when we're actually getting a chance to have everybody chime in. And because basically what the issue is, it helps us get out of the same people talking to the same people.

On Team Y, Dr. Roberts does some project management but most of this work is done by another team member. He has done a lot of work to develop and manage one of the core efforts on the project associated with a specific NSF project outcome. As the member of the team with the most formal training in EngEd research methods, he has done a lot to help the undergraduate students who have worked on the project learn about qualitative research methods and literature reviews. He is also one of the theories of change experts on the project. In this role he,

> So it's essentially my role to really help decipher our theory of change. And, like, from [an] engineering education standpoint, then I help do my best to help [Dr. Peters] understand it, and then we both do our best to communicate it to the rest of the team and get the buy in.

While all of Team Y's members are at different institutions across the United States, the NSF funding they received has helped create opportunities for Dr. Roberts to develop relationships with the other members of Team Y and feel like part of the team.

> Having NSF approved funds to support meeting with folks once a week for an hour, that makes a huge difference. It helps bring people together having support to go to conferences, where we get to see each other physically, versus virtually. We eat dinner together when we're at the conferences, that helps create some togetherness or feeling like I'm inside.

B. Perspectives Taken

When the team is making decisions, Dr. Roberts described that he is often in the position of recognizing the value in the ideas proposed by the team while simultaneously recognizing that the team is resource constrained: "…all of these ideas are great. The tough part is how do we pick the greatest out of good ideas?" When faced with this dilemma, he described two different ways he assesses ideas: 1) by considering the value to the community and 2) by considering the buy-in from the rest of the core team. These approaches directly align with his values, which are discussed in subsection C below.

> So, we did a survey earlier to ask our community of practice faculty members, Hey, would you be interested in a module on [topic]? What topics would you be interested in talking about? So just recognizing…even if we had a really good idea or a topic that would be valuable for students to learn or faculty members to engage with, if they're not going to do it, they're not going to do it…Other ways, again, is having folks bring evidence to the table. And it can be from previous literature or again, from a broader base of knowledge outside of peer reviewed academic literature. Having folks thoroughly describe and explain it to the whole group, I think is really critical. So again, even if it is valid and useful, but if the rest of the group doesn't understand it, then from a team dynamic standpoint, we're not actually going to do the highest quality of work on it.

C. Values

We see Dr. Roberts' values reflected in the project efforts he has chosen to focus on, the approach he takes to select research methods, and the way he defines "good science". As an individual researcher, the methods and approaches Dr. Roberts uses sit at the tension of doing work that matters across communities with different goals and perspectives.

> I like to use the best method that fits the question, or that best supports the community I'm looking to support. So that's grown a lot for me, because I guess from an academic standpoint, I definitely understand there's like research limitations and assumptions and things that make the research process the most efficient, or what some would call valid from another researcher's perspective. But I've also learned a lot and thought about what is going to be most useful for the community. So even if the statistical process can potentially start to really imply causation, just the way that the statistics are set up…Many times those numbers aren't supported or appreciated or used by communities. So getting a deeper understanding of is it a lack of evidence issue? Is it a political issue? Is it a technical issue?...really wrapping my head around all, some of these other aspects, I think sometimes get left out of academic research, and put that into my research process to then select the best method.

His epistemic values of what makes "good science" includes 1) hearing from diverse perspectives ("…it makes the quality of the work much better when we're actually getting a chance to have everybody chime in."); 2) alignment with objectives; and 3) using approaches that increase research quality. As one way to think about research quality, Dr. Roberts describes an approach he uses:

> …the Q3 framework that was created at [University of Georgia]. I think is a really underappreciated qualitative research tool because it answers a lot of questions about research quality, in a way that doesn't box you in but makes you think through so many different dimensions, that's important.

D. Feelings/Affect

Dr. Roberts hopes Team Y can engage in more healthy conflict when discussing different ideas to make a decision. This desire aligns with his value of considering diverse perspectives to support the quality of the team's work. As part of this desire, he has taken on the role of devil's advocate:

> And respectfully, and say, hey, well, I'm gonna let you know right now, because we're not having any conflict. And no one's talking about the alternative, I'm gonna bring it up. I'm not gonna say I agree or disagree, but I'm gonna bring it up, because we need to make this make sense. And external folks potentially are going to disagree. So let's recognize that and think through a solution a little bit more.

As part of this process, he pays attention to the expressions of his other team members to identify when more time needs to be spent discussing a specific topic.

> let's talk about this a little bit longer, because I noticed so-and-so actually did have something to say, not necessarily to the point of disagreement, but they had something to say where it wasn't as clear, or they wanted to add to it and we didn't get to that. And instead of just moving forward, let's let's extend the time for that. And then trying to pay attention to facial expressions in meetings to see what's going on. And people look confused. They seem bought in, are they focused, are they not? Which was much easier in person, but can also be done virtually.

VI. Implications and Future Work

Our preliminary results represent an initial operationalization of the dimensions of epistemic identity enactment. We were able to identify aspects of each dimension in our interview with Dr. Roberts. Through this preliminary analysis, we identified dimensions that were less prominent than others, such as feelings/affect. We also identified ways that the dimensions interacted for Dr. Roberts' (e.g., perspectives taken and values).

In future work, we will deepen our analysis by identifying categories and conducting axial coding of this interview [37]. We will also analyze our field notes and memos from our observations of Team Y's weekly meetings to identify the dimensions of epistemic identity enactment to further our understanding of Dr. Roberts' epistemic identity. To gain a better understanding of epistemic identity enactment on EngEd research teams, we will analyze the interviews with the other members of Team Y. This analysis will allow us to identify unique features of individuals' epistemic identity enactment as well as patterns in identity enactment.

Acknowledgment

This material is based upon work supported by the National Science Foundation under Grant Numbers 2346868 and 2144698. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. We would like to express

gratitude to Team Y for participating in this study and for their willingness to open their meetings to us and provide feedback on the initial drafts of this paper. We also thank Dr. Roberts for taking the time to participate in an interview and share their views on research in general and the work being done on Project X. Finally, we would like to thank the members of the ENLITE Group who gave feedback on the drafts of this paper.

REFERENCES

[1] M. Borrego and J. Bernhard, "The Emergence of Engineering Education Research as an Internationally Connected Field of Inquiry," *J. Eng. Educ.*, vol. 100, no. 1, pp. 14–47, 2011, doi: 10.1002/j.2168-9830.2011.tb00003.x.

[2] E. Altamirano, J. S. London, K. Lau, N. Waree, and S. Cruz, "Understanding research engagement practices among engineering education stakeholders to promote the impact of research on practice," *Australas. J. Eng. Educ.*, vol. 23, no. 2, pp. 106–116, Jul. 2018, doi: 10.1080/22054952.2018.1556770.

[3] C. Baillie, E. Ko, W. Newstetter, and D. F. Radcliffe, "Advancing Diverse and Inclusive Engineering Education Practices through Interdisciplinary Research and Scholarship," *J. Eng. Educ.*, vol. 100, no. 1, pp. 6–13, Jan. 2011, doi: 10.1002/j.2168-9830.2011.tb00002.x.

[4] *Facilitating Interdisciplinary Research*. Washington, D.C.: National Academies Press, 2004, p. 11153. doi: 10.17226/11153.

[5] S. Menken *et al.*, Eds., *An introduction to interdisciplinary research: theory and practice*. in Perspectives on interdisciplinarity, no. Volume 2. Amsterdam: Amsterdam University Press, 2016.

[6] J. Davies, "Disciplining the Disciplines," in *Evidence, Inference and Enquiry*, P. Dawid, W. Twining, and M. Vasilaki, Eds., British Academy, 2011, p. 0. doi: 10.5871/bacad/9780197264843.003.0003.

[7] K. Knorr Cetina, *Epistemic Cultures: How the Sciences Make Knowledge*. Harvard University Press, 1999.

[8] M. MacLeod, "What makes interdisciplinarity difficult? Some consequences of domain specificity in interdisciplinary practice," *Synthese*, vol. 195, no. 2, pp. 697–720, Feb. 2018, doi: 10.1007/s11229-016-1236-4.

[9] S. Lele and R. Norgaard, "Practicing Interdisciplinarity," *BioScience*, vol. 55, Nov. 2005, doi: 10.1641/0006-3568(2005)055[0967:PI]2.0.CO;2.

[10] E. Brister, "Disciplinary capture and epistemological obstacles to interdisciplinary research: Lessons from central African conservation disputes," *Stud. Hist. Philos. Sci. Part C Stud. Hist. Philos. Biol. Biomed. Sci.*, vol. 56, pp. 82–91, Apr. 2016, doi: 10.1016/j.shpsc.2015.11.001.

[11] N. Borrego, Maura Lynita, "Characteristics of Successful Cross-disciplinary Engineering Education Collaborations," *J. Eng. Educ.*, pp. 123–134, Apr. 2008.

[12] M. Boon and S. Van Baalen, "Epistemology for interdisciplinary research – shifting philosophical paradigms of science," *Eur. J. Philos. Sci.*, vol. 9, no. 1, p. 16, Jan. 2019, doi: 10.1007/s13194-018-0242-4.

[13] K. L. Hall *et al.*, "Assessing the Value of Team Science," *Am. J. Prev. Med.*, vol. 42, no. 2, pp. 157–163, Feb. 2012, doi: 10.1016/j.amepre.2011.10.011.

[14] C. Pohl and G. Hirsch Hadorn, *Principles for Designing Transdisciplinary Research*. 2007. doi: 10.14512/9783962388638.

[15] M. R. Salazar, T. K. Lant, S. M. Fiore, and E. Salas, "Facilitating Innovation in Diverse Science Teams Through Integrative Capacity," *Small Group Res.*, vol. 43, no. 5, pp. 527–558, 2012, doi: 10.1177/1046496412453622.

[16] National Research Council, *Enhancing the Effectiveness of Team Science*. Washington, D.C.: National Academies Press, 2015, p. 19007. doi: 10.17226/19007.

[17] K. L. Hall, A. L. Vogel, and R. T. Croyle, *Strategies for Team Science Success Handbook of Evidence-Based Principles for Cross-Disciplinary Science and Practical Lessons Learned from Health Researchers / edited by Kara L. Hall, Amanda L. Vogel, Robert T. Croyle.*, 1st ed. 2019. Cham: Springer International Publishing, 2019.

[18] S. Wagenknecht, "Facing the Incompleteness of Epistemic Trust: Managing Dependence in Scientific Practice," *Soc. Epistemol.*, vol. 29, no. 2, pp. 160–184, 2015, doi: 10.1080/02691728.2013.794872.

[19] L. M. Osbeck and Nersessian, Nancy J., "Epistemic Identities in Interdisciplinary Science," *Perspect. Sci.*, vol. 25, no. 2, pp. 226–260, 2017, doi: 10.1162/POSC_a_00242.

[20] H. Andersen, "Collaboration, interdisciplinarity, and the epistemology of contemporary science," *Stud. Hist. Philos. Sci. Part A*, vol. 56, pp. 1–10, Apr. 2016, doi: 10.1016/j.shpsa.2015.10.006.

[21] N. J. Nersessian, "The Cognitive-Cultural Systems of the Research Laboratory," *Organ. Stud.*, vol. 27, no. 1, pp. 125–145, Jan. 2006, doi: 10.1177/0170840606061842.

[22] L. M. Osbeck, N. J. Nersessian, K. R. Malone, and W. C. Newstetter, *Science as psychology: Sense-making and identity in science practice.* in Science as psychology: Sense-making and identity in science practice. New York, NY, US: Cambridge University Press, 2011, pp. viii, 279.

[23] A. M. Pallas, "Preparing Education Doctoral Students for Epistemological Diversity," *Educ. Res.*, vol. 30, no. 5, pp. 1–6, Jun. 2001, doi: 10.3102/0013189X030005006.

[24] E. P. Douglas, M. Koro-Ljungberg, and M. Borrego, "Challenges and promises of overcoming epistemological and methodological partiality: Advancing engineering education through acceptance of diverse ways of knowing," *Eur. J. Eng. Educ.*, vol. 35, no. 3, pp. 247–257, Jun. 2010, doi: 10.1080/03043791003703177.

[25] B. Flyvbjerg, *Making Social Science Matter: Why Social Inquiry Fails and How it Can Succeed Again*, vol. 37. 2001. doi: 10.2307/1061731.

[26] M. Borrego, E. P. Douglas, and C. T. Amelink, "Quantitative, Qualitative, and Mixed Research Methods in Engineering Education," *J. Eng. Educ.*, vol. 98, no. 1, pp. 53–66, Jan. 2009, doi: 10.1002/j.2168-9830.2009.tb01005.x.

[27] J. M. Case and G. Light, "Emerging Research Methodologies in Engineering Education Research," *J. Eng. Educ.*, vol. 100, no. 1, pp. 186–210, Jan. 2011, doi: 10.1002/j.2168-9830.2011.tb00008.x.

[28] A. Slaton and A. Pawley, "The Power and Politics of Engineering Education Research Design: Saving the 'Small N,'" *Eng. Stud.*, vol. 10, no. 2–3, pp. 133–157, 2018, doi: 10.1080/19378629.2018.1550785.

[29] K. Beddoes, "Using peer reviews to examine micropolitics and disciplinary development of engineering education: a case study," *Discourse Stud. Cult. Polit. Educ.*, vol. 35, no. 2, pp. 266–277, Mar. 2014, doi: 10.1080/01596306.2012.745735.

[30] A. Cheville *et al.*, "Work in Progress: What is the Impact of Research in Engineering Education on University Administrators?," in *2019 ASEE Annual Conference & Exposition Proceedings*, Tampa, Florida: ASEE Conferences, Jun. 2019, p. 33664. doi: 10.18260/1-2--33664.

[31] M. A. Armstrong and J. Jovanovic, "The intersectional matrix: Rethinking institutional change for URM women in STEM.," *J. Divers. High. Educ.*, vol. 10, no. 3, pp. 216–231, 2017, doi: 10.1037/dhe0000021.

[32] M. Dalal, "Thinking using a Mixed Methods Approach".

[33] J. Seniuk Cicek, J. Paul, R. Bezerra Rodrigues, P. Sheridan, and R. Paul, "Journeying into Engineering Education Research," *Australas. J. Eng. Educ.*, vol. 28, no. 1, pp. 110–119, Jan. 2023, doi: 10.1080/22054952.2023.2219576.

[34] M. Klassen and J. M. Case, "Legitimating Engineering Education Research: A View from Sociology of Knowledge," in *2019 Research in Engineering Education Symposium*, Research in Engineering Education Network, 2019, p. 11.

[35] K. Beddoes, "Methodology discourses as boundary work in the construction of engineering education," *Soc. Stud. Sci.*, vol. 44, no. 2, pp. 293–312, Apr. 2014, doi: 10.1177/0306312713510431.

[36] C. J. Faber, R. L. Kajfez, D. M. Lee, L. C. Benson, M. S. Kennedy, and E. G. Creamer, "A grounded theory model of the dynamics of undergraduate engineering students' researcher identity and epistemic thinking," *J. Res. Sci. Teach.*, vol. 59, no. 4, pp. 529–560, Apr. 2022, doi: 10.1002/tea.21736.

[37] K. Charmaz, *Constructing Grounded Theory*, 2nd ed. Sage Publications, Inc., 2014.