

Epistemological Tensions in Engineering Education Research: How do we Negotiate Them?

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Abstract— This work-in-progress research paper contemplates the epistemological paradigms that support and drive research in engineering education, and the subsequent tensions that arise. Through collaborative autoethnography, the authors explore their academic experiences while conducting engineering education research during their Ph.D. programs. Three theoretical models of mentoring relationships, academic/professional identity, and levels of inquiry development are fused to conceptualize the doctoral journey and guide and interpret the data. The question, ‘*What factors affect epistemological tensions in engineering education research for an emergent academic?*’ is explored. The initial findings continue the dialogue discovered in the literature by asking how the community should negotiate these tensions in order to cultivate increased vigor and scholarship in the field.

Keywords—epistemological tensions; epistemological diversity; engineering education research; collaborative autoethnography

I. INTRODUCTION

The rapid emergence of engineering education as a field of inquiry [1], coupled with the growing unease in the lack of epistemological and theoretical understandings used to guide the research [2], create ‘epistemological confusion, methodological questions and uncertainty’ [3, p. 248] in the area. This concern is arguably made more important by the fact that engineering education is a discipline of ‘low consensus,’ characterized by less definitive standards for ‘rigor’ [4, p. 92]. The explicit understanding and acknowledgement by the researcher of the epistemology that interweaves a study increases the ‘vigor’ (a term referenced by Donna Riley as a replacement for ‘rigor’ [5], intended to imply thoroughness and a standard of excellence through ‘engagement’ over ‘compliance’ [5, p. 262]) and credibility of the work. This adds value to the research, which is of particular interest to engineering education researchers today [6] [7]. Further, the explicit understanding and acknowledgement by engineering

education researchers of the diverse epistemologies that exist and lend themselves to engineering education research are crucial to the healthy evolution of the discipline.

This work-in-progress research paper was initiated when a Ph.D. Candidate experienced tensions while conducting engineering education research. Upon reflection, she recognized these conflicts as fundamentally generated by epistemological differences between her and some of her mentors. She shared these deliberations with a faculty member with whom she had collaborated on previous research projects and who had also completed graduate work in engineering education. The faculty member admitted to experiencing similar tensions while engaged in engineering education research, both as a doctoral student and after, as an academic, albeit engendered from different perspectives. The interest in exploring these epistemological tensions and how they manifest in engineering education research led to the development of this work.

This study is designed as a collaborative autoethnography, in which the researchers are the participants. It is guided by the question: *What factors affect epistemological tensions in engineering education research for an emergent academic?*, with ‘emergent academic’ in this case intended to define graduate students who are training as scholars in engineering education, but to also encompass consideration of academics who are established in their own technical fields, but are ‘new’ or ‘emergent’ to engineering education. A brief summary of the literature is presented, followed by a description of how three theoretical frameworks are fused to model the evolution of mentoring relationships, professional identity, and levels of scholarship to guide this exploration. An excerpt from each collaborative autoethnography is shared, followed by considerations of initial findings.

This work adds to the small body of research in the area on the largely unconscious, dominating, and influential grounding of the field of engineering education in positivism, and the resulting tensions that arise. It extends the dialogue by asking how the community should negotiate these tensions in order to cultivate increased vigor in the discipline.

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II. LITERATURE REVIEW

Others have perceived epistemological tensions in the field of engineering education [2-4][8-11]. For this study, epistemology is defined as how a person ‘values and understands knowledge’ [8, p. 124], such as how knowledge is acquired. Epistemological tension can be described as discord between distinct views of what knowledge is, and how it is achieved and valued.

In engineering education, epistemological tension is in some regards inherent, resulting from the merging of two characteristically distinctive epistemological fields. Generally, engineering identifies with a primarily positivistic or post-positivistic epistemology, whereas education and the social sciences identify with a variety of epistemologies, many of which find their roots in interpretivism [2]. A paper presented at the 39th ASEE/IEEE Frontiers in Education conference in 2009 discusses these philosophical considerations [9]. The authors explain how academics new to education research naturally lean on the dominant research paradigm of their primary discipline to explore the field. A researcher new to engineering education is often educated as an engineer [4]. In this positivist/post-positivist dominant field, engineers typically view the world as objectivist and absolute, guided by rationalism and empiricism, with one truth that can be hypothesized, tested, and proven. Engineering generally favours a paradigm that resides in a singular epistemology [3], albeit a paradigm more ‘nuanced’ than commonly ascribed [11, p. 408], and values quantitative research designs and statistical analyses above other research approaches [8]. In contrast, education and the social sciences support interpretivism, which is directed by the notion that truth is subjective, constructed between people, and within context. Hence many truths and ‘knowledges’ can be construed, with data “mediated through personal ‘stories,’” and facts deeply intertwined with values [10, p. 2]. In this paradigm, the interpretation of data is dependent on the theoretical lens through which the findings are viewed. As [9] state, ‘Given the complexity of learning and in particular the individual factors that impact on that learning, conclusive evidence can be difficult, if not impossible, to obtain.’ As such, interpretivism lends itself to educational research (p. 3).

The epistemological dualism that presents itself in engineering education can result in polarizing views, and confusion [10] on how to approach research in the field. Importantly, as epistemology is deeply tied to discipline, a person’s epistemology affects what they view as legitimate research designs, including what research questions are appropriate to ask, and which methodologies are correct [8] or acceptable. These deeply held beliefs, often unconscious, could create tensions when one researcher’s epistemological views are inherently different from another’s.

III. THEORETICAL FRAMEWORKS

Work to characterize the tension that the present researchers experienced during their graduate studies in engineering education led to the identification of three theoretical frameworks: Kram’s four phases of a mentoring relationship [12], Kajfez’s Model of Professional Identity Development [13], and Streveler, Borrego and Smith’s Levels of Inquiry [14]. These frameworks lend themselves specifically to constructs that define the graduate student experience: namely, the relationship between the graduate student and her advisor/supervisor, i.e., mentorship; the graduate student’s development of her own professional identity; and the graduate student’s development of scholarship, i.e., the attainment of the knowledge, skills, and aptitudes required to become a scholar in one’s field. These three frameworks are used in parallel to explore the research question, *What factors affect epistemological tensions in engineering education research for an emergent academic?* and guide the researchers’ autoethnographical explorations for this study.

A. Kram’s Four Phases of a Mentoring Relationship

Kram’s four phases of a mentoring relationship [12] is used to model the stages a doctoral student should ideally experience in the interaction with their supervisor(s) through the graduate journey. These stages are *initiation*, *cultivation*, *separation*, and *redefinition* [12] and in this study, are theorized to represent the development and gradual release of the doctoral student into a professional career of academia [14]. The first two of Kram’s stages represent the guided part of the relationship, where the supervisor(s) sets concrete tasks and expectations, and works closely with her student to oversee her progress [14]. The latter two stages represent the gradual release elements of the model, culminating with the student as an autonomous academic [14].

B. Kajfez’s Model of Professional Identity Development

Kajfez’s Model of Professional Identity Development is a fusion of possible-selves and self-determination theory [13]. Possible-selves theory describes the individual in the present, positing the future identity to which they wish to aspire, and the identity they want to avoid [15]. Self-determination theory expresses how an individual’s motivation is ignited by their perceived interest and assessment of their own competence, autonomy, and relatedness in their community of practice [15].

C. Streveler, Borrego and Smith’s Levels of Inquiry

Streveler, Borrego and Smith’s Levels of Inquiry was developed for a five-day engineering education workshop

conducted in 2005 to coach academics new to the field of engineering education research [14][4]. The model is explained as ‘a continuum representing various levels of rigor in education-related inquiry,’ where *Excellent Teaching* transforms into *Scholarly Teaching*, followed by *Scholarship of Teaching*, and finally, *Rigorous Research in Engineering Education* [14]. The authors attribute the first three descriptions to the work of Hutchings and Shulman, and add a fourth level to describe the intended transition into the scholarship required of ‘rigorous engineering education research’ [4, p. 93].

For the purposes of this study, and the focus on the professional development of an academic in engineering education, Streveler, Borrego and Smith’s Levels of Inquiry [14] is re-envisioned to emphasize research. Research is conceptualized as the tool of the academic, and attaining a high level of research skills is theorized as the goal of the doctoral student for her Future Self. The levels are reframed as *Excellent Research*, which ascribes the use of relevant content and research methods; the introduction to learning, pedagogical, cognitive, and social theories; and the concepts of theoretical frameworks and epistemology [4]. *Scholarly Research*, exemplified by relevant content, research methods, data collection and analyses, guided by research questions, informed by best practice and best knowledge, and inviting collaboration and review, follows as the second level [4]. *Scholarship of Research*, which is public, open to critique and evaluation, and is in a form that others can build on, is next [4]. This level involves developing research questions, designing studies, conducting investigation and analyses and interpreting results. It has local appeal [4]. Finally, *Vigorous Research in Engineering Education* is achieved. Research at this level is also public and open to critique and evaluation, is in a form that others can build on, and involves developing research questions, designing studies, conducting investigation and analyses, and interpreting results [4]. However, research questions are tied to a theoretical framework, and data are interpreted through a theoretical lens, allowing for the research to build on theory, which can increase the significance of the findings [4]. The research is carefully designed, with explicit attention to the epistemology that informs the methodology and methods used [4]. The study has wide appeal, and holds up to scrutiny by a broad audience, creating a potential for greater impact of results [4].

D. Combining Theories into One Framework

Kram’s phases of a mentoring relationship [12] are juxtaposed with Kajfez’s Model of Professional Identity Development [13] to account for the influence of mentorship on the development of professional identity through the doctoral journey. As such, the levels are conceptualized as *Initiation (Current Self)* (i.e., *Self at beginning of journey*); *Cultivation (Competence)*;

Separation (Autonomy); and *Redefinition (Future Self)* – (i.e., *Self at end of journey*), with *Relatedness*, *Motivation*, and *Identity-Development* bracketing the four levels.

Streveler, Borrego and Smith’s Levels of Inquiry [14], newly reframed into the *Levels of mentoring, professional development, and scholarship in a doctoral journey* theoretical framework, is fused with Kram and Kajfez’s models to demonstrate the links for a doctoral student between the development of scholarship, mentoring relationships, and professional identity. Stage models are useful frameworks for understanding growth progressions when approached with a flexible linear interpretation, as the stages ‘overlap’ [15, p. 3]. These reframed theoretical models guide the creation and interpretation of the present researchers’ collaborative autoethnographies (see Table I).

IV. METHODOLOGY AND METHODS

A. Research Design

As this study was born out of a retrospective need to explore the epistemological tensions experienced during doctoral studies and subsequent professional development in engineering education, the researchers chose collaborative autoethnography as their methodological approach, grounded in an interpretivistic epistemology. Collaborative autoethnography borrows from the tradition of autobiography. It uses writing as a tool to engage in reflection; ethnography, to more fully understand its culture [15]; and collaboration, to account for, and benefit from the interaction of a group [16]. As both researchers were already emerged in their engineering education community, and desired to examine the epistemological tensions experienced in retrospect, collaborative autoethnography aligned with their research goals.

B. Data Collection and Analysis

Collaborative autoethnography is a form of narrative research, and a specific type of qualitative research [17] based in constructionism. It prioritizes rich detail over generalization, enabling the voices of the participants to emerge through the research [17]. Stories are constructed through the narrator’s perspectives, experiences, and social interactions [18][19]. When narratives are the unit of analysis in research [20], they are co-constructed by the participant and the researcher, retold for chronological relevance [21] or viewed through specific theoretical lenses, while remaining true to the teller’s voice [17].

The researchers wrote their autoethnographies using the *Levels of mentoring, professional development, and scholarship in a doctoral journey* theoretical framework to guide their reflections. A reiterative and collaborative process of critical reflection was then undertaken, where the researchers used their autoethnographies as the space from which to dialogue about their retrospective experiences,

guided by the newly constructed theoretical framework. Through this collaborative autoethnographical approach, the researchers were intent on using the disclosure of individual identity and experiences to understand the sociocultural context of the engineering education community where they reside [16].

V. AUTOETHNOGRAPHIES

For the purpose of this work-in-progress paper, only an excerpt of each researcher's (i.e., *participant's*) collaborative autoethnography is presented. The intent is to capture an example of the epistemological tensions experienced by each during their doctoral/professional journeys to illustrate the nature of this study. The levels of mentoring, professional development, and scholarship in the fused conceptual framework (see Appendix A) are referenced through the text, and the terms are capitalized.

A. First Participant

The first participant had a professional goal to be a 'qualitative researcher' as her Future Self. She was aligned with the epistemological paradigms that fit qualitative research methodologies and methods. She felt very strongly that this is where her educational strengths lay, and that these skills would be an asset for the field of engineering education, as the literature showed that qualitative methodologies were more unfamiliar to the academics working in the discipline (e.g., [22]). Additionally, she was passionate about this methodological area. When expressing this view to one of her mentors during the Initiation and Cultivation stages however, the participant was 'chastised' for identifying with qualitative methods rather than asking the research questions first, and *then* designing the study and choosing the methods to best answer the research questions. As much as this is an extremely important methodological consideration, and study design alignment is paramount for vigorous research, the participant noticed that the research questions modeled for her were asked – whether consciously or unconsciously – specifically (i.e., hypocritically) positioned within a positivistic paradigm, and then revised to fit particular quantitative analyses methods. There is nothing wrong with this approach; in fact, it is what happens in qualitative research as design alignment is continually balanced throughout the study. Rather, the source of tension was the epistemological tug-of-war that had ensued, with the mentor in the position of power with the clearly positivistic bent ultimately winning the 'war.' The participant's sense was that there was an underlying assumption that when the stamp of positivism and its quantitative methods were applied to research, the research and subsequent findings were felt superior (more 'rigorous', 'gold-starred'), and ultimately more useful for engineers.

B. Second Participant

The second participant's academic journey was shaped by the design engineering champion who participated in her M.Ed. studies and who became her Ph.D. supervisor. At the time, this seemed a natural fit because he (the design champion, now Ph.D. supervisor) was supportive of the second participant's interest in advancing interpretivist research in engineering education and willing to supervise graduate studies in that area. Additionally, he knew that the selection of coursework, the thesis topic, and the approach used would be very untraditional in engineering circles and may require him to defend it at some level to Faculty administration. The degree was formally in an engineering discipline, and somewhat subversively (within the academic structure) focussed on engineering education. The Ph.D. supervisor's commitment to student learning and curriculum innovation in engineering was evident throughout his long and successful academic career, and it was no surprise that he would support doctoral work in this area. Yet, his own subject matter expertise in engineering education as a discipline and in interpretivist approaches to scholarship therein was more limited than that of his Ph.D. student (i.e., the second participant), even at the start of the second participant's Ph.D. degree. While doctoral studies are intended to be much more self-directed than the Master degree and one generally expects the Ph.D. graduate's knowledge in an area to eventually exceed that of her supervisor, the second participant nonetheless experienced the doctoral degree process as significantly more self-directed than she would have wanted, finding the experiences of Initiation and Cultivation largely absent. In particular, her work focussed on the experiences of engineering 'outsiders' and thus initiated her to post-modernism and critical theory, which are in themselves difficult to grasp and even more so for those with well-trained positivist default modes, which accounted for both the second participant and her doctoral supervisor. The second participant continuously wondered whether the intellectual growth she nonetheless experienced and reflected in her dissertation would be considered 'enough' – scholarly enough, novel enough, and substantial enough both in an absolute sense and also in relation to her M.Ed. thesis – to warrant a Ph.D. degree – a question which was perhaps in itself a positivist reduction.

V. DIRECTIONS FOR FUTURE WORK

Both researchers wish to emphasize that no permanent harm was caused as a result of these tensions experienced in each case. Contrariwise, reflecting on these tensions provides an opportunity for them to garner significant insight, work that will continue with the full analysis of these collaborative autoethnographies.

REFERENCES

- [1] L. Malmi, et al., "How authors did it – A methodological analysis of recent engineering education research papers in the European Journal of Engineering Education," *Euro. J. Eng. Educ.*, vol. 43, no. 2, pp. 171–189, 2018. DOI: 10.1080/03043797.2016.1202905
- [2] A. Johri, "Creating theoretical insights in engineering education," *J. Eng. Educ.*, vol. 99, no. 3, pp. 183–184, 2010.
- [3] 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," *Euro. J. Eng. Educ.*, vol. 35, no. 3, pp. 247–257, 2010. DOI: 10.1080/03043791003703177
- [4] M. Borrego, "Conceptual difficulties experienced by trained engineers learning educational research methods," *J. Eng. Educ.*, vol. 96, no. 2, 2007.
- [5] D. Riley, "Rigor/Us: Building boundaries and disciplining diversity with standards of merit," *Eng. Studies*, vol. 9, no. 3, pp. 249 – 265, 2017. DOI: 10.1080/19378629.2017.1408631
- [6] Johri, A. and B. M. Olds, "Introduction," in *Cambridge Handbook of Engineering Education Research*. New York: Cambridge University Press, 2014, pp. 1–2.
- [7] 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
- [8] M. Borrego and L. K. Newswander, "Characteristics of successful cross-disciplinary engineering education collaborations," *J. Eng. Educ.*, vol. 97, no. 2, pp. 123–134, 2008. DOI: 10.1002/j.2168-9830.2008.tb00962.x
- [9] S. Cairncross and T. McEwan, "Researching engineering education: Some philosophical considerations," *Proc. - Front. Educ. Conf. FIE*, pp. 1–6, 2009.
- [10] C. Baillie and E. P. Douglas, "Confusions and conventions: Qualitative research in engineering education," *J. Eng. Educ.*, vol. 103, no. 1, pp. 1–7, 2014. DOI 10.1002/jee.20031
- [11] D. Montfort, S. Brown, and D. Shinew, "The personal epistemologies of civil engineering faculty," *J. Eng. Educ.*, vol. 103, no. 3., pp. 388–416, 2014. DOI 10.1002/jee.20050
- [12] K. E. Kram, "Phases of the mentor relationship," *Academy of Manag. J.*, vol. 26, no. 4, pp. 608–625, 1983.
- [13] R. L. Kajfez, *The Motivation and Identity Development of Graduate Teaching Assistants in First-Year Engineering Programs*. Blacksburg, VA: Virginia Tech, 2013.
- [14] R. A. Streveler, M. Borrego, and K. A. Smith, K. A., "Moving from the 'scholarship of teaching and learning' to 'educational research': An example from engineering," in *To Improve the Academy*, vol. 25, D. R. Robertson and L. B. Nilson, Eds. Bolton, MA: Anker, 2007, pp. 139–149.
- [15] R. McCord, C. Hixson, E. L. Ingram, and L. D. McNair, "Graduate student and faculty member: An exploration of career and personal decisions," *Proc. - Am. Soc. Eng. Ed. Conf. ASEE*, pp. 1–16, 2014.
- [16] J. Seniuk Cicek, P. Sheridan, L. Kuley, and R.M. Paul, "Characterizing the engineering education graduate student experience in Canada: Research development and reflections," *Proc. - Am. Soc. Eng. Ed. Conf. ASEE*, pp. 1–9, 2017.
- [17] M. Scheidt and A. Godwin, "A narrative approach to understanding underrepresented students' pathways into engineering," *Proc. - Front. Educ. Conf. FIE*, pp. 1–5, 2017.
- [18] G. R. Butler, "Personal experience narratives and the social construction of meaning in confrontational discourse," *J. Am. Folklore.*, vol. 115, no. 456, pp. 154–174, 2002.
- [19] M. R. Somers, "The narrative constitution of identity: A relational and network approach," *Theory Soc.*, vol. 23, pp. 605–649, 1994.
- [20] J. Elliott, *Using Narrative in Social Research: Qualitative and Quantitative Approaches*. Sage Publications, 2005.
- [21] J. A. Ollerenshaw and J. W. Creswell, "Narrative research: A comparison of two restorying data analysis approaches," *Qual. Inq.*, vol. 8, no. 3, pp. 329–347, 2002.
- [22] J. Case and G. Light, "Emerging methodologies in eng. education research," *J. Eng. Educ.*, vol. 100, no. 1, pp. 186–210, 2011.

APPENDIX A. Conceptual framework for a doctoral journey: Levels of mentoring, professional development, and scholarship. Authors credit [12–14].

Levels	Levels of mentoring & professional development (adapted from [12][13])	Levels of scholarship (adapted from [14])	Characteristics of the level of scholarship: purpose and scope (adapted from [14])
1	Initiation (Current Self) [start of journey]	Excellence in Research	Involves use of relevant content and research methods. Pedagogical, cognitive and social theories, theoretical frameworks and epistemology are introduced.
2	Cultivation (Competence)	Scholarly Research	Relevant content, methods, data collection & analyses; guided by research questions; informed by best practice & knowledge; invites collaboration & review
3	Separation (Autonomy)	Scholarship of Research	Public, open to critique; involves developing research questions, designing studies, conducting investigation & analyses, interpreting results. Has local appeal.
4	Redefinition (Future Self) [Self at end of journey]	Vigorous Research in Engineering Education	Public, open to critique; a form others can build on; involves developing research questions, designing studies, conducting investigation, analyses, interpreting results. Research builds on theory (research questions tied to theoretical framework; data interpreted through theoretical lens). Explicit attention to epistemology informing methodology & methods. Has broad appeal, holds up to scrutiny by wide audience. Potential for greater significance of findings and impact of results.