Exploring Intercultural Competency Development Among Engineering Graduate Students in Faculty-Run Laboratories

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RFE: Exploring Intercultural Competency Development Among Engineering Graduate Students in Faculty-Run Laboratories

Introduction and Project Rationale

In an increasingly global world, engineers must be capable of working effectively across cultural boundaries [1]. This need is particularly salient in engineering, as innovations and designs must function across diverse cultural and physical boundaries. Consequently, engineers at all levels are expected to develop intercultural competencies that enable effective collaboration and problem-solving in multicultural environments [2]. These expectations are formalized through ABET accreditation criteria [3], leading many universities to incorporate global programming into formal curricula and extracurricular activities.

To date, many educational initiatives aimed at developing intercultural competence have focused on undergraduate students, often through study abroad and international research experiences. Scholars have shown that these experiences can lead to increased cultural awareness and greater understanding of globalization [4]-[6]. Additionally, scholars have incorporated micro-modules in engineering courses during the regular semester to achieve similar goals of heightened cultural awareness and interactions, without the limitations of international travel [7]-[9]. While these efforts with undergraduate students have demonstrated positive outcomes, graduate-level engineering education and experiences are largely overlooked [10].

This absence is notable given that over 58% of engineering doctoral students and 68% of engineering master's students in the United States are international [11]. We see a unique opportunity to investigate and leverage graduate research laboratories as spaces where meaningful intercultural competency development may occur. Here, we bound the definition of a graduate research laboratory as the space and people, led by a faculty member Principal Investigator, who conduct research that supports graduate student researchers (and others) in the pursuit of research degrees such as master's degrees and PhDs. Graduate engineering laboratories are highly multicultural spaces characterized by goal-oriented teamwork. This environment brings together students from diverse national, cultural, and disciplinary backgrounds, creating a natural context in which intercultural competencies can develop during everyday research practices and social interactions. Despite this potential, there remains a significant gap in the literature regarding how intercultural competence is developed and supported among graduate engineering students. We begin to fill this gap by investigating graduate students' intercultural competency development within laboratory settings.

Project Description and Current Status

Purpose. This project works to define and assess the development of intercultural competency in graduate-level engineering spaces. Through a multi-phase mixed methods research design, the study aims to formalize an understanding of the social, cultural, and organizational dynamics that influence intercultural competency development in graduate research settings. Ultimately, the findings from this project will inform evidence-based strategies to intentionally use research laboratories as sites for intercultural learning, having direct implications for graduate education and mentoring practices and a broader impact on preparing a globally competent engineering workforce.

Theoretical Framework. Broadly, this project used Posselt's model for graduate student socialization (MGSS) [12] and Deardorff's process model of intercultural competency [2], [13] as guiding frameworks in the development of data collection methods and initial analyses. Deardorff's model has been operationalized previously to examine engineering students specifically, presenting the cognitive, social, and relational aspects of engaging with the beliefs, values, attitudes, and knowledge necessary to interact effectively with individuals outside one's own background. Examining intercultural competency development as a process rather than as a static outcome fits well within conceptualizations of graduate study as ontological, a process of becoming through socialization [14], [15]. To account for the other developmental and socializing influences that occur within graduate education, this project also leveraged Posselt's (2018) MGSS. The MGSS presents an ideal for holistic support, through three main areas of support that graduate students need to navigate the socialization process the most effectively: (1) academic support, (2) psychosocial support, and (3) advising on the sociocultural rules of the discipline. To learn, gain, or engage in the process of intercultural competence, students must be provided with a level of holistic support. While the MGSS and process model of intercultural competence were the primary theoretical perspectives used in the initial framing of the study, additional perspectives have been leveraged in accompaniment to assist in sensemaking and research design as we continue to refine our understanding of intercultural competency and the inner workings of graduate lab groups. Additional perspectives that are being used as we move towards longitudinal exploration are those concerned with small group formation, maintenance, and cohesion [16], as well as socialization stages over time [17].

Project Structure. This project has two distinct phases; we report on the first phase in this paper. The first phase focused on developing quantitative measures for intercultural competency that are appropriate for this context and understanding current competencies in graduate students as well as identifying. While we initially planned to begin with a nationwide survey, we found that existing open-access quantitative instruments to measure intercultural competency did not transfer well to the specific context we are investigating. This realization led us to conduct cognitive interviews with the most promising instrument, which then led us to deploy a large-

scale, qualitative interview phase. We are currently using these two sets of interviews to develop a survey for phase two.

Cognitive Interviews. We conducted cognitive interviews based on the extended cultural intelligence survey (E-CQS), an established, open-access intercultural competency scale [18]. Justification of how we decided on this scale is provided in [19]. We interviewed graduate engineering students (n = 16) in mechanical engineering departments from two large, research-intensive, land-grant institutions in the United States. The cognitive interview approach was primarily used to investigate how participants interpreted and engaged with items from the ECQS, an established, open-access intercultural competency scale [18], with particular attention to how well item assumptions aligned with the realities of students' lived experiences in faculty-led laboratory settings. Findings from the study indicated that several items from the scale were difficult for participants to situate within their day-to-day laboratory interactions, often eliciting ambiguity, discomfort, or responses disconnected from students' lab contexts [19]. The study subsequently highlighted that direct deployment of existing scales, such as the ECQS, could risk invalid or ethically problematic findings, emphasizing the importance of contextual grounding and validation when selecting and deploying quantitative instruments to assess intercultural competency in graduate engineering research environments.

An added concern following the findings from this study was to ensure that the survey data collected during Phase 2 would come from more accurate, contextually modified, and validated instruments. Instruments assessing intercultural competency are available; however, many are not openly accessible or are developed with other contexts in mind. From these cognitive interviews and work in framing intercultural competency for engineering graduate students, we argue that engineering graduate labs are unique, complex environments with a wide range of ecological factors and outcomes, adding complexity to examining how intercultural competency is defined, enacted, or developed in this context.

Cross-Sectional Interviews. We carried out cross-sectional interviews with 61 participants to understand what intercultural competency development currently entails in faculty-run labs. These interviews will help us develop a survey for Phase 2 by allowing us to identify related constructs that might be particularly relevant or related to intercultural competency. While data analysis is ongoing, patterns from current data collection and analysis include:

1. Lab group cohesion can lead to a supportive lab climate even in the case of non-ideal advisor-advisee relationships; cohesive peer groups provide a critical safety net that sustains student well-being and facilitates cross-cultural peer mentorship and culture sharing.
2. Psychological safety in labs is dependent on a) the quality of interactions with advisor(s) and research group members and b) sociocultural norms which influence students' expectations of the graduate research environment. We see the potential for psychological

safety to emerge as a necessary precursor for intercultural interactions, allowing lab peers to communicate effectively, share personal issues, and work effectively without fear of marginalization.

3. Growth mindset beliefs about research and communication appear to shape how students approach intercultural challenges. When students describe research and communication skills as learnable, they are more likely to seek feedback, adjust their communication strategies, and stay engaged across language or cultural differences, whereas more fixed framings of ability are associated with withdrawing from difficult interactions.

Notably, findings so far were not directly tied to an established definition of intercultural competence but were closely tied to group dynamics and communication. Part of the difficulty in unpacking intercultural competency in interviews may have been rooted in either social desirability or ambiguity of concepts. Moving into Phase 2, we have emphasized identifying related theoretical constructs and instruments concerned with understanding intercultural competency in engineering graduate labs.

Conclusion and Next Steps

The second phase of this project will build on the results of the first phase with a nationwide quantitative survey and a longitudinal study focused on graduate students working in multicultural research laboratories. We are using our findings from phase one to develop a survey instrument that can be deployed to graduate engineering students nationwide. Findings from the cross-sectional interviews and initial survey highlighted the ambiguity of measuring intercultural competence in the graduate context. Defining intercultural competence can be nebulous and built on several other concepts. To bolster the next phase, the research team has drawn on initial findings to strengthen data collection. Namely, in the nationwide survey, we have moved away from the general, surface-level measures of intercultural competence that we piloted in Phase 1 in favor of adapting or using concrete or context-driven measures, such as the global engineering competency scale (GECS) [20], team psychological safety and learning behavior scale (TPS) [21], and sources of meaning in academia scale [22]. Alongside these measures, we will ask for more detailed responses about lab group composition and participant demographics to provide additional context to responses. From this survey, we will recruit participants for a longitudinal study, which will allow us to examine how intercultural competencies change over time in faculty-run laboratories.

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