Latina Engineering Student Graduate Study Decision Processes – Development and Initial Results of a Mixed-Methods Investigation

Dr. Bruce Frederick Carroll, University of Florida

Dr. Carroll is an Associate Professor of Mechanical and Aerospace Engineering at the University of Florida. He holds an affiliate appointment in Engineering Education. His research interests include engineering identity, self-efficacy, and matriculation of Latin/a/o students to graduate school. He works with survey methods and overlaps with machine learning using quantitative methods and sequential mixed methods approaches.

Dr. Janice Mejía, Northwestern University

Dr. Mejia is an Associate Professor of Instruction in the Department of Industrial Engineering and Management Sciences. She also teaches in the Design Thinking and Communication (DTC), Masters in Engineering Management (MEM), and College Prep programs. Her research interests focus on mixed methods research in engineering education, curriculum assessment and development, and engineering identity.

Dr. Kent J. Crippen, University of Florida

Kent Crippen is a Professor of STEM education in the School of Teaching and Learning at the University of Florida and a Fellow of the American Association for the Advancement of Science.

Sheila Castro, University of Florida

Latina Engineering Student Graduate Study Decision Process – Development of a Mixed-Methods Investigation

Introduction

Observations in the Mechanical and Aerospace Engineering department of a large land-grant university with approximately 20% Latina/o enrollment revealed that Latina engineering students are significantly less likely to attend graduate school than women from other ethnic or racial groups. This observation is consistent with national trends showing underrepresentation of Latina/o populations in STEM disciplines.[1], [2] With this motivating background, a study has been undertaken to explore the social, cultural, educational, and institutional factors affecting matriculation of undergraduate Latina engineering students into graduate engineering programs and/or industry careers. A research team was formed with four members (co-authors of this paper) from diverse backgrounds but a common commitment toward an asset-based approach that avoids marginalizing individuals in the research design process and by selecting respective methods.[3] Results of these team discussions and decisions sought balance between various philosophical perspectives. This work-in-progress paper describes the mixed-methods research design considerations in formulating the study with emphasis on the quantitative portion. Detailed development of the qualitative portions of the study are still in progress and will be reported at future date.

Positionality Statement

The authors openly acknowledge and reflect on their subjective stance and potential biases by providing a positionality statement that encompasses our backgrounds and experiences as they may relate to this work. We begin with this statement to assist readers in understanding possible influences this bias may have in our process. Bruce Carroll is a white male engineering educator with a tendency toward an emic account from the institutional perspective given his many years in administrative positions. However, he has strong personal sensitivities to individuals and families fighting for rights. Kent Crippen is a white male science educator who champions change in educational systems to meet the needs of every student. He has worked on multiple projects with engineering faculty but views himself as an outsider in engineering circles. Janice Mejia is a Latina engineering educator and an immigrant in the United States. Prior to teaching in academia, she worked in for-profit and non-profit sectors to optimize technologies, processes, and policies in organizations. She provides unique emic and etic perspectives to the research problem. Sheila Castro is a Latina, first-generation doctoral student and former high school science teacher. Despite not having direct engineering experience, she is drawn to understand and incorporate diverse perspectives within this field. All four researchers are committed to embracing anti-deficit approaches of engineering education research for promoting broader, more equitable participation in STEM professions.

Project Design

Given the intent for a comprehensive exploration of this complex phenomenon at the scale of a department and college, a mixed-methods approach is adopted to provide the fullest possible exploration of the decision-making process of Latina engineering students relative to graduate study or directly entering the workforce following completion of the undergraduate

degree. An explanatory sequential design [4] is employed. This approach is recognized as particularly useful for expanding quantitative results to help explain differences between groups as well as the limitations of the survey instrument itself [4]. A quantitative first-stage survey of engineering students using a modified College Achievement Model (CAM) framework [5] is followed by a second-stage qualitative analysis of participant interviews using the Community Cultural Wealth Model (CCWM) [6], [7].

The CAM quantitative framework has been adapted by others for use in qualitative studies of Latina engineering students [8]. Based on that approach, the CAM appears suitable for use in the current work, especially for portions of the work focused on institutional factors. The quantitative CAM is based on Tinto's theory of student departure [9], [10]. Frequent criticisms of work based on Tinto's framework point out that an emphasis on institutional integration can lead to deficit overtones [9], [10]. For example, by comparing and contrasting the minoritized group to the majority population, implies the need for the underrepresented group to adapt to the institutional environment to be successful [11], [12].

Following a different approach, Espino [1] discusses the importance of Bourdieu's concept of social and cultural capital [13]–[15] in graduate school access and persistence. Cultural capital can take on various forms, including "cultural knowledge, skills, abilities, norms, preferences or mannerisms" [1] utilized by the majority group to advance academically. The cultural capital of the majority may differ from the forms of capital possessed and utilized by minoritized groups. The CCWM [6], [7], which combines the concept of social and cultural capital with critical theory, has been used to explore ways Latina/o students utilize their cultural wealth to navigate and find success in higher education settings [6], [16].

While utilizing two theoretical frameworks provides a broad exploration of the topic, the research team was concerned about the philosophical and epistemological coherence between the quantitative first stage and the qualitative second stage. The team initially considered replacing the CAM survey section on racial identity (with emphasis on Black students) with items related to ethnic identity [17]–[19]. While making the CAM survey items more appropriate to Latina engineering students, this approach would still leave the two research stages disjointed and unconnected since ethnic identity is a narrowly focused construct that fails to encompass all relevant parameters. Greater coherence is achieved by incorporating aspects of the CCWM model in the first-stage survey instrument. Using Hiramori's [20] quantitative implementation of the CCWM as a guide to modify CAM survey items related to racial identity [5], we will leverage the quantitative first stage results for planning the qualitative CCWM framework in the second stage of our study.

Efforts were also taken to incorporate the emerging best practices of QuantCrit [21] across the entire mixed-methods study to ensure the critical theory nature of the CCWM is reflected in any quantitative implementation of that theory. Recommendations are also incorporated from the work of Mejia et al. [3] for research integrating a critical perspective as we considered anti-deficit framing and critical theory questions in the development and design of the methods. Castillo and Gilborn [22] suggest considering five foundational principles when adapting a critical theoretical framework to a quantitative study: 1) The Centrality of Racism, 2) Numbers are Not Neutral, 3) Categories are Neither Natural nor Given, 4) Voice and Insight, and

5) Social Justice/Equity Orientation. A discussion of how the five principles are incorporated into the current research design follows.

Principle 1. The Centrality of Racism. The first principle acknowledges that issues related to race/racism are embedded in all aspects of society [23] in overt and more subtle ways. Research studies may tend to mask issues related to racism, especially in quantitative studies where race is treated as a variable[21]. Castillo and Gillborn [21] recommend quantitative studies include a positionality statement, common in qualitative work but much less so in quantitative approaches, to acknowledge that biases may be present and to assist readers in understanding possible influences. Similarly, Mejia et al.[3] emphasize the importance for researchers to reflect on their positionality relative to the work. Principle 1 also calls for an anti-deficit framing of research questions[21]. For the design of our study, a decision was made to ask two research questions, one from a more traditional perspective and the second from an explicitly asset-based perspective to counter any tendency toward deficit thinking. The first research question is *RQ1: How do Latina engineering students describe the factors related to their decision, decision processes, or intentions to enter graduate school and/or engineering career pathways?* This research question is more aligned with the CAM perspective with factors tending to be interpreted as underlying constructs impacting the decision or decision processes. A second research question was developed to more explicitly bring in the CCWM asset-based perspective. *RQ2: How do Latina engineering students describe the social, cultural, educational, and institutional experiences that impact their decision, decision process, or intentions to enter graduate school and/or engineering pathways?*

Principle 2. Numbers are Not Neutral. Quantitative data appears to be objective and free of bias in engineering disciplines. However, deeper consideration reveals how biases can be embedded within the quantitative approach [22]. Care is needed in selecting the sample population and defining relevant measurement variables [21]. For this study, the measurement constructs from the CAM are explicitly augmented with survey items that incorporate CCWM insights. Survey questions based on the CAM are related to the constructs of academic self-efficacy, peer group interactions, and faculty integration [5]. Survey questions based on a quantitative implementation of CCWM [20] are related to aspirational, linguistic, familial, social, navigational, and resistant forms of social and cultural capital. Additionally, Latina engineering students who are the central participants, are being engaged in think-aloud reviews of the survey instrument to refine the survey instrument and help avoid "blind-spots" in the research design.

Principle 3. Categories are Neither 'Natural' Nor Given. The operationalization of variables such as race or gender have significant implications. Categories may be created, omitted, or grouped together in ways that change or affect the interpretation of the results [22]. Steps being taken to address this principle, include: 1) defining relevant classifications of gender and race by following practices recommended by the 2020 US Census, while allowing participants to self-describe their racial/ethnic identity if the provided categories do not match their identity and 2) data will be disaggregated by gender and ethnicity/race**.** We also plan to solicit help from Latina/o engineering student organizations and student services in identifying and recruiting the participants to ensure the group of interest is sufficiently represented.

Principle 4. Voice and Insight. When formulating a study and analyzing/interpreting the data, it is important to prioritize the views and perspectives of the group of interest. Transparency

is desired so that the experiences of marginalized groups are not masked by the views of a larger majority [21]–[23]. Recommendations to address this tenant [21] incorporated into the current study include emphasizing person-centered data analysis techniques.[24], [25] Latent class analysis will be used to look for underlying patterns of responses from study participants. Less emphasis is placed on identifying underlying variable-centric constructs. This is reflected by the decision to use broader quantitative implementations of CCWM to allow broader measures of relevant forms of cultural wealth as opposed to a series of survey items specifically related to ethic identity constructs. The mixed-methods approach being employed is also a recognition of this principle. The quantitative first-stage will be utilized to help guide the qualitative second-stage allowing greater opportunity for the group of interest to tell their story.

Principle 5. Social Justice/Equity Orientation. The final principle emphasizes using results to promote equity and justice [22]. The underlying goal of the study is to explore the decisions, decision process, and intentions of Latina engineering students. Efforts are being taken to explicitly avoid deficit type comparisons of this minority group to the broader majority, for example by employing a person-centered perspective in evaluating quantitative results. The hope is this study will prioritize the voice of Latina engineering students and encourage engineering departments to better understand and respond to the educational needs and career goals of Latina students. As mentioned in Principle 2, students from the target population are being consulted in the development of survey instruments and in the formulation of the qualitative second-stage, with the intention that the work provides a liberative stimulus for participants [3].

Conclusion

Given the need and desire for addressing the historical issues of representation and participation in engineering, coupled with the sensitivities and intricacies of addressing this complex social phenomenon, we anticipate this study being of relevance and interest to a diverse group of ASEE researchers. The principles presented form the basis of incorporating Community Cultural Wealth questions within the quantitative portion of a mixed-methods approach. Motivation for a mixed-methods study is to prioritize the participant's voice regarding their decision processes related to academic and career choices and decisions regarding graduate study. Future work will include a direct comparison of insights gained via qualitative and quantitative aspects of the study.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 2306262 and 2306263. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

[1] M. M. Espino, "Exploring the role of community cultural wealth in graduate school access and persistence for mexican american phds," *American Journal of Education*, vol. 120, no. 4, pp. 545–574, Aug. 2014, doi: 10.1086/676911.

[2] M. M. Camacho and S. M. Lord, "Quebrando fronteras: Trends among Latino and Latina undergraduate engineers.," *Journal of Hispanic Higher Education*, vol. 10, no. 2, pp. 134–146, 2011.

[3] J. Mejia, R. Revelo, I. Villanueva, and J. Mejia, "Critical Theoretical Frameworks in Engineering Education: An Anti-Deficit and Liberative Approach," *Education Sciences*, vol. 8, no. 4, p. 158, Sep. 2018, doi: 10.3390/educsci8040158.

[4] J. W. Creswell and V. L. Plano Clark, *Designing and Conducting Mixed Methods Research*, 3rd ed. SAGE Publications, Inc, 2017, p. 518.

[5] K. W. Reid, "Black gold: Understanding the relationships between racial identity, self-efficacy, institutional integration and academic achievement of Black males in research …," Doctoral dissertation, Harvard University, Cambridge, 2007.

[6] T. Yosso, W. Smith, M. Ceja, and D. Solórzano, "Critical race theory, racial microaggressions, and campus racial climate for latina/o undergraduates," *Harv. Educ. Rev.*, vol. 79, no. 4, pp. 659–691, Dec. 2009, doi: 10.17763/haer.79.4.m6867014157m707l.

[7] T. J. Yosso, "Whose culture has capital?," in *Critical race theory in education: all god's children got a song*, A. D. Dixson, C. K. Rousseau Anderson, and J. K. Donnor, Eds. 2nd edition. | New York, NY : Routledge is an imprint of the Taylor & Francis Group, an Informa Business, [2017]: Routledge, 2016, pp. 113–136.

[8] D. Verdin and A. Godwin, "Exploring latina first-generation college students' multiple identities, self-efficacy, and institutional integration to inform achievement in engineering," *J. Women Minor. Sci. Eng.*, vol. 24, no. 3, pp. 261–290, 2018, doi: 10.1615/JWomenMinorScienEng.2018018667.

[9] J. M. Braxton and E. M. Brier, "Melding organizational and interactional theories of student attrition: A path analytic study," *Rev. High. Ed.*, vol. 13, no. 1, pp. 47–61, 1989, doi: 10.1353/rhe.1989.0003.

[10] A. M. Brower, "The 'second half' of student integration," *J. Higher Educ.*, vol. 63, no. 4, pp. 441–462, Jul. 1992, doi: 10.1080/00221546.1992.11778378.

[11] G. D. Kuh and P. G. Love, "A cultural perspective on student departure," in *Reworking the student departure puzzle*, J. M. Braxton, Ed. Vanderbilt University Press, 2020, pp. 196–212.

[12] L. I. Rendón, R. E. Jalomo, and A. Nora, "Theoretical considerations in the study of minority student retention in higher education," in *Reworking the student departure puzzle*, J. M. Braxton, Ed. Vanderbilt University Press, 2020, pp. 127–156.

[13] P. Bourdieu, "The Forms of Capital," in *Handbook of theory and research for the sociology of education*, vol. 241, New York, NY: Greenwood, 1986, pp. 241–258.

[14] P. Bourdieu, "Outline of a theory of practice," in *The new social theory reader*, S. Seidman and J. C. Alexander, Eds. Routledge, 2020, pp. 80–86.

[15] P. M. McDonough and A. M. Nunez, "Bourdieu's sociology of education: Identifying persistent inequality, unmasking domination, and fighting social reproduction.," *Critique and utopia: New developments in the sociology of education*, pp. 139–154, 2007.

[16] N. A. Luna and M. Martinez, "A qualitative study using community cultural wealth to understand the educational experiences of latino college students," *Journal of Praxis in Multicultural Education*, vol. 7, no. 1, Apr. 2013, doi: 10.9741/2161-2978.1045.

[17] E. Yoon, "Measuring ethnic identity in the Ethnic Identity Scale and the Multigroup Ethnic Identity Measure-Revised.," *Cultur. Divers. Ethnic Minor. Psychol.*, vol. 17, no. 2, pp. 144–155, Apr. 2011, doi: 10.1037/a0023361.

[18] A. J. Umaña-Taylor, A. Yazedjian, and M. Bámaca-Gómez, "Developing the ethnic identity scale using eriksonian and social identity perspectives," *Identity*, vol. 4, no. 1, pp. 9–38, Jan. 2004, doi: 10.1207/S1532706XID0401_2.

[19] S. Douglass and A. J. Umaña-Taylor, "A brief form of the ethnic identity scale: development and empirical validation," *Identity*, vol. 15, no. 1, pp. 48–65, Jan. 2015, doi: 10.1080/15283488.2014.989442.

[20] D. Hiramori, E. Knaphus-Soran, and E. Litzler, "Critically quantitative: measuring community cultural wealth on surveys," presented at the 2021 ASEE Virtual Annual Conference Content Access, Jul. 2021, doi: 10.18260/1-2--36880.

[21] W. Castillo and D. Gilborn, "How to 'QuantCrit:' Practices and Questions for Education Data Researchers and Users," *EdWorkingPapers.com*, 2022, doi: 10.26300/v5kh-dd65.

[22] D. Gillborn, P. Warmington, and S. Demack, "QuantCrit: education, policy, 'Big Data' and principles for a critical race theory of statistics," *Race Ethnicity and Education*, vol. 21, no. 2, pp. 1–22, Sep. 2017, doi: 10.1080/13613324.2017.1377417.

[23] C. Priddie and R. Renbarger, "Connecting quantcrit to gifted education research: an introduction," *Gifted Child Quarterly*, vol. 67, no. 1, pp. 80–89, Jan. 2023, doi: 10.1177/00169862221116636.

[24] L. R. Bergman and K. Trost, "The Person-Oriented Versus the Variable-Oriented Approach: Are They Complementary, Opposites, or Exploring Different Worlds?," *Merrill Palmer Q.*, vol. 52, no. 3, pp. 601–632, 2006, doi: 10.1353/mpq.2006.0023.

[25] M. C. Howard and M. E. Hoffman, "Variable-Centered, Person-Centered, and Person-Specific Approaches," *Organizational Research Methods*, vol. 21, no. 4, p. 109442811774402, Dec. 2017, doi: 10.1177/1094428117744021.