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Work in Progress: Longitudinal Study of Identity-based Motivation of Students Participating in Chemical Engineering Research Center Programs

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WIP: Longitudinal study of Identity-based Motivation of Students Participating in Chemical Engineering Research Center Programs

Introduction

This Work in Progress paper describes the ongoing process of studying the development of students' Identity-based Motivation through participation in STEM programs offered by a chemical engineering research center. The Center for Innovative and Strategic Transformation of Alkane Resources (CISTAR) is a National Science Foundation (NSF) Engineering Research Center (ERC), which mission is to attain U.S. shale gas potential responsibly by working in partnership with industry to develop technological innovations and build a diverse and innovative workforce. The CISTAR Engineering Workforce Development pillar uses the framework of Identity-based Motivation to promote skills and ways for all students, from middle school to doctoral students, to see themselves as active participants in the hydrocarbon workforce to achieve a robust system of engineering education and pathways. Students' identities, or how they see themselves as an individual, within particular roles, or as part of a larger group, have been linked to engineering career choices [1]–[3], student persistence [4]–[6], academic success [7], [8], and other outcomes directly related to CISTAR Engineering Workforce Development goals.

We are preparing a longitudinal survey instrument to measure participants' identity-based motivation and career intentions/pathways for the duration of the CISTAR grant (until the year 2027). This survey is the first of its kind to use Identity-based Motivation measures in engineering education outside of graduate students and will be appropriate for late high school students through graduate students. The survey will be sent yearly to the participants of CISTAR programs (Graduate and Undergraduate Fellows [our term for students affiliated with the Center], postdoctoral scholars, Research Experiences for Teachers [RET] participants, Research Experiences for Undergraduates [REU] or Research Experience and Mentoring [REM] participants, Young Scholar Program participants).

This study brings particular challenges in development and implementation that we discuss in the rest of this paper. In particular, program evaluation often focuses on immediate or outcomes some time after the event (often up to 6 months). In this study, we take advantage of the unusual length of the ERC grant duration (10 years) to be able to reflect on the long-term impact of STEM programs in the development of identities and motivations along career pathways. In this Work in Progress paper, we describe the ongoing process for developing the first round of surveys, as well as discussing considerations for conducting longitudinal survey research.

Motivation

Growing up, most children are asked, "What do you want to be when you grow up?" Although the answers might seem general or related to their particular interests or the influence of parental or other adult figures, many studies of why students choose STEM careers indicate that early exposure to STEM fields, representational role models, and activities aligned with personal interests can support identity development and subsequent career decisions [9]–[12]. These

influences continue to play an important role in high school students' [1], [13], [14] and undergraduates' pathways [4], [15]–[17] into and through STEM. Additionally, these influences also affect how engineering graduate students experience their education and engage in the broader STEM research community [18], [19]. Identity work is also particularly challenging for marginalized students (women and Black, Indigenous, Latinx, first-generation, LGBTQ+, and disabled) who must not only work to author identities as STEM people but also do so within fields with hegemonic norms of Whiteness, masculinity, cisheteronormativity [20]–[27].

Framework

The development of students' identities, or how they see themselves as an individual, within particular roles, or as part of a larger group, have been linked to engineering career choices [1]–[3], student persistence [4]–[6], academic success [7], [8], and other outcomes related to CISTAR Engineering Workforce Development goals. Identity-based Motivation consists of three constructs: action readiness, dynamic construction, and interpretation of difficulty [28]. When students perceive STEM and engineering as congruent with their future goals, they develop action readiness to pursue goals aligned with their identities. This framing also acknowledges the importance of context in shaping which identities are important to students (i.e., dynamic construction). Finally, when a behavior feels consistent with important identities, difficulties will be interpreted as meaning that the behavior is important, not impossible and, therefore, effort is meaningful, not pointless (i.e., interpretation of difficulty). We use this framework to understand how the CISTAR context can help shape STEM role identities, acquisition of relevant knowledge, skills, and abilities in the STEM domain, goal setting, and motivation to pursue STEM career pathways. We also use this framing to understand how these STEM identities are embedded within a large sociocultural contexts of who becomes a STEM professional to develop pathways for marginalized students in STEM.

Methods

We hypothesize that exposure to research experiences that develop STEM-relevant knowledge, skills, and abilities will also support students' identity-based motivations and long-term career pathways into STEM. To measure the impact of students' participation in CISTAR programs on their identity-based motivation and career intentions/pathways, we are preparing a longitudinal survey instrument of these constructs for the duration of the CISTAR grant. The process will run until the end of the CISTAR NSF project, estimated for 2027. The survey will be sent yearly to an estimated maximum of 1155 participants of CISTAR programs (which includes students from secondary education through graduate education in a variety of ongoing and summer programming). Each participant will be contacted via a provided email to update their professional progression. The maximum amount of time that a participant might be in the study is starting in Summer 2021 through Fall 2027. As new cohorts of participants in CISTAR engage with the center each year, they will be added to the study.

Survey development

The first round of surveys comprises four topics: task difficulty questions, identity-based motivation questions (engineering, science, and computer science), student sustained interest in

STEM or career intentions, graduate and undergraduate academic preparation questions, as well as demographics. Asking these questions over time will provide information on the dynamic construction of these constructs in relation to career pathway development. First, the task difficulty questions (Table 1) assess how students evaluate the difficulty of research tasks, communication and dissemination tasks, class-related tasks, and collaboration tasks. We have adapted these items from a study of engineering graduate students [29], which developed engineering-specific items from Oyserman [28]. Second, the identity questions are specified by area of work, research, or study. Role identities are contextually specific and as such, we have formulated questions for engineering, science, or computer science consistent with previous work in mathematics, science, and engineering [1], [13], [14]. Students will choose the field of study most relevant to them to answer these questions, as ERC's are interdisciplinary and may involve students from across STEM solving engineering programs. Third, items measuring student pathways and sustained interest were developed for this study from The ERC Evaluation Consortium's Multi Engineering Research Center Instrument Inventory [30] to assess the student's willingness to continue their STEM paths, such as the pursuit of additional degrees and which career plans they might consider. Finally, we also ask students to self-report their academic preparation for undergraduate or graduate school (when applicable). These questions refer to standardized test results, GPAs, or if any person might have contributed to the selection of a career path. While we acknowledge that these self-report measures may have some reporting bias, they can provide some indication of student pathways and decisions. All the survey items were based on instruments published with validity evidence [1], [13], [14], [28], [29], [30]. We will continue the process of validation with new populations as a part of this study.

Table 1 - Task difficulty items related to research experiences.

I feel like an [Engineer, Computer Science, Science person] when...
When I read journal articles
When I write about research
When I create a poster about research
When I conduct research
When I attend conferences
When I present my research results
When I attend my classes
When I do homework
When I collaborate with other students
When I apply my problem-solving skills in my everyday life
When my team members appreciate my contributions to the project
When I feel that my engineering skills will contribute to society
When I volunteer for activities that promote others' interest in STEM

Anticipated Results

With a projected large number of participants (anticipated $n = 1155$), we will be able to investigate both how program experiences influence students' identity-based motivations and trajectories as well as for whom these experiences were most effective. The results of this work will provide an insight into how students perceive themselves as STEM people throughout and

beyond their participation in an NSF ERC and support an understanding of how identity-based motivation develops over time and shapes career trajectories. These results will help to adapt STEM programs not only to the needs of the STEM market but also adjust to the needs of the diverse STEM population.

Considerations for longitudinal survey research

The longitudinal nature of this project will allow us to understand how these identity-based motivations change over time and the particular pathways students take after an engagement with CISTAR. These types of studies can provide unique insights into the pathways of students engaged in an NSF-sponsored program as well as provide a nuanced understanding of the pathways into and through undergraduate education and beyond as linked to identity and motivation. Moreover, other research programs, such as MIDFIELD [31], collect transcript data, which provides useful information for student pathways through formal education, but cannot link decision points to student's internalized states (i.e., identity and motivation). The direct Identity-based Motivation data to be collected by CISTAR Engineering Workforce Development provides an opportunity for long-term research because it can look at the impact of linking Identity-based Motivation over time with student pathways.

One of the other challenges with longitudinal data is the likelihood of attrition. We plan to build a strong rapport with participants during their time with CISTAR as well as discuss how their data will help inform our evaluation of programs and future efforts to support STEM career pathways. Regular updates from the center on ongoing efforts will also provide a channel for regular communication beyond the ask for survey data. We also plan to provide information back to participants about the ongoing research to engage them in the process.

An additional challenge that we foresee is the process of consenting students engaged in the Young Scholars program. These students are rising juniors and seniors in high school, while some students are over eighteen years of age, many fall under the vulnerable populations considerations in *45 CFR 46*. We are currently working with our IRB to develop protocols for online engagement and data collection.

Future Work

While this Work in Progress paper presents the ongoing process of the development of instruments to assess the impact of linking Identity-based Motivation longitudinally with student pathways, we are developing strategies to use the collected data for improving the center's programs. Our future work will focus on the successful implementation of data collection efforts and provide beginning information about the impact of research experiences on participants' identity-based motivation and career interests. We plan to begin this process in Summer 2021 with the implementation of virtual REU, REM, and RET programs and will continue efforts through the life of the Center. After the data collection, we plan to use that data to not only improve the center's programs but also to better understand students' career pathways and the influence of research experiences on those trajectories.

References

[1] A. Godwin, G. Potvin, Z. Hazari, and R. Lock, "Identity, Critical Agency, and Engineering: An Affective Model for Predicting Engineering as a Career Choice," *Journal of Engineering Education*, vol. 105, no. 2, pp. 312–340, Apr. 2016, doi: 10.1002/jee.20118.

[2] A. V. Maltese and R. H. Tai, "Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students," *Science education (Salem, Mass.)*, vol. 95, no. 5, pp. 877–907, 2011, doi: 10.1002/sce.20441.

[3] S. Y. Yoon, M. Dyehouse, A. M. Lucietto, H. A. Diefes-Dux, and B. M. Capobianco, "The Effects of Integrated Science, Technology, and Engineering Education on Elementary Students' Knowledge and Identity Development: Effects of Integrated STEM Education on Students," *School science and mathematics*, vol. 114, no. 8, pp. 380–391, 2014, doi: 10.1111/ssm.12090.

[4] O. Pierrakos, T. K. Beam, J. Constantz, A. Johri, and R. Anderson, "On the development of a professional identity: Engineering persisters vs engineering switchers," in *2009 39th IEEE Frontiers in Education Conference*, 2009, pp. 1–6.

[5] B. Geisinger and D. R. Raman, "Why They Leave: Understanding Student Attrition from Engineering Majors," *International Journal of Engineering Education*, vol. 29, no. 4, pp. 914–925, Jan. 2013.

[6] K. L. Meyers, M. W. Ohland, A. L. Pawley, S. E. Silliman, K. A. Smith, and others, "Factors relating to engineering identity," *Global Journal of Engineering Education*, vol. 14, no. 1, pp. 119–131, 2012.

[7] R. Stevens, K. O'connor, L. Garrison, A. Jocuns, and D. M. Amos, "Becoming an engineer: Toward a three dimensional view of engineering learning," *Journal of Engineering Education*, vol. 97, no. 3, pp. 355–368, 2008.

[8] K. L. Tonso, "Teams that Work: Campus Culture, Engineer Identity, and Social Interactions," *Journal of Engineering Education*, vol. 95, no. 1, pp. 25–37, 2006, doi: 10.1002/j.2168-9830.2006.tb00875.x.

[9] B. M. Capobianco, B. F. French, and H. A. Diefes-Du, "Engineering Identity Development Among Pre-Adolescent Learners," *Journal of Engineering Education*, vol. 101, no. 4, pp. 698–716, Oct. 2012, doi: 10.1002/j.2168-9830.2012.tb01125.x.

[10] M. M. Hynes, C. Joslyn, A. Hira, Jr. Holly James, and N. Jubelt, "Exploring Diverse Pre-College Students' Interests and Understandings of Engineering to Promote Engineering Education for All," *International Journal of Engineering Education*, vol. 32, no. 5B, pp. 2318–2327, Sep. 2016.

[11] A. V. Maltese and R. H. Tai, "Eyeballs in the Fridge: Sources of early interest in science," *International Journal of Science Education*, vol. 32, no. 5, pp. 669–685, Mar. 2010, doi: 10.1080/09500690902792385.

[12] M. Portsmore, M. Pickering, and C. Rogers, "Stomp: Student Teacher Outreach Mentorship Program," in *Association for Engineering Education - Engineering Library Division Papers*, Atlanta, 2003, p. 8.1030.1.

[13] Z. Hazari, G. Sonnert, P. M. Sadler, and M. Shanahan, "Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study," *Journal of Research in Science Teaching*, vol. 47, no. 8, pp. 978–1003, 2010, doi: 10.1002/tea.20363.

[14] C. A. P. Cass, Z. Hazari, J. Cribbs, P. M. Sadler, and G. Sonnert, "Examining the impact of mathematics identity on the choice of engineering careers for male and female students," in *2011 Frontiers in Education Conference (FIE)*, Rapid City, SD, USA, Oct. 2011, pp. F2H-1-F2H-5. doi: 10.1109/FIE.2011.6142881.

[15] A. D. Patrick, M. Borrego, and A. N. Prybutok, "Predicting Persistence in Engineering through an Engineering Identity Scale," *International Journal of Engineering Education*, vol. 34, no. 2,Part A, pp. 351–363, Mar. 2018.

[16] A. Godwin and G. Potvin, "Pushing and pulling Sara: A case study of the contrasting influences of high school and university experiences on engineering agency, identity, and participation," *Journal of Research in Science Teaching*, vol. 54, no. 4, pp. 439–462, 2017, doi: 10.1002/tea.21372.

[17] A. Godwin and A. Kirn, "Identity-based motivation: Connections between first-year students' engineering role identities and future-time perspectives," *J. Eng. Educ.*, vol. 109, no. 3, pp. 362–383, Jul. 2020, doi: 10.1002/jee.20324.

[18] C. G. P. Berdanier, C. Whitehair, A. Kirn, and D. Satterfield, "Analysis of social media forums to elicit narratives of graduate engineering student attrition," *J. Eng. Educ.*, vol. 109, no. 1, pp. 125–147, Jan. 2020, doi: 10.1002/jee.20299.

[19] H. L. Perkins *et al.*, "An intersectional approach to exploring engineering graduate students' identities and academic relationships," *International Journal of Gender, Science and Technology*, vol. 11, no. 3, pp. 440–465, 2020.

[20] B. A. Burt, K. L. Williams, and W. A. Smith, "Into the Storm: Ecological and Sociological Impediments to Black Males' Persistence in Engineering Graduate Programs," *American Educational Research Journal*, vol. 55, no. 5, pp. 965–1006, Oct. 2018, doi: 10.3102/0002831218763587.

[21] S. Secules, A. Gupta, A. Elby, and C. Turpen, "Zooming Out from the Struggling Individual Student: An Account of the Cultural Construction of Engineering Ability in an Undergraduate Programming Class: An Account of the Cultural Construction of Engineering Ability," *J. Eng. Educ.*, vol. 107, no. 1, pp. 56–86, Jan. 2018, doi: 10.1002/jee.20191.

[22] E. O. McGee and D. B. Martin, "'You Would Not Believe What I Have to Go Through to Prove My Intellectual Value!' Stereotype Management Among Academically Successful Black Mathematics and Engineering Students," *American Educational Research Journal*, vol. 48, no. 6, pp. 1347–1389, Dec. 2011, doi: 10.3102/0002831211423972.

[23] S. J. Basu and A. C. Barton, "Developing a sustained interest in science among urban minority youth," *J. Res. Sci. Teach.*, vol. 44, no. 3, pp. 466–489, Mar. 2007, doi: 10.1002/tea.20143.

[24] E. A. Cech and T. J. Waidzunas, "Navigating the heteronormativity of engineering: the experiences of lesbian, gay, and bisexual students," *Engineering Studies*, vol. 3, no. 1, pp. 1–24, Apr. 2011, doi: 10.1080/19378629.2010.545065.

[25] C. McCall, A. Shew, D. R. Simmons, M. C. Paretti, and L. D. McNair, "Exploring student disability and professional identity: navigating sociocultural expectations in U.S. undergraduate civil engineering programs," *Australasian Journal of Engineering Education*, vol. 25, no. 1, pp. 79–89, Jan. 2020, doi: 10.1080/22054952.2020.1720434.

[26] R. A. Revelo Alonso, "Engineering familia: The role of a professional organization in the development of engineering identities of Latina/o undergraduates," Ph.D., University of Illinois at Urbana-Champaign, United States -- Illinois, 2015. Accessed: Mar. 07, 2021.

[Online]. Available: http://search.proquest.com/docview/1748662367/abstract/67E260FA87274C15PQ/1
[27] 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 Scien Eng*, vol. 24, no. 3, pp. 261–290, 2018, doi: 10.1615/JWomenMinorScienEng.2018018667.
[28] D. Oyserman, "Identity-based motivation: Implications for action-readiness, procedural-readiness, and consumer behavior," *Journal of Consumer Psychology*, vol. 19, no. 3, pp. 250–260, Jul. 2009, doi: 10.1016/j.jcps.2009.05.008.
[29] H. L. Perkins, M. Bahnson, C. Cass, M. A. Tsugawa-Nieves, and A. Kirn, "Development and Testing of an Instrument to Understand Engineering Doctoral Students' Identities and Motivations," presented at the 2018 ASEE Annual Conference & Exposition, Jun. 2018. Accessed: Mar. 07, 2021. [Online]. Available: https://peer.asee.org/development-and-testing-of-an-instrument-to-understand-engineering-doctoral-students-identities-and-motivations
[30] Z. Zhao *et al.*, "Design and Development: NSF Engineering Research Centers Unite: Developing and Testing a Suite of Instruments to Enhance Overall Education Program Evaluation," presented at the 2021 ASEE Virtual Annual Conference, Jul. 2021.
[31] M. W. Ohland *et al.*, "Board 95: Expanding Access to and Participation in MIDFIELD (Year 3)," Atlanta, United States, Jun. 2019. Accessed: Mar. 07, 2021. [Online]. Available: https://search.proquest.com/docview/2314032679?pq-origsite=primo&