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Effects of High Impact Educational Practices on Engineering and Computer Science Student Participation, Persistence, and Success at Land Grant Universities – Year 2

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Introduction and Background

The science, technology, engineering and mathematics (STEM) workforce contributes to the U.S. economy by supporting 67% of jobs and 69% of the gross domestic product [1]. Currently, there is an increased demand for engineering and computer science (E/CS) professionals, particularly those from underrepresented (e.g., gender, racial, ethnic) and underserved (socio-economic, geographically isolated) groups who bring diversity of thought and experience to the national E/CS workforce [2]. Correspondingly, educational institutions are called upon to develop capabilities to attract, engage, and retain students from these diverse backgrounds in E/CS programs of study.

To encourage and enable diverse students to opt into and persist within E/CS programs of study, there is a critical need to engage students in supportive and enriching opportunities from which to learn and grow. The importance of student engagement for promoting student growth and development has been researched to such an extent that its utility is widely agreed upon [5]. Importantly, it has been shown that both academic and extracurricular aspects of a student's learning processes are characterized by engagement [6]. High Impact Educational Practices (HIP) provide useful opportunities for deep student engagement and, thus, positively influence student retention and persistence [4]. Kuh [3] identified eleven curricular and extracurricular HIP (i.e., collaborative assignments and projects, common intellectual experiences, eportfolios, first year seminars and experiences, global learning and study abroad, internships, learning communities, senior culminating experiences, service and community-based learning, undergraduate research, and writing intensive courses). In computer science and engineering education fields, however, the extent to which HIP affects persistence and retention has not been fully investigated. This project aims to examine E/CS undergraduate student engagement in HIP and to understand the factors that contribute to positive engagement experiences.

The Project

The current project started in 2019 as a joint project between Utah State University (USU) and Washington State University (WSU), two western land grant universities. While USU is considered to be a Predominantly White Institution (PWI), WSU has recently become a Hispanic Serving Institution (HSI) [7]. A sequential, explanatory, mixed-methods research approach is used to examine E/CS student engagement in HIP.

During Project Year 1, we conducted an initial examination of the National Survey of Students Engagement (NSSE) for years 2012 and 2017 for WSU and USU. NSSE assesses the extent to which students engage in educational practices associated with high levels of learning and development [8]. Based on our initial observations from the NSSE survey results, we developed a survey for WSU and USU E/CS undergraduate students. Findings from Year 1 activities were used to conduct focus group interviews with E/CS students who had completed

the survey in order to further develop and refine the survey finding. During Year 2, we developed focus group interview protocols, purposely selected focus group participants and completed focus group interviews. Emerging findings from these focus groups are presented later in this paper.

Project Purpose

The purpose of this project is to develop and disseminate evidence-based recommendations for implementing HIP for E/CS undergraduates at rural, land-grant universities, with the long-term goals of improving student outcomes and broadening the effects of such participation among women and underrepresented group members in engineering and computer science (E/CS) degree programs.

Research Questions

This sequential, explanatory, mixed-methods study is guided by the following research questions (RQ):

1. To what extent do E/CS students participate in HIP?
2. What relationships (if any) exist between E/CS student participation in HIP and their educational outcomes (i.e., persistence in major, academic performance, and graduation)?
3. How do contextual factors (e.g., institutional, programmatic, personal, social, financial, etc.) affect E/CS student awareness of, interest in, and participation in HIP?

Year 1 Recap

Year 1 project activities were conducted to answer Research Questions 1 and 2. NSSE (2012 and 2017) survey data (N=3223) gathered from freshmen and seniors at USU and WSU were analyzed as described in [8]. A survey informed by this analysis was developed and deployed in the spring of 2020. Survey respondents (N = 531) were students enrolled in undergraduate E/CS programs at either institution. Frequency distribution analyses were conducted to assess the respondents' level of participation in extracurricular HIPs (i.e., global learning and study aboard, internships, learning communities, service and community-based learning, and undergraduate research) [9]. We focused on these six HIP in our research because they 1) improve students' deep learning of educational content, 2) contribute towards their learning experiences and personal development [10] and 3) can be facilitated without required changes to the engineering program curricula.

Year 1 results indicated that E/CS student engagement in internship and undergraduate research was much higher compared to other activities, including across underrepresented minority groups. Alternatively, E/CS student engagement in learning communities, service and community-based learning, and global learning and study abroad was comparatively lower. Forty three percent of participants reported that they did not participate in any HIP activity and only nineteen percent participated in two or more HIP. Sixty five percent of Latinx or Hispanic Americans reported non-participation; the percentage of non-participation is higher for Latinx or Hispanic Americans that any other racial or ethnic groups examined in the study [9].

Further statistical analysis was conducted to understand the effects of HIP participation, coursework enjoyability, and confidence at completing a degree on the academic success of E/CS students [11]. Exploratory factor analysis was used to derive an "academic success" variable from five items that sought to measure how students persevere to attain academic goals. Results suggested a significant relationship ($p < .05$) between engagement in HIP and attainment of academic goals. An increase in HIP was correlated with increased academic achievement goals. Therefore, it was inferred that E/CS students should be provided with increased number of opportunities to participate in HIP by their instructors and institutions.

Dissemination of Year 1 Findings

The project team presented the following papers in the 2021 ASEE Virtual Annual Conference highlighting the activities of Year 1 of the project.

1. We presented a paper reporting on the findings from National Survey of Student Engagement (NSSE) 2012 and 2017 surveys [8]. A review of data related to the participation of first-year and senior student in different high impact educational practices (HIP) at USU and WSU was presented in this paper:

> E.R. Ewumi, O. Adesope, C.S. Claiborn and A. Minichiello, "Insights Gathered from the National Survey of Student Engagement (NSSE) About Engineering/Computer Science Participation in High-impact Educational Practices at Two Western Land-grant Institutions." July 2021.

2. We presented a paper that examined the frequency distribution analysis of participation of E/CS undergraduates enrolled at two western land-grant institutions across five HIP (i.e., global learning and study aboard internships, learning communities, service and community-based learning, and undergraduate research) that are offered outside of required E/CS curricula [9].

> A. Minichiello, M. Asghar, E.R. Ewumi, C.S. Claiborn, and O. Adesope, "A Characterization of Engineering and Computer Science Undergraduate Participation in High-impact Educational Practices at Two Western Land-grant Institutions." July 2021.

3. We presented a paper that examined the factors that predict academic success in engineering and computer science (E/CS) [11]. Specifically, this study sought to understand the effects of HIP, coursework enjoyability, and confidence at completing a degree on academic success of the underrepresented and nontraditional E/CS students:

> O. Adesope, O.J. Sunday, C.S. Claiborn, E.R. Ewumi, A. Minichiello and M. Asghar, "Investigating factors that predict academic success in engineering and computer science." July 2021.

4. We presented a paper summarizing the progress we had made in the Year 1 of the project [12]. Findings were presented as a poster in the NSF Grantees Poster Session.

> C.S. Claiborn, A. Minichiello, O. Adesope, E.R. Ewumi and M. Asghar, "Effects of High Impact Educational Practices on Engineering and Computer Science Student Participation, Persistence, and Success at Land Grant Universities." July 2021.

Year 2 Major Activities

Year 2 project activities centered on answering Research Question 3 and contributing further insights towards research questions 1 and 2. Focus groups with E/CS student survey participants were conducted via video conferencing across both institutions. Data from these focus groups were transcribed, verified, coded and back-coded to generate results. Four coders were involved in the qualitative analysis of data from focus groups. Emerging findings from this analysis are presented in the following section.

Data Generation

Survey results from Year 1 of the project were used to develop focus group interview protocols and guide the purposeful selection of focus group participants. Focus group interviews were conducted with 27 E/CS undergraduates (12 males, 15 females, 16 engineering students, 11 computer science students) across both institutions via video conferencing (i.e., ZOOM) during the spring and fall 2021 semesters. Each focus group lasted between 60 to 90 minutes and was facilitated by two researchers. Demographic information related to the focus group participants (i.e., institution, year of study, discipline, race and ethnicity, and gender) are provided in Figure 1.

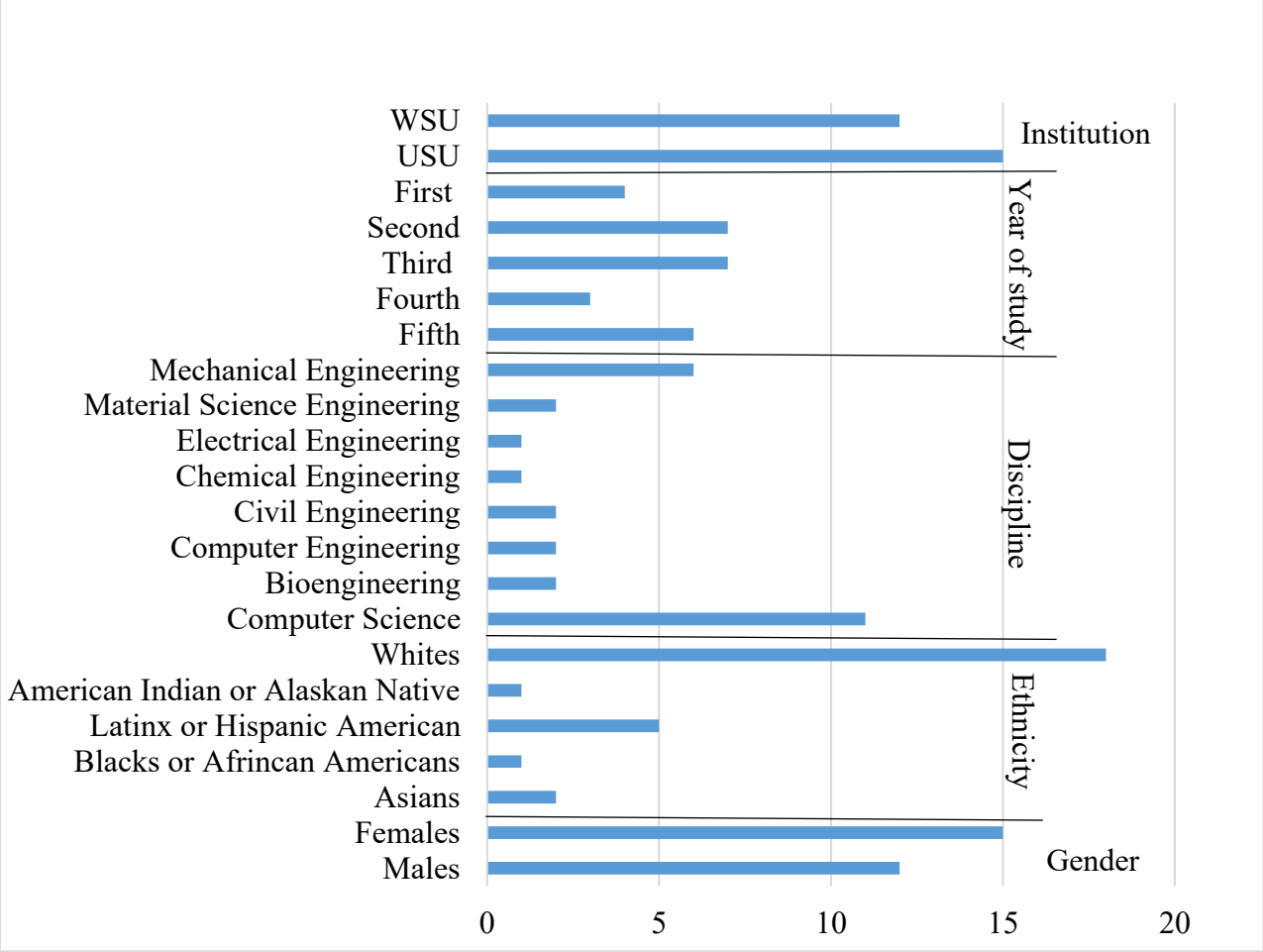

Figure 1. *Focus group participant details*

Year 2 Emerging Findings

Emerging findings from the focus groups, based on the first iteration of qualitative coding [13] are presented here. Year 1 project activities [9] had revealed that 43% participants did not engage in any HIP. Our observations from the focus groups revealed many barriers which may be contributing factors to such high non-participation rates. Lack of opportunities, male dominance (for women), lack of awareness, financial costs, lack of interest, required time outside of existing academic workload, and personal reasons are among some of the major factors posing obstacles to participation in HIP.

We observed that CS programs may not offer capstone experiences but are rich in project-based learning. CS students reported engaging in them due to their perceived benefit of preparing them for professional careers. For example, one of the participant from the CS group said:

> "So we broke up our class. How this professor does it. We broke up our class into different teams as part of the project. So for example, this project for the user interface and for the database and we kind of rotate responsibility. So almost forming like a mini company."

In contrast, engineering programs offer capstone experience but may not offer efficient project-based learning. A participant from the engineering group appreciated capstone experiences because they help get hands-on experience. The participant said:

> "It's as much about practicing as an engineer versus just learning the basics of what engineering is."

We also noted that CS students commented that they had limited opportunities for undergraduate research engagement as compared to engineering students. CS participants did seem interested in engaging in undergraduate research if they had an opportunity to do so. Reflecting on the opinion of other CS participants in one of the focus groups about involvement in undergraduate research, a participant expressed the following views:

> "It seemed like all three of us were pretty interested in doing undergraduate research, but it was never really made an option."

The availability of many undergraduate research opportunities for engineering students was noticeable and may be attributed to the fact that their professors have active funded research projects in which they hire graduate and undergraduate students. As pointed out by a participant from the engineering group:

> "Right now I'm actually working in a professor's lab with a PhD student on their research projects."

Similarly, internships seemed plentiful for engineering students but not for CS students. Still, students from both groups seemed to appreciate the benefits they can get from such opportunities related to their degree completion and professional careers. The fact that most internships pay a salary also made them desirable.

We also noted that women in engineering were very involved in leadership roles. For example, at least five of the female participants from engineering groups were either presidents or vice presidents of different clubs and societies. In contrast, women in CS seemed more concerned about male dominance and being the only female in a club. For example, one of the female participants from the CS group expressed her frustration in the following words:

> "I would be much more likely to stick with the club if I walked in and there was another female in the room versus I walk in and then there's a bunch of males. If there's no other females then it does really make you feel more intimidated and, like you, don't belong."

Service and community-based learning, and global learning and study abroad were the HIPs with the least participation. Our previous study about the frequency distribution of HIP in Year 1 had also suggested low participation in these two HIP [9]. Interestingly, participation in service and community-based learning was low because many E/CS participants were not aware of the opportunities to participate in these types of activities. In the case of global learning and study abroad, most of the E/CS participants were not as interested because of its financial cost and the perception that it would cause a disruption in their degree program.

We also noted issues involving HIP awareness among E/CS students. There were mixed feelings about the usefulness of departmental emails informing students about HIP opportunities. Email frequency, length and organization seemed to be important factors for students as they decide to either read or ignore the emails. This observation suggests that changes to the management and formatting and dissemination of departmental emails with information of HIP opportunities and/or other activities and events may be needed in order for students to take full advantage of them. Interestingly, we noted that students described how professors taking a few minutes at the start of their lecture to inform about the class about HIP opportunities may have a greater effect in terms of motivating students to engage in them.

Year 3 Activities

Research activities during Project Year 3 will focus on conducting a qualitative thematic analysis of the focus group data. Findings from survey and focus group data will then be combined to develop a deeper understanding of why and how E/CS students participate in the HIP at their university, taking into account the institutional and programmatic contexts at each institution. Ultimately, the project will develop and disseminate recommendations for improving diverse E/CS student awareness of, interest in, and participation in HIP, at similar land grant institutions nationally. The project team expects to publish three journal papers from their mixed-methods sequential explanatory study during spring and fall 2022. A paper submission at 2023 ASEE Annual Conference reflecting on recommendations and broader observations from the overall project is also anticipated.

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References

[1] C. McEntee, "STEM Supports 67% of U.S. Jobs - Eos", Eos, 2020. [Online]. Available: https://eos.org/agu-news/stem-supports-67-of-u-s-jobs.

[2] R. Varma, "U.S. science and engineering workforce: Underrepresentation of women and minorities," *American Behavioral Scientist,* vol. 62, no. 5, pp. 692-697, 2018. Available: 10.1177/0002764218768847.

[3] M.W. Ohland, S.D. Sheppard, G. Lichtenstein, O. Eris, D. Chachra, & R.A. Layton, "Persistence, engagement, and migration in engineering programs," *Journal of Engineering Education*, vol. 97, pp. 259-278, 2008.

[4] G.D. Kuh, "High impact educational practices: What they are, who has access to them, and why they matter," *Washington, DC: Association of American colleges and Universities, 2008*.

[5] V. Trowler & P. Trowler, *Student engagement evidence summary*. York, UK: Higher Education Academy, 2010.

[6] J.A. Fredricks, P.C. Blumenfeld, & A.H. Paris, "School engagement: Potential of the concept, state of the evidence," *Review of Educational Research*, vol. 74, no. 1, pp. 59-109, 2004.

[7] "Hispanic Association of Colleges and Universities – HSIs," *Hacu.net*, 2019. [Online]. Available: https://www.hacu.net/hacu/HSIs.asp.

[8] E.R. Ewumi, O. Adesope, C.S. Claiborn, A. Minichiello, "Work-in-Progress (WIP): Insights gathered from the National Survey of Student Engagement (NSSE) about engineering/computer science participation in high impact educational practices at two western land grant institutions," In *2021 ASEE Virtual Annual Conference Content Access, 2021*.

[9] A. Minichiello, M. Asghar, E.R. Ewumi, O. Adesope, C.S. Claiborn, "A characterization of engineering and computer science undergraduate participation in high impact engagement practices at two western land grant universities," In *2021 ASEE Virtual Annual Conference Content Access, 2021*.

[10] G.D. Kuh and K. O'Donnell, *Ensuring Quality & Taking High-Impact Practices to Scale*. Washington, DC: AAC&U, 2013.

[11] O. Adesope, A. Minichiello, E.R. Ewumi, M. Asghar, O.J. Sunday, C.S. Claiborn, "Investigating factors that predict academic success in engineering and computer science," In *2021 ASEE Virtual Annual Conference Content Access, 2021*.

[12] C.S. Claiborn, A. Minichiello, O. Adesope, E.R. Ewumi and M. Asghar, "Effects of high impact educational practices on engineering and computer science student participation, persistence, and success at land grant universities," In *2021 ASEE Virtual Annual Conference Content Access, 2021*.

[13] J. Saldaña, *The coding manual for qualitative researchers*, 3rd ed. Sage, 2016.