ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #38383

Engineering Education Enrichment (e3) Initiative: A Co-Curricular Program Intended to Improve Persistence and Career Success for Low-Income and First-Generation Engineering Students

Hannah Huvard (Postdoctoral Researcher)

Dr. Huvard is currently a Postdoctoral researcher at New Mexico State University. Her research focuses on non-traditional frameworks and measures of success in undergraduate STEM programs and courses.

Hengameh Bayat

PhD Candidate in chemical engineering at New Mexico State University

Sandra M. Way (Associate Professor)

Catherine Brewer (Assistant Professor)

Addison Miller

I am an undergraduate student studying Aerospace and Mechanical engineering. I contribute to two separate research projects and participate in multiple student organizations. My interest include flight dynamics, aircraft design, propulsions (aircraft and rocketry), and bringing positive opportunities to others.

Antonio Garcia (Associate Dean of Engineering)

Engineering Education Enrichment (e3) Initiative: A Co-Curricular Program Intended to Improve Persistence and Career Success for Low-Income and First-Generation Engineering Students

Abstract

The College of Engineering at New Mexico State University (NMSU) has created a co-curricular Engineering Education Enrichment (e3) Initiative through a grant funded by the National Science Foundation (IUSE: HSI Award #1953466). The goal of the e3 Initiative is to provide project-based, hands-on learning experiences to undergraduate engineering students. Specifically, the initiative has a target population of low-income and first-generation engineering students. These experiences are largely student-led so that students are empowered to take charge of their own learning as adults. Students choose from a variety of industry-guided design projects, industry-recognized certifications, and entrepreneurship training. As part of the e3 Initiative, there is ongoing research analyzing various aspects of this initiative. Specifically, this research is examining who participates in the e3 program and what effects this program has on students' social-psychological traits, which have been previously shown to be important indicators of retention and persistence in engineering. These traits include engineering identity, self-efficacy, and self-directed learning. Using survey data from both e3 Initiative participants and non-participants in fall 2020 and spring 2021, our preliminary results indicate that females are more likely to participate, while low-income students are less likely to participate in the e3 Initiative at NMSU. Other preliminary results from survey data indicate that e3 Initiative participants saw a significant increase in their engineering identity after completion of their chosen project or certificate, specifically in regards to their recognition as an engineer by their family, peers, and instructors.

Introduction

Society is experiencing accelerating change: big data, the Internet of Things, machine learning, artificial intelligence, robotics, 3D printing, biotechnology, nanotechnology, renewable energy, satellites, and drones are some of the technologies creating new opportunities and demanding a skilled engineering workforce. The rapid pace of innovation and the growing number of products rely on engineers, as designers, to have a wider range of skills and knowledge [1]. The need for critical thinking and adaptive learning skills have been anticipated by engineering educators to meet these rapid changes [2]. However, the current structure of a 4-year engineering degree continues to lag behind more nimble approaches to training the workforce, such as partnerships between companies and mass open online course (MOOC) providers [3]. Although accreditation plans show intentional opportunities for students to access and integrate knowledge independently in design courses, internships, or research experiences [4], there is a growing acceptance that learning should be directed by more than pedagogy alone in order to educate engineers.

Our vision to meet the challenge of accelerating change is to construct engineering curricula that are guided by both andragogy (self-directed, adult learning; [5] and pedagogy (teacher-directed learning; [5]. Such curricula aim to communicate directly to students the need for them to take charge of their learning early in their engineering degree programs. The building of andragogy to inform curricula programs emphasizes a systems approach to dealing with accelerated change and focuses higher education resources into knowledge generation via research, while strengthening foundational topics to bolster critical thinking.

To generate an undergraduate engineering curricula that is guided by andragogy to complement the pedagogy within standard course work, the College of Engineering at New Mexico State University (NMSU) created a co-curricular Engineering Education Enrichment (e3) Initiative through a grant funded by the National Science Foundation (IUSE: HSI Award #1953466). NMSU is a Hispanic Serving Institute (HSI) and land-grant university, so this initiative has a target population of low-income and first-generation students (although any full-time engineering undergraduate student at NMSU that is a U.S. citizen or permanent resident is eligible to participate). Hispanic Serving Institutions are well-equipped to improve access to college opportunities for low-income communities, but often struggle to make math, science, and engineering curricula relevant. One goal of the initiative is to facilitate social mobility by providing low income and first-generation students co-curricular opportunities they may not independently pursue. Thus, the e3 Initiative engages eligible engineering students in andragogical learning by providing project-based, hands-on learning experiences that are largely self-directed.

In the e3 Initiative, students choose their own path and participate in engineering activities outside of their normal coursework that are designed to aid in their development as an engineer. As such, andragogy, or self-directed adult learning serves as a guide for how the program is structured. Since the e3 Initiative is a co-curricular program, students direct their learning based on their current interests or needs. In doing so, they assert control over their engineering education outside of the classroom. Furthermore, by taking this approach, the e3 Initiative is designed to support social-psychological traits like engineering self-efficacy and engineering identity as students direct their learning in the program.

The primary purpose of this paper is to describe the structure of this new initiative and what research is being conducted regarding the e3 Initiative. As part of the NSF grant, we are conducting a series of research studies analyzing various aspects of this program. This includes, but is not limited to, which students are voluntarily choosing to participate in this program and what benefits participants may gain in regards to several social-psychological traits. Considering that the e3 Initiative is targeted towards low-income and first-generation students, we are particularly interested in if these students are more or less likely to voluntarily participate in this program since it is outside their standard engineering coursework. Thus, the first strand of research related to the e3 Initiative is to describe specific student demographic traits that may predict voluntary participation in the e3 Initiative to assess the extent to which the actual participants of the program align with the targeted student population. The second strand of research is related to identifying if participating in the e3 Initiative increases students' self-directed learning, engineering self-efficacy, and engineering identity, which are social-psychological traits that have been previously shown to be important indicators of engineering students' persistence and degree completion [6], [7]. This paper describes the findings related to e3 Initiative participation and social-psychological traits from the first year of the program.

Literature Review

The e3 Initiative was designed to meet the growing interest of students and employers for more hands-on training within undergraduate engineering programs. As a co-curricular program, student participants develop professional skills through industry-guided design projects, industry-recognized certifications, and entrepreneurship training. Similar co-curricular programs designed for undergraduate engineering students have reported benefits in students' problem-solving skills, application of engineering knowledge to real-world problems, and engineering-specific skills [8], [9].

Beyond practical skills gained, co-curricular programs have the potential to improve engineering education by enhancing students' leadership, ethical training, professional skills, and a variety of social-psychological traits [9]–[13]. Finelli et al. [11] explain how the engineering profession requires engineers to understand and incorporate many ethical standards into their work, but most engineering curricula do not formally teach ethics. Co-curricular activities have the capacity to allow for students to learn and understand ethical issues outside of the classroom [11]. Athreya and Kalkhoff [10] describe a program that helps students grow as engineers by learning about leadership. Even though the program is not directly related to engineering projects, the centering of the activities around students' growth as people and as leaders can be incorporated into their curricula and co-curricular engineering projects. Millunchick and Zhou [13] used several surveys to show that participation in a co-curricular organization leads to higher outcomes in Bonding Social Capital, Bridging Social Capital, Major Satisfaction, and Engineering Identity. Similarly, Reeve et al. [14] concluded that "pre-post surveys which bookend [a] month-long certificate program suggest that students perceive themselves as more knowledgeable, self-aware, socially skilled communicators by the end of the course" (p. 9).

The development and implementation of co-curricular engineering programs also have implications for equity and accessibility to professional experience. Cartile et al. [8] explain:

> A primary motivation for integrating aspects of the cocurricular model into academic contexts such as capstone and engineering science course projects is to improve resource allocation, promote equity by increasing accessibility to this type of university experience thereby improving student motivation and success, recognize the value gained through engineering design experiential learning, and contribute to improving the quality of engineers graduating. (p. 8)

Revelo [15] echoes this argument: the community aspect of some engineering co-curricular programs is beneficial for minority students and creates an environment in which they can thrive. These communities of co-curricular learning help students that may otherwise be intimidated of engineering as a profession or have historically been marginalized in STEM:

> Although in the literature becoming an engineer is usually framed as an individual's success, these students viewed being and becoming an engineer with a collective perspective. In that being or becoming an engineer was not just about one's success, but it was also about the success of the group. ([15], p. 10)

Programs like the e3 Initiative are intended to provide an important space for students that may not otherwise seek professional opportunities within their area of study while in school.

The e3 Initiative is unique in that it is student-led, meaning that participants largely choose their own path while receiving guidance from other students, program administrators, and/or industry mentors. For example, students may pursue a professional certificate in program languages such as Python, SolidWorks, or Matlab. Alternatively, students may work on a team project for a real-world client or design competition. To date, e3 Initiative participants have worked on developing wind turbines, handicap accessible playgrounds, biodiesel reactors, and a remote detector of blood pressure. In addition, e3 Initiative participants have the opportunity to work with industry mentors, translating co-curricular activities into job-applicable skills and relevant experience as students prepare to enter the workforce.

The e3 Initiative

The e3 Initiative is intended to specifically benefit low-income and first-generation students, although all NMSU engineering students that are U.S. citizens or permanent residents are eligible and invited to participate. Students do not incur any costs to participate and receive a stipend for successful completion of their selected project. To date, there have been 258 e3 Initiative participants across three semesters (fall 2020, spring 2021, and fall 2021). Each student enrolled in the e3 Initiative selects from one of three experiences: certifications, individual or group design projects, or entrepreneurship development. Participants may also choose to be paired with an industry mentor during their time in the e3 Initiative. This mentorship provides students with help on their selected project as well as guidance outside of the classroom as they start to navigate life as an engineer beyond college.

Professional certification has been shown to be valuable to many employers and could land students an interview with some companies. Companies see candidates with professional

certifications as “self-starters" who take initiative to forward their career paths. In some cases, companies require that new employees obtain certain certificates within a specified time of working with them; students with a jumpstart on that process have a “leg-up” on their competition [16]. The certification option allows students to work at their own pace to complete industry-approved certifications -- all the while benefiting from the support and guidance of College of Engineering faculty and staff. The e3 Initiative pays for students’ certification courses and exams. A list of certification courses is provided to students who express interest in this track and students are permitted to suggest additional certification options.

Design projects inspire engineering students to apply their technical knowledge and creativity in new ways. The Aggie Innovation Space (AIS) at NMSU facilitates the project success of the students through enabling them to execute work based on client goals while enhancing their communication, problem-solving, and teamwork skills. The AIS provides students access to experienced fabrication and design mentors and the latest engineering design software and tools, including 3D printers, a fully-stocked electronics lab, a variety of sensors and programmable development boards, robotics kits, extensive multidisciplinary software, and low-resolution prototyping materials.

Students who choose the entrepreneurship option participate in the NMSU Arrowhead Center’s Crimson Entrepreneurs Program. This program is sponsored by Studio G, NMSU’s student business accelerator that is ranked as one of the Top 20 University Business Incubators in the world by UBI Global. The e3 Initiative participants of this option develop their entrepreneurial skills by understanding how innovative product designs can translate into business opportunities.

Research on Year One Program Impacts

During the first program year, we examined who chooses to participate in the e3 Initiative and what effects participation has on students’ social-psychological traits that have been previously shown to be important indicators of retention and persistence in engineering [6], [7]. These traits include engineering identity, self-efficacy, and self-directed learning (SDL). The development of engineering identity, self-efficacy, and SDL, and participation in co-curricular learning activities, are critical pathways to persistence in pursuing educational and professional achievements. High levels of engineering identity and self-efficacy benefit students’ persistence and inclusion within engineering [7], [17]. A significant positive relationship between SDL and academic achievement in various disciplines, including nursing [18], engineering [6], [19], and social sciences [20], has also been reported.

Methods

Our research questions were:

1. Which students are more likely to participate in the e3 Initiative?
2. Do e3 Initiative participants see an increase in their engineering identity, self-efficacy, or self-directed learning after finishing the program?

Eight hundred undergraduate engineering students at NMSU were randomly invited to participate in the e3 Initiative by email in July and August 2020. One hundred and twelve students voluntarily enrolled to participate in the e3 Initiative for the fall 2020 semester and

spring 2021. For Research Question #1, a survey was distributed via email to e3 Initiative participants and to students that were invited to participate in the e3 Initiative but did not accept (defined as “non-participants”) as a comparison group. Participants that successfully completed their selected track within the e3 Initiative took the survey at two time points -- at the beginning and end of their e3 experience to serve as a pre/post test of several social-psychological traits. In total, 301 undergraduate engineering students took the survey in fall 2020 and spring 2021, with 112 of those being e3 Initiative participants and the other 189 being non-participants of the e3 Initiative. Demographics of all survey respondents can be found in Table 1. Income status was determined by survey respondents' self-reported status of free and reduced lunch eligibility in elementary and/or high school. First generation status was determined by parents’ and/or legal guardians’ highest level of education.

Table 1

Demographics of Survey Respondents: Fall 2020-Spring 2021

Variable	**e3 Participants**	**e3 Non-Participants**
Sample Size (N)	112	189
Average Age (Years)	22.8	21.9
Gender: Male	58%	72.6%
Race/Ethnicity: White	47.7%	43.6%
Race/Ethnicity: Hispanic or Latino	59.4%	62.6%
Low Income	50%	44.4%
First Generation	32%	34.3%

Survey Instrument and Measures

The survey included demographic questions (age, gender, socioeconomic status, and first-generation status), as well as three scales related to students’ self-reported levels of engineering identity, self-efficacy, and SDL. The engineering identity scale was adapted from Godwin’s [7] Measure of Engineering Identity, which includes questions related to students’ interest in engineering, recognition for contributions to their field by self and others, and perceptions of competence and performance in engineering. General engineering self-efficacy was measured using six items from previously published scales [21] in which engineering students’ perceptions of their capability to perform generic tasks in learning engineering content and competence in doing engineering coursework were considered. The Self-Directed Learning

Aptitude Scale (SDLAS), which had been developed and validated [22], was utilized to indicate the level of SDL.

Data Analysis

The survey was administered electronically via REDCap [23] and was imported into IBM SPSS Statistics 27 for analysis. Before analysis, the data were checked for errors and cleaned. Respondents who were under the age of 18, who did not consent to participate/allow for the collection of institutional data, and who did not provide complete responses were removed prior to analysis. For the three scales of engineering identity, engineering self-efficacy, and SDL, mean scores were taken for analysis. For Research Question #1, a logistic regression was used to predict participation in the e3 Initiative in terms of students' demographic factors (age, gender, race/ethnicity, and first-generation status). For Research Question #2, students' pre/post mean scores for engineering identity, engineering self-efficacy, and SDL were compared via t-tests.

Preliminary Results

Regarding Research Question #1, our preliminary results indicate that males were significantly less likely to participate in the e3 Initiative than females ($\beta = -0.16$, $p = 0.009$). Additionally, low-income students were also significantly less likely to participate in the e3 Initiative at NMSU when compared to their higher income peers ($\beta = -0.027$, $p = 0.05$). Regarding Research Question #2, our preliminary results from survey data indicate that e3 Initiative participants saw a significant increase in their engineering identity after completion of their chosen project or certificate, specifically in regards to their recognition as an engineer by their family, peers, and instructors ($t(31) = 2.1$, $p = 0.02$).

Discussion

The e3 Initiative is a unique co-curricular program that engages students to self-direct their learning outside of formal engineering classrooms. Participants select their own experience and path within the e3 program based on their own individual needs and interests. Participants have the choice between pursuing an engineering certification, an individual or group design project, or entrepreneurial development. In doing so, the e3 Initiative is guided by andragogical (adult, self-directed) learning techniques that complement more traditional engineering pedagogy found in undergraduate engineering courses.

The first part of the research being conducted on the e3 Initiative regarding who chooses to voluntarily participate is unique in that it focuses on ensuring the Initiative's target population is being served. One goal of the initiative is to facilitate social mobility by providing low income and first-generation students co-curricular opportunities they may not independently pursue [8]. However, low income students were found to be significantly less likely to voluntarily participate in this initiative compared to their higher income peers. This is particularly interesting when considering that almost half (46%) of the total survey sample was classified as low-income (based on their free and reduced lunch eligibility). As Cartile et al. [8] explained, co-curricular programs can "improve resource allocation [and] promote equity by increasing accessibility to this type of university experience" (p. 8). However, if low income students are not voluntarily

signing up for the e3 Initiative on their own, the e3 Initiative itself may remain inaccessible for these students.

First generation students were neither more nor less likely to participate in the e3 Initiative than their continuing education peers. Based on the target student population of the e3 Initiative (low income and first generation engineering students), we would like to see first generation students being more likely to voluntarily participate as this program was specifically designed with their unique needs in mind.

Females comprised only 33% of the survey sample, yet were significantly more likely to voluntarily participate in the e3 Initiative. Male students, although being the gender-majority in this study, were less likely to participate. Women continue to remain underrepresented in engineering fields, starting at the undergraduate level [24], but our results support past research that women are more likely to participate in co-curricular activities in college than men [25].

The second part of our research on the e3 Initiative may serve as a model for other co-curricular program evaluation because we are focusing on social-psychological trait development rather than more traditional outcomes. Social-psychological traits, like a strong engineering identity, have been previously shown to be important for students' development as engineers [9]–[13]. Our results that participants saw a significant increase in their engineering identity indicates that the e3 Initiative may provide students with more than just technical skills, as their experiences within the initiative bolster their and others' view of themselves as an engineer in a positive way. Specifically, e3 Initiative participants experienced a significant increase to their recognition as an engineer by their family, peers, and instructors. Thus, the hands-on/active participation in the e3 Initiative may have provided experiences in which the students felt like they were 'doing' engineering, thereby being 'seen' as an engineer by others. This is in stark contrast to many undergraduate STEM courses, which remain a passive experience for the learner. This type of recognition, as a piece of their overall identity as an engineer, has previously been shown to be important for students' persistence in engineering [7], [17]). Thus, the e3 Initiative should continue to provide experiences in which students feel, act, and are recognized as engineers.

Conclusion

The e3 Initiative may serve as a model for future co-curricular undergraduate engineering programs, with its unique self-directed structure, industry mentoring for undergraduate students, and resume building certificates and project experience. The results from our preliminary research on the e3 Initiative will inform future program recruitment strategies. Specifically, we recommend recruitment of e3 participants to be more targeted towards low income and first generation students, who may differentially benefit from the initiative. Additional research is currently being conducted to understand how the e3 Initiative may become more accessible to these students, so that the initiative ultimately serves the targeted population of low income and first generation engineering students. The e3 Initiative should also continue to be attractive to female undergraduate engineering students, who remain underrepresented in undergraduate engineering [24]. This research may also serve as a model for similar co-curricular programs at other Hispanic Serving Institutes and how they can examine whether their target population matches the actual population being served. Understanding which students are choosing to

participate in an optional, co-curricular program is essential to ensuring that target student populations are being reached and that future recruitment strategies are better matched to students' traits and resources. Finally, co-curricular program evaluation should be expanded to include social-psychological traits, as these traits are important indicators of persistence and could be a substantial result of participation in such programs.

Acknowledgements

The research team would like to thank the College of Engineering at New Mexico State University (NMSU), e3 Initiative staff & personnel, e3 Initiative participants, and all survey respondents. Funding for this project is provided by the National Science Foundation (IUSE: HSI Award #1953466).

References

[1] Study International Staff, "The importance of engineering in the modern world," *Study International*, Mar. 29, 2018. https://www.studyinternational.com/news/importance-engineering-modern-world/ (accessed Feb. 07, 2022).

[2] D. H. Cropley, "Promoting creativity and innovation in engineering education," *Psychology of Aesthetics, Creativity, and the Arts*, vol. 9, no. 2, pp. 161–171, May 2015, doi: 10.1037/aca0000008.

[3] J. Rosendale and L. Wilkie, "Scaling workforce development: using MOOCs to reduce costs and narrow the skills gap," *Development and Learning in Organizations: An International Journal*, vol. 35, no. 2, pp. 18–21, Jan. 2020, doi: 10.1108/DLO-11-2019-0258.

[4] S. Senel, D. Yalcin, and O. Yildirim, "Accreditation For Academic Quality," in *International Multidisciplinary Scientific GeoConference*, 2008, pp. SGEM, 2, 627.

[5] S. Pew, "Andragogy and pedagogy as foundational theory for student motivation in higher education," *InSight: a collection of faculty scholarship*, vol. 2, pp. 14–25, 2007, [Online]. Available: https://eric.ed.gov/?id=EJ864274

[6] K. A. Douglas, T. Fernandez, M. Fosmire, A. S. Van Epps, and S. Purzer, "Self‐directed information literacy scale: A comprehensive validation study," *J. Eng. Educ.*, vol. 109, no. 4, pp. 685–703, Oct. 2020, doi: 10.1002/jee.20355.

[7] A. Godwin, "The development of a measure of engineering identity," presented at the 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana, Jan. 2016. doi: 10.18260/p.26122.

[8] A. Cartile, C. Marsden, and S. Liscouët-Hanke, "Teaching and learning design engineering: What we can learn from co-curricular activities," in *Proc. 2019 Canadian Engineering Education Association (CEEA-ACEG19) Conf.*, Ottawa, Canada, Nov. 2019, pp. 1–9. doi: 10.24908/pceea.vi0.13756.

[9] M. H. Shehata, "Co-curricular activities and their role in supporting experiential learning," in *Proc. 2015 Canadian Engineering Education Association (CEEA15) Conf.*, Ontario, Canada, Aug. 2015, pp. 1–5. doi: 10.24908/pceea.v0i0.5791.

[10] K. S. Athreya and M. T. Kalkhoff, "The Engineering Leadership Program: A co-curricular learning environment by and for students," *JSTEM*, vol. 11, no. 3, pp. 70–74, May 2010,

Accessed: Jan. 31, 2022. [Online]. Available: https://www.jstem.org/jstem/index.php/JSTEM/article/view/1608
[11] C. J. Finelli *et al.*, "An assessment of engineering students' curricular and co-curricular experiences and their ethical development," *J. Eng. Educ.*, vol. 101, no. 3, pp. 469–494, Jul. 2012, doi: 10.1002/j.2168-9830.2012.tb00058.x.
[12] D. R. Fisher, A. Bagiati, and S. E. Sarma, "Fostering 21st century skills in engineering undergraduates through co-curricular involvement," in *ASEE Annual Conference & Exposition*, Indianapolis, IN, 2014, p. 24.623.1. [Online]. Available: https://peer.asee.org/fostering-21st-century-skills-in-engineering-undergraduates-through-co-curricular-involvement
[13] J. M. Millunchick and Y. Zhou, "The effect of clusters of participation in engineering co-curricular activities on student outcomes," 2020. doi: 10.18260/1-2--35305.
[14] D. Reeve *et al.*, "Curricular and co-curricular leadership learning for engineering students," *Collect. essays learn. teach.*, vol. 8, p. 1, Jun. 2015, doi: 10.22329/celt.v8i0.4283.
[15] R. A. Revelo, "Engineering identity development of Latina and Latino members of the Society of Hispanic Professional Engineers," in *2015 ASEE Annual Conference & Exposition*, 2015, pp. 26.629.1–26.629.13. doi: 10.18260/p.23967.
[16] "Are certificates worth it for engineers?," *Peak Technical*, Jan. 17, 2020. https://www.peaktechnical.com
[17] A. Godwin, G. Potvin, and Z. Hazari, "The development of critical engineering agency, identity, and the impact on engineering career choices," presented at the 2013 ASEE Annual Conference & Exposition, Atlanta, Georgia, 2013. doi: 10.18260/1-2--22569.
[18] L. Cadorin, V. Bressan, and A. Palese, "Instruments evaluating the self-directed learning abilities among nursing students and nurses: A systematic review of psychometric properties," *BMC Med. Educ.*, vol. 17, no. 1, p. 229, Nov. 2017, doi: 10.1186/s12909-017-1072-3.
[19] T. A. Litzinger, J. C. Wise, and S. H. Lee, "Self‐directed learning readiness among engineering undergraduate students," *J. Eng. Educ.*, vol. 94, no. 2, pp. 215–221, Apr. 2005, doi: 10.1002/j.2168-9830.2005.tb00842.x.
[20] İ. A. Tekkol and M. Demirel, "An investigation of self-directed learning skills of undergraduate students," *Front. Psychol.*, vol. 9, p. 2324, Nov. 2018, doi: 10.3389/fpsyg.2018.02324.
[21] N. A. Mamaril, E. L. Usher, C. R. Li, D. R. Economy, and M. S. Kennedy, "Measuring undergraduate students' engineering self‐efficacy: A validation study," *J. Eng. Educ.*, vol. 105, no. 2, pp. 366–395, Apr. 2016, doi: 10.1002/jee.20121.
[22] S. M. Abd-El-Fattah, "Garrison's model of self-directed learning: Preliminary validation and relationship to academic achievement," *Span. J. Psychol.*, vol. 13, no. 2, pp. 586–596, Nov. 2010, doi: 10.1017/s1138741600002262.
[23] P. A. Harris, R. Taylor, R. Thielke, J. Payne, N. Gonzalez, and J. G. Conde, "Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support," *J. Biomed. Inform.*, vol. 42, no. 2, pp. 377–381, Apr. 2009, doi: 10.1016/j.jbi.2008.08.010.
[24] K. N. Smith and J. G. Gayles, "'Girl Power': Gendered academic and workplace experiences of college women in engineering," *Soc. Sci.*, vol. 7, no. 1, p. 11, Jan. 2018, doi: 10.3390/socsci7010011.
[25] R. Kwon, S. Brint, K. Curwin, and A. Cantwell, "Co-Curricular learning at research

universities: Results from the SERU survey," *J. Stud. Aff. Res. Pract.*, vol. 57, no. 1, pp. 90–112, Jan. 2020, doi: 10.1080/19496591.2019.1644118.