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Promoting Research Career Pathways among Engineering Transfer Students at Two-Year Institutions Using Course-Based Undergraduate Research Experiences (CURES)

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Introduction

Undergraduate research experiences (URE) are an effective approach for enhancing student success within STEM fields [1]. Due to their documented ability to improve outcomes amongst historically underrepresented individuals [2], UREs are a promising strategy for improving representation within the STEM workforce. Unfortunately, the large-scale adoption of UREs using traditional models has been limited by the natural scalability issues associated with traditional apprenticeship-based models [3].

Course-based undergraduate research experiences (CUREs) are a viable alternative for increasing participation in UR. While these experiences have been disproportionally implemented within the life and physical sciences disciplines to date [4], their utilization within engineering is increasing. Although the formal definition of CURES varies across the literature, the integration of experiential learning opportunities organized around a motivating research question are generally common across implementations.

CURES are a uniquely valuable intervention for deployment at two-year institutions, where many students face restrictions which prohibit their participation in extracurricular activities. The implementation of CURES at two-year institutions presents unique challenges versus universities due to the lack of existing research infrastructure. In addition, many students attending two-year institutions are from historically marginalized groups, and may have limited resource awareness and self-efficacy as it relates to performing research.

This paper describes ongoing work towards establishing research literacy amongst engineering students through the introduction of a CURE within the multidisciplinary Introduction to Engineering course at San Antonio College (SAC). The CURE operates under a unique model, where grant-funding supports a corporate partner for each course. This work-in-progress manuscript details the series of learning modules and assignments which were utilized during the Fall 2022 semester to introduce students to the engineering research process. Results from a preliminary assessment intended to assess enrollees' basic research literacy are also presented, along with ongoing modifications to the Spring 2023 CURE implementation within the course.

Related Work

Various CURES within engineering courses have been previously described in the literature. Most engineering CURES have been implemented within sophomore level or later courses [4]. For Example, Mena et al. [5] designed a novel CURE implementation within a senior-level aerospace engineering course. In this model, graduate students served as research mentors for undergraduate students. The course initiated with a few weeks of dedicated lecture content intended to provide a common baseline of skills. The proposed CUREs model described herein utilizes a similar approach of initiating the semester with dedicated lecture content before transitioning to the research-based content.

Potter et al. [6] implemented a CURE within a required sophomore-level ergonomics and work design course in the Industrial and Manufacturing Systems Engineering course at Iowa State University. This CURE was intended to address the aforementioned scalability issues associated with traditional URE models within their program. Similar to Mena et al., this CURES structure

also utilized a few weeks at the beginning of the course to establish a common baseline of skills using lecture-based delivery. The research experience was structured into a series of lab experiences which focused on the development of practical skills and were based upon prior research topics within the department. The proposed CURE model introduced herein also focused on formulating the research assignment using practical applications motivated by the sponsor.

While most CURES have been implemented within traditional four-year University environments, some successful implementations at two-year institutions have been previously described in disciplines outside of engineering. The implementation of CURES within two-year institutions is particularly valuable due to the ability to prepare students to apply for research experiences after transferring [7]. For example, Bangera et al. [8] implemented a CURE based upon genomic sequencing, where students sequence and analyze DNA segments. Similar to the CURE structure described herein, this project was structured to develop transferrable skills across projects, thereby maximizing the learning impact of CURES.

Background Information

The development of CURES within the Introduction to Engineering course at SAC was initiated during the Summer 2022 semester. This effort was accelerated due to the receipt of a grant from the Department of Education, which was intended to support the development of CURES across STEM disciplines to increase the number of underrepresented individuals completing bachelor's degree. This grant also provided dedicated funding to support corporate sponsors to assist with the CURES project. The engineering program was chosen for the initial pilot CURES implementation due to its expanding relationships with the local technical community. The Introduction to Engineering course was chosen for the initial CURES implementation because – 1) it has the largest enrollment of all courses within the program, 2) the associated learning outcomes (LOs) are very high-level (versus the specific LOs associated with discipline-specific courses, such as Circuit Analysis, Statics, and Dynamics), and are thus more easily satisfied using general project-based assessments.

To initiate the CURES development process, course learning outcomes were assessed to identify the subset of outcomes which did not easily integrate within a research-based project. Course LOs are provided below:

1. Describe the engineering majors, engineering profession, roles, organization, engineering ethics, and careers; investigate professional societies and licensing as a professional engineer; create an initial career development plan and understand the importance of lifelong learning.
2. Use technical communication skills to explain the analysis and results of introductory laboratory exercises in engineering and computer science.
3. Explain the engineering analysis and design process and use it to solve problems.
4. Analyze data collected during laboratory exercises designed to expose students to the different engineering disciplines.
5. Describe the impact engineering has had on the modern world.
6. As part of a team, design a simple engineering device, write a design report, and present the design.

7. Demonstrate computer literacy through computer aided analysis, graphing, documentation, and presentation of results.
8. Create detailed plans for degrees at the community level and university level, analyze the transfer options (between community college and university), analyze success and effectiveness strategies.
9. Use engineering ethics to analyze possible dilemmas that working engineers face, and the potential effects of ethical versus unethical behavior, on society.

As noted above, the considerable project-based focus of the outcomes creates a natural environment for developing CURES within the course. Objectives which did not directly integrate into projects (i.e.: elements of LO 1, etc.) were either integrated into an introductory course module (Module 1: Introduction to Engineering), or were introduced and assessed as secondary assignments during the CUREs portion of the course described in the following section.

Due to the accelerated course redesign time frame, initial corporate partners were exclusively recruited from the professional network of the instructor. The initial candidate group included both large R&D focused organizations, along with smaller start-up companies. While all parties expressed an interest in the collaboration opportunity, smaller organizations were more willing to commit to the initial implementation. We hypothesize that this willingness was due to the natural agility associated with their flatter organizational structure. The Fall 2022 CURES partner was Alt-Bionics, a local start-up company in the smart prosthetics space.

Fall 2022 CURES Implementation

Due to limitations on available laboratory facilities within the engineering department, the initial CURES project for the Fall 2022 semester was structured purely as a research immersion experience (i.e.: no accompany hands-on project). This experience initiated with students completing an *Introduction to Research Module*, which introduced the basic concepts of the research process, the process for generating and disseminating research within engineering, the importance of research within engineering workflows, along with employment pathways into research positions within engineering. Before beginning the module, an assessment of students' initial research literacy was also conducted as described in the following section. At the conclusion of this module (Week 9), students completed a discussion board assignment where they were asked to propose innovations related to the business model of the corporate partner and identify supporting literature as part of a discussion board assignment. The prompts for this assignment are listed below –

1. Based upon your current interests/knowledge of emerging technology (i.e.: artificial intelligence, robotics, advanced materials, 3D printing, etc.), propose a potential innovation in smart prosthetics (i.e.: how do you think technology could make them better)? Please describe your thoughts in 2-4 sentences (discuss what the innovation is, why it would improve performance, and why this would matter to potential customers).

2. Based upon your proposed innovation in 1), please identify a few potential key words/search phrases to use in order to identify relevant research literature. Based upon the key words/search phrases you develop, please perform a basic literature search using Google Scholar and include a screenshot of your results (can paste or attach).

3. Based upon your search results for 2), identify a paper in your results that you feel is the strongest and most related to your search terms. Write a sentence or two justifying your choice using the criteria mentioned in last week's research lecture.

4. Review the abstract for the paper you selected in 3), and write a summary (one to two sentences) detailing what the contribution of the paper was to the engineering body of knowledge

5. Based upon your basic literature review, attempt to structure your idea from 1) as a research question (if you feel comfortable, feel free to extend this to a research hypothesis)

To support students within this assignment, relevant emerging technical content (i.e. 3D printing, photogrammetry, artificial intelligence, sensors, etc.) was integrated into the instructional modules presented at the beginning of course.

During Week 12 of the course, students were asked to pick two of their classmates' posts which were most aligned with their proposed innovations. As part of this response, students were asked to share why they selected this post, and also describe the abstract that they provided as part of their initial post.

The CURES project concluded with the completion of a guided review of a scientific paper. The innovations proposed by students as part of the aforementioned discussion board assignments were clustered into three general categories – 1) improving prosthetic fit through the use of photogrammetry and 3D printing, 2) restoring the sense of touch through distributed sensing and tactile feedback systems, and 3) utilizing artificial intelligence algorithms as part of the prosthetic control algorithm to improve the user experience through reduced latency. Based upon this clustering, three research papers of varying complexity and depth were identified by the course instructor (Topic 1: [9], Topic 2: [10], Topic 3: [11]). A series of guided research questions were then developed for each of the assigned papers. Students were assigned one of the three papers based upon their responses to the initial discussion board assignment, but were permitted to change their selection if desired.

Results from Fall 2022 Initial Assessment

Before beginning the *Introduction to Research Module,* an assessment was deployed to investigate students' research literacy. The assessment consisted of the seven prompts listed below. Students were instructed to state their agreement with each prompt using a 1 (strongly disagree) to 5 (strongly agree) Likert scale.

1. I am aware of the importance of research within engineering.
2. I am aware of the basic initial steps for performing research in an academic environment.
3. I am familiar with the process of finding scientific literature to perform engineering research.
4. I am familiar with the basic process of summarizing scientific literature for a literature review.
5. I am aware of the common educational pathway required to become involved in engineering research.
6. I am interested in potentially pursuing a graduate degree in engineering.

7. I am aware of the general costs and benefits associated with pursuing a graduate degree in engineering.

Responses for each of the seven prompts are tabulated below for the 11 students completing the survey.

Question ID	Mean +/- Standard Deviation
1	4.4 +/- 0.8
2	2.6 +/- 1.2
3	3.6 +/- 0.9
4	3.0 +/- 0.9
5	3.2 +/- 1.0
6	3.5 +/- 1.0
7	3.7 +/- 1.2

Although the sample size of responses is limited, observations of the above responses indicate that although respondents were aware of the importance of research within engineering, and expressed some interest in potentially attending graduate school, their self-reported awareness of the engineering research process was limited. While no post-assessment was conducted due to time constraints, students generally performed well on all assignments associated with the CURES project, with many specifically mentioning the CURES project as a positive course element within the final survey.

Modifications for Spring 2023 Implementation

To improve the student experience in the Spring 2023 CURES implementation, additional elements were added to provide students with additional active learning experiences. Namely, since the Spring 2023 partner is active in the energy resource management space, two additional related experimental learning activities were added – 1) participation of students in the Department of Energy's Solar District Cup, and 2) a lab activity involving the design of an acoustic-based human occupancy detector using the Arduino IoT kit. This latter project was chosen as the corporate sponsor had previously developed related intellectual property within the space. These components are being implemented in addition to the guided research review experience which was previously described. We hypothesize that these additional active learning opportunities will further improve student engagement.

Summary and Future Work

An approach for enhancing the research literacy of first-year engineering students at a two-year institution using a research immersion CURES was described herein. This experience provides students with an introduction to the engineering research process, along with additional integrated content to improve their resource awareness as it relates to engineering research career pathways (i.e.: graduate school application process, funding opportunities for graduate school, etc.). The experience was structured to expose students to relevant technological advancements related to the business model of the corporate partner.

Future work will focus on further enhancing the course experience to provide additional hands-on experiential learning opportunities. A formal assessment of the modified course is being conducted by an external evaluator during the Spring 2023 implementation. Results from this assessment, along with longitudinal measures of student persistence, will be reported in future publications. In addition, strategies for developing offramps to programming which further enhances participants' research identity and skills, such as peer mentor guided small group research experiences [12], are also being explored.

REFERENCES

[1] National Academies of Sciences, Engineering, and Medicine, "Undergraduate research experiences for STEM students: Successes, challenges, and opportunities.", 2017.

[2] P.W. Schultz et al., "Patching the pipeline: Reducing educational disparities in the sciences through minority training programs", Educational evaluation and policy analysis, vol. 33, no. 1, pp.95-114, 2011.

[3] L. A. Beninson, J. Koski, E. Villa, R. Faram, and S. E. O'Connor, "VI. Evaluation of the Research Experiences for Undergraduates (REU) sites program," The emerging role of exosomes in stress physiology, p. 118, 2013.

[4] A. J. Buchanan and G. R. Fisher, "Current Status and Implementation of Science Practices in Course-Based Undergraduate Research Experiences (CUREs): A Systematic Literature Review", CBE—Life Sciences Education, vol. 21, no. 4, p.83, 2022.

[5] I.B. Mena, S. Schmitz, and D. McLaughlin, "An Evaluation of a Course That Introduces Undergraduate Students to Authentic Aerospace Engineering Research". Advances in Engineering Education, vol. 4, no. 4, p.n4., 2015.

[6] L. Potter, R. Stone, A. Fyock, and D. Popejoy-Sheriff, "Implementing a Course-based Undergraduate Research Experience (CURE) into an IE Curriculum", 2018.

[7] G. Bangera, and S.E. Brownell, "Course-based undergraduate research experiences can make scientific research more inclusive". CBE—Life Sciences Education, vol. 13, no. 4, pp. 602-606, 2014.

[8] G. Bangera, K. Harrington, and I. Shaver, "Hands-On, Hands-Off: The Community College Genomics (ComGen) Course-Based Undergraduate Research Experience", 2022.

[9] R. Ismail et al., "Affordable and faster transradial prosthetic socket production using photogrammetry and 3d printing", Electronics, vol. 9, no. 9, p.1456, 2020.

[10] H. Fares et al., "Distributed sensing and stimulation systems for sense of touch restoration in prosthetics", in Proc. IEEE 2017 New Generation of CAS (NGCAS), pp. 177-180, 2017.

[11] D.K. Luu et al., "Artificial Intelligence Enables Real-Time and Intuitive Control of Prostheses via Nerve Interface", IEEE Transactions on Biomedical Engineering, vol. 69, no. 10, pp.3051-3063, 2022.

[12] A. Larweck, A. L. Hooker and H. Griffith, "Accelerating Freshmen Engineering Students into Undergraduate Research Experiences," *2022 IEEE Integrated STEM Education Conference (ISEC)*, Princeton, NJ, USA, 2022, pp. 252-254, doi: 10.1109/ISEC54952.2022.10025196.